III. 大学院学位論文

DISSERTATIONS

A. 大学院博士課程論文梗概

Doctor's Dissertations

電気系工学専攻

A1. 光ファイバパラメトリック飽和増幅とその応用

金 磊

Saturated Fiber Optical Parametric Amplification and Its Applications

By Jin Lei

The devices based on the phenomenon of parametric amplification can be used in many fields of lightwave systems. In this work, I investigate the saturation properties of parametric amplification, and propose practical schemes to improve the devices performance.

In principle, fiber optical parametric amplifiers (FOPAs) can provide high gain uniform over a wide wavelength range. They add little noise to the amplified signal. For several signal-processing applications including optical signal regeneration, phase conjugation, and wavelength conversion, FOPAs are the promising candidates. I theoretically and numerically explain the power saturation and the additional phase noise brought by the FOPA. Based on the theory, the power saturation and the additional phase noise brought by the FOPA are explained. It is found that the saturation in a FOPA originates from the power exchanging periodically. The equation to calculate an approximation to the saturated signal output power is presented. I also propose a scheme for alleviating the phase noise brought by the FOPA at the saturated state. Amplitude-noise and additional phase noise reduction of BPSK and QPSK signals based on the saturated FOPA was numerically studied. The dispersion difference term Δk is one decisive factor for the saturated FOPA. The FOPA can be optimized by controlling the dispersion relation between the pump, signal and idler, and this provides the means to deal with PSK signals.

Fiber optical parametric oscillators (FOPOs) are coherent sources that can provide ultra-broadband tunability and high output power levels and are been considered for applications such as medical imaging and sensing. The aim of this topic is concentrating on providing an alternative besides ordinary rare-earth doped fiber laser.

While most recent literature has focused on advancing the performance of these devices experimentally, theoretical studies are still scarce. In contrast, ordinary laser theory is very mature, has been thoroughly studied and is now well understood from the point of view of fundamental physics. The differences between the gain saturation process in lasers using ordinary gain medium and FOPOs are analyzed. For a phase insensitive FOPO with one pump, there is an optimized output coupling ratio to get a maximum output power, which is close to 1. It is significantly different from the case of lasers using an ordinary gain medium where optimized output coupling ratio is close to 0. By the optimization of coupling ratio, the FOPO with multi-watt output power is realized. The wavelength-swept source based on FOPO operating in near infrared (NIR) and short wavelength near infrared (SWIR) band is also experimentally demonstrated.

A2. 無線センサネットワークにおけるトークン利用型データ収集方式

劉 進志

Token-Scheduled Data Collection in Wireless Sensor Network

By Liu Jinzhi

This paper aims for realization of reliable real-time high throughput data collection with topology adaptability. The pursuit of high throughput data, topology adaptability, real-time and reliability is especially required by applications like volcanic activity monitoring. Such applications are deployed under harsh environmental conditions and need large size data transfer. They tend to focus more on high network throughput, low collection delay and high delivery ratio, as opposed to energy efficiency. One such example is the air-dropped volcanic monitoring sensor network: one sensor node generates 440~bytes per second. Since such sensor networks are deployed under harsh environmental conditions, both software and hardware failures are dif-

ficult to be avoided. Node failures cause network topology changes. Therefore, the system should be developed to be resilient to topology changes. The system should also be able to provide low delay collection with high delivery ratio, i.e. reliability according to the application requirements.

Toward realization of high throughput, topology adaptability, high delivery ratio and real-time collection, there are two dilemmas.

First, there is a dilemma between high throughput and topology adaptability. Although CSMA is suitable for realization of topology adaptability, it is inefficient in achieving high throughput due to the constant medium probing. In contrast, the contention-free medium access control protocols based on TDMA are more suitable for high throughput data collection. Yet, topology adaptability is an open issue for TDMA. The scheduling burden of traditional TDMA is complex in wireless sensor network. Since traditional TDMA endeavors to assign a fixed transmission time slot to each sensor node, the rescheduling task is heavy upon network changes, especially for the centralized TDMA that needs to reassign time slots for all of the sensor nodes.

Different from existing works, this paper assumes uniform traffic, which makes sense because the traffic patterns of most data collection applications are uniform. Energy efficiency in terms of duty cycle has also not been considered since applications like volcanic monitoring are endurable in keeping radio always on.

Under the premises, this paper proposes TKN-TWN: token based multi-channel TDMA to tackle the dilemma between high throughput and topology adaptability. Two features characterize the design of TKN-TWN: (1) TKN-TWN arbitrates burst data transmission using multiple tokens. (2) TKN-TWN leverages multi-channel TDMA for efficient packet forwarding, where time slot assignment is further associated with the token ownership for throughput optimization. The time slot assignment in TKN-TWN is self-determined based on routing information. As a result, topology adaptability in TKN-TWN only involves robust token passing and routing recovery. TKN-TWN is able to conditionally break the myth that TDMA does not adapt well to topology changes and maintain high throughput as well.

Second, there is a dilemma between reliability and real-time. In order to provide reliable data collection, end-to-end packet loss recovery is needed. To this end, the sink node has to deliver the lost packets' information to related sensor nodes. However, implementation of downward communication from sink node to source node is difficult for high throughput data collection due to the limited bandwidth. Therefore existing works such as PIP and Flush use flow to provide bi-direction communication between two end points of sink node and source node, which involves flow setting up and tearing down. Such approaches are suitable for bulk data transfer in applications like structure health monitoring that normally requires one-shot short term data collection. But since the flow setting up and tearing down causes delay to data collection, connection-oriented data collection using flow is not suitable for applications like volcano monitoring that requires long term consistent real-time data collection.

Toward realization of reliability, TKN-TWN exploits the bi-direction token passing for end-to-end packet loss recovery, which affords TKN-TWN the leverage to achieve high delivery ratio with connection-less communication. The sink node piggybacks lost packets' information on token messages. When distributing tokens in a new collection round, the sink node loads the lost packet's information on the token messages. Upon tokens' arrival, source nodes check and retransmit the lost packets in the first place. Since token based scheduling is not connection-oriented, low delay data collection can be achieved. Considering that the piggyback capacity of one single token message is limited, Token-Burst is also proposed to flexibly extend the piggyback capacity when needed.

The author implements TKN-TWN on Tmote Sky with TinyOS 2.1.1 operating system. Analysis regarding the token passing and collection throughput is given. Evaluation verifies the analysis and shows that TKN-TWN is able to provide throughput of 9.7 KByte/s. The experimental results in a deployed network consisting of 32 sensor nodes show that TKN-TWN is robust to network changes caused by occasional node failures. 100% data collection has been achieved in the experiment. To the best knowledge, this work is the first to consider reliable high throughput data collection with topology adaptability and low delay using token-based scheduling.

A3. 都市型マイクログリッドにおけるエネルギー貯蔵装置の運用計画および運転制御に関する研究

下田 英介

Study on Operation Planning and Control of Energy Storage System in Urban Type Microgrid

By Eisuke Shimoda

Recently, the government of Japan has promoted to install a large amount of renewable sources. However, a large amount of intermittent renewable sources, photovoltaic generation and wind turbine, might disturb stable power supply, because these generation system outputs depend on a weather condition. Microgrid is one of the solutions to supply stable electrical power with a large amount of intermittent renewable sources. In a microgrid, several types of distributed generations (DGs) and energy storage systems (ESSs) are controlled according to load demand and outputs of intermittent renewable sources.

In a microgrid, power flow of point of common coupling (PCC) must be kept almost constant. However, efficiency of DGs and ESSs might drop to a lower value and there is a possibility that the convenience of a consumer may be spoiled if outputs of DGs and ESSs are controlled. An optimized operation planning for DGs and ESSs is necessary to solve this problem. Optimized operation planning for DGs and ESSs requires a lot of calculation time to search solution space. Therefore, operation planning in a specified period is made in advance, and a

predicted electrical load is used for operation planning.
In order to draw up more economic operation planning, it is necessary to consider the following two points
(a) To increase accuracy in the electrical load prediction
(b) To reflect the part-load efficiency of DGs and ESSs in the operation planning

This paper shows an electrical load forecasting method and an optimized operation planning method for microgrid. There are some methods to predict the electrical load, such as Artificial Neural Network (ANN). However, most of these methods have need of a lot of learning data to increase accuracy in the prediction. For the electrical load prediction, this paper uses an operation planning of the heat sources which run according to heat load prediction. It is possible to increase accuracy in electrical load prediction easily, because power consumption of heat sources accounts for the large portion of whole load variation in microgrid.

And then, in the operation planning, this paper considers the part-load efficiency of DGs and ESSs. Especially, the part-load efficiency of ESS has a strong relationship with this direct-current (DC) characteristic and this state of charge (SOC). To reflect the DC characteristic, more accurate and economic plan can be made.

On the other hand, another advantage of constructing the microgrid is islanding operation. In islanding operation, microgrid is separate with the existing power system, and DGs supply electrical power to load. However, it is difficult to balance the quantities between the load demand and power supply, frequency and voltage fluctuation are easy to arise in islanding area. Therefore, positive power compensation using energy storage systems (ESSs) is necessary to keep high level power quality.
This paper will also give control strategy of ESS to realize high quality power supply in islanding operation including transition term. And this paper will show operation results by using existing microgrid systems.

The centralized controller calculates output reference value of each DG by using a control method called “combined cascade control method”. In this control, the load and intermittent renewable sources fluctuation components that are too fast to be compensated by a DG will be compensated by other ones whose response is faster than the DG. Therefore, it is possible to adjust outputs of DGs for load sharing according to these response speeds.
By the way, centralized control has need of much information to calculate reference value. If the DGs are scattered about in a microgrid, it is difficult to correct all synchronized information at high-speed.

Therefore, the authors adopt a local control to compensate rapid load and intermittent renewable sources power fluctuation that are not compensated by centralized control. Local controller on ESS that has the quickest response in the DGs observes both power flow of PCC for the grid connecting operation and rotating machine output for the islanding operation at high speed. This controller autonomously modifies the reference value of the centralized controller on the basis of these observed values.

A4. 通信波長帯単一量子ドットにおけるコヒーレント光電子相互作用に関する研究

都木 宏之

Study on Coherent Light-Matter Interaction in Single Quantum Dot at Telecom Wavelength

By Hiroyuki Takagi

An exciton in a self-assembled quantum dot (QD) is a promising candidate for qubits, which form key elements of quantum computation. For the quantum information processing, we need to control the states of the qubits, which can be achieved by using light (or “photons”). Photons can be another important constitute of the quatum computation, which propagate quantum information from a quantum information device to spatially separated another one. For this purpose, controlling interaction between excitons and photons is a significantly important technology.

In order to enhance the interaction between photons and excitons (or light and matter), we used nanocavities, which are composed of defects in the regularly aligned air-holes, known as photonic crystals (PhC). PhC nanocavities provide very small mode volume, which is as small as the cubic of resonant wavelength of the mode. This small mode volume enables strong interaction between confined photons and matters. Here, we used the two-dimensional (2D) PhC nanocavity in GaAs slab including InAs self-assembled quantum dots. For the scalable quantum computation devise, the connection between each devise is desired to be composed of optical fibers. In this purpose, we chose telecom wavelength at which we can use optical fibers and matured optical devises designed for telecom applications.
In this thesis, we focus on the interaction between excitons in QDs and PhC nanocavities.

At first, we focus on the design of H1-type nanocavities. H1-type nanocavities are formed by a single missing air-hole in a triangular 2D PhC lattice, which show distinguished features: a wide variety of confined cavity modes, high Q factors, and small mode volumes V. Especially, doubly-degenerate, orthogonally-polarized dipole modes in H1 PhC nanocavities have been receiving much attention due to their various potential applications, including the cavity-assisted generation of entangled photons, spin-photon media conversion and all optical switches. Our newly-designed H1-type PhC nanocavity simultaneously exhibit high Q factor, small mode volume, and efficient vertical emission for the dipole modes. These superior properties have been achieved by shifting and shrinking the first to third closest neighbor holes around the defect. This modification maintains the six-fold rotational symmetry, so that the degeneracy of the two dipole modes is not broken. Through numerical simulations, we calculated this modification improves Q factors up to 62,000. Remarkably, the same cavity with the high Q design exhibits a large coupling efficiency of 0.38 (assuming an objective lens with a moderate numerical aperture of 0.65). Under other design parameters, we demonstrate that coupling efficiency can be improved to over 0.6, while keeping high Q

factors over 50,000.

We fabricated the newly-designed nanocavities into a GaAs wafer including InAs QDs, and the increase of both Q and coupling efficiency, relative to unoptimized H1 cavities fabricated in the same way, was experimentally confirmed. At optimum design parameters, the maximum experimental cavity Q of 25,000, which is the highest value ever reported for the dipole modes of H1 PhC nanocavities, is observed.

By using this newly-designed H1-type nanocavity, we experimentally demonstrate large energy shift (> 0.06 meV) caused by optical Stark effect on the QD exciton with extremely low excitation laser power at wavelength around 950nm. This is achieved by employing the newly-designed H1-type PhC nanocavity. Furthermore, from analytical estimation, we supposed that this large energy shift was caused by only four or five cavity photons. This implies the possibility to realize single-photon level optical devises.

In order to coherently control the state of the qubits, or excitons in the QD, using Rabi oscillation is the promising way. We successfully observed exciton Rabi oscillations with picosecond pulses at telecom wavelength around 1300 nm. This suggests that we can coherently control the exciton state withing the decoherence time of the system and using fiber optic devises. Furthermore, we successfully observed optical Stark shift at telecom wavelength as similar to the one in 950nm. This provides a great advantage in realizing practical and scalable quantum computing system. The suggested techniques and observed effects pave the way for practical implementations of future quantum information devices.

A5. 真空遮断器における非持続性破壊放電現象

徐 碩

Non-Sustained Disruptive Discharge in Vacuum Circuit Breaker

By Shuo Xu

Non-Sustained Disruptive Discharge (NSDD) is disruptive discharge in the Vacuum Circuit Breaker (VCB) after the current interruption without leading to power frequency current flow into the shielded electrical element. This research investigates NSDD to enable the comprehensive understanding of NSDD from phenomena to theory.

A Synthetic Circuit is constructed to investigate NSDD in VCB. This circuit consists of high voltage circuit for the insulation test; and the large current circuit to generate arc current. An optical fiber-based control system is developed to control the system.

Firstly, NSDD related particles, generated during arc, are studied by optical method and collection method. Through the optical observation, the particle phenomenon is confirmed: The size of the particle is within 200 microns in diameter; the lifetime of the particle is generally less than 1/4 cycle of the power frequency. And, two types of particles are confirmed. One type is the loosely contacted particle on the electrode surface. The other type is that the welded particles on the cathode during arcing time.

According to the results, particles are considered to be weakly related to the discharge. For further confirmation, some particles are introduced onto the electrode surface for dielectric test. The results show that the discharge take place before any movement of the particles. Thus, particles are acting as protrusions on the electrode surface to induce discharge.

Then, the surface condition of the electrodes are scanned and observed. Before arc, the electrode surface roughness is less than 5 micron. However, after arc, the surface roughness goes up to 50 micron for 4kA arc current; and up to 170 micron for 10kA arc current. For 10kA arc current, the arc left some craters on the surfaces of the electrodes.

Based on the above consideration, point-to-plane insulation structure is constructed in vacuum. Residual vapor is observed even when the strong field emission disappears, which implies that that local protrusion on the point electrode surface is polished by the current to release vapor. Particles are generated on the point electrode surface during cathode time. Through the analysis of the field emission waveform, the field emission has relative larger field enhancement factor than that of the voltage falling side. That means the discharge will be relatively easy on the voltage rising side. Thus the initiation of the discharge is considered as the Joule Heating from the Field emission. So, the research of NSDD is equivalent to the research of the discharge using the arced electrodes in the vacuum chamber, without initial particles and plasma.

The dielectric strength test result shows that the insulation level gets higher and higher in experiment sequence. And, the anode electrodes while arcing time, for both AgWC and CuCr, always have the higher insulation level than that of the cathode electrode. This indicates that the cathode surface is eroded more seriously than the anode electrodes during arcing time.

The second test result is the predischarge current is in the order of mA. Using the Child Langmuir equation, the field emission results lead to the voltage-current relationship for the predischarge. Thus, the discharge will be expected if the current exceeds the critical value at specific voltage.

For the third observation is that, using the high speed video camera, the discharge is observed. The discharge initiated as a ball shape, and then develops as a bridge to shorten the gap of the VCB. While using exposure time at 100ns order, the discharge process is observed as single cathode spot discharge. The discharge waveform shows that the time scale of the discharge is around 300ns, and the current is about 30A.

In order to confirm the sustainability of the discharge, current limiting resistor is used to suppress the current of the discharge. The discharge is always going to be disruptive. After the discharge, the dielectric strength will get self-restored. According to the measurement of the dielectric recovery experiment, the dielectric recovery time constant for 5mm vacuum gap is 5.7μs, and 7μs for 10mm gap. By using the gas-cloud expansion model in vacuum, the time constants of the two are coincident.

The theory analysis of the NSDD is performed too. As the analysis results show, the discharge is not so strongly depend on

the metal vapor density, but strongly dependent on the ionization cross section of the material. The self-sustainable condition for the discharge is in the order of tens volts. Thus, the discharge in vacuum is always disruptive. After discharge, the metal vapor will expand to vacuum, the insulation level gets recovered, and thus the discharge is turned to be non-sustained, as termed non-sustained in NSDD.

The consequences of NSDD to the three-phase system is investigated using results from single phase research. According to the simulation for lumped and distributed parameters elements using EMTP, the overvoltage to the VCB is most serious for the ungrounded long transmission line type load.

A6. 太陽光発電が大量導入された電力系統における電力貯蔵設備を考慮した最適電源運用計画に関する研究

相原 良太

Study on Optimal Weekly Operation Scheduling of Power System Considering Energy Storage System with a Large Penetration of Photovoltaic Generation.

By Ryota Aihara

It is expected that a large amount of renewable energy such as photovoltaic power generation (PV) and wind power generation into power system is a solution to environmental problems. Japanese government aims at installing a large amount of PV in power system. Since the power output from the PV is random and intermittent in nature, the PV generation poses many challenges to the power system operation. When the load demand is small and at the same time the PV generates a large amount of power, the balance between power supply and demand cannot be maintained. This problem is called “surplus power problem"". In addition to this problem, it is also necessary to consider the uncertain output characteristic of PV.

In this thesis, it is presented that the effective use of Pumped Storage Hydro Power Plant (PSHPP) to solve the above problems caused by PV. The PSHPP is installed originally for load leveling within one day. The PSHPP is usually operated as a generator in the daytime and a pump in the nighttime. In the near future, however, it will be operated with the optimal scheduling considering a large penetration of PV. The effectiveness of the optimal operation of the PSHPP is evaluated by Monte Carlo simulation considering stochastic fluctuation of the load demand and PV output as uncertainties. The pareto optimal solution is used to evaluate the effectiveness of proposed method. The evaluation indices are power supply reliability using LOLP (Loss of Load Probability) and weekly fuel cost.

In the weekly scheduling, a generation schedule is found by solving an optimization problem in which the fuel cost is minimized. A Tabu Search method is used in the optimization algorithm. The control variable of the optimization problem is power output of the PSHPP. The hot reserve capacity of the thermal power plant is considered as a constraint. In this thesis, a hot reserve capacity for the stable power system operation is assumed at a constant amount during the whole simulation time for a fundamental study. Two types of hot reserve rates are assumed here. The one is the reserve rate corresponding to the load demand. The other corresponds to the theoretical PV output. In this simulation, the level of water in the reservoir of the PSHPP may shift from its schedule because an unexpected imbalance of supply and demand is compensated by emergency operation of the PSHPP. In order to solve this problem, this thesis proposes a new weekly simulation method, by which the optimal weekly PSHPP scheduling is determined day by day. As proposed method requires huge computation load, a new efficient optimization method for operation planning of the PSHPP for a new weekly scheduling is also presented. This method adopts efficient economic load dispatching (ELD) in the optimization algorithm. Furthermore, to reduce the iteration times in the optimization process, the optimal solution candidates stored in the database are used. When an optimization starts, its initial solution is referred from the candidates stored in the database which has the same condition. This technique is expected to be helpful for speed-up of the optimization process.

The simulation results show that the proposed method is very effective in terms of fast computation, and that LOLP index is improved when the hot reserve capacity is increased. In contrast, the probability of the surplus power is getting large. It can be said that too large hot reserve capacity may cause surplus power problem.

Based on the above results, a new method which determines an optimal hot reserve capacity is proposed, which is a new optimization method whose control variables are hot reserve rate corresponding to load demand for each time period. It is made clear that the secured reserve capacity is relatively low compared to the constant reserve amount especially in the daytime on Saturday and Sunday. However, in this case, LOLP index is not so good compared with that under the power system condition without PV.

Finally, an optimal operation scheduling method of Battery Energy Storage System (BESS) in cooperation with the PSHPP is proposed in this thesis. Although the BESS could be considered as a solution to the problem caused by PV, their high cost is preventing them from being considered as a solution in most situations. However, the power system may not be operated without installing the BESS when a large penetration of PV is installed. Therefore, a new weekly scheduling method with a PSHPP and BESS is considered. The operation scheduling of PSHPP and BESS are optimized by Tabu search method. The simulation results show that the proposed method is very effective to improve the power supply reliability and suppress the surplus power even if a large penetration of PV generation is installed.

A7. 中性粒子ビーム入射と磁気リコネクションの高出力加熱を用いた超高ベータ トーラスプラズマの生成と維持

伊井 亨

Formation and sustainment of ultra-high-beta spherical torus plasmas by use of neutral beam injection and high power heating of magnetic reconnection

By Toru Ii

My dissertation objectives are formation and sustainment of ultra-high-beta spherical torus plasmas by use of neutral beam injection (NBI) and high power heating of magnetic reconnection. To achieve the goal, we revealed experimentally a new fast mechanism of three-dimensional (3D) magnetic reconnection. We also developed a new NBI system, made the NB injection experiment for oblate field-reversed configurations (FRCs), and performed formation experiments of ultra-high-beta spherical tokamaks (STs).

First, we investigated a new phenomenon of 3D magnetic reconnection in TS-4 torus plasma merging experiments by measuring directly the 3D structures of the current sheet. Removal of all toroidal asymmetry of the device reveals that a strong external drive of reconnection inflow increases the toroidal asymmetry of the current sheet only during the reconnection. This spontaneous 3D deformation of the current sheet increases the reconnection outflow as well as the reconnection electric field, probably because local compression of the current sheet to a thickness less than the ion gyroradius triggers its strong dissipation of the current sheet, responsible for the onset of 3D reconnection. These observations indicate that the 3D reconnection is a newly observed spontaneous process of fast reconnection.

To develop a new two-fluid type interpretation of the reconnection heating, we also studied quantitatively the effect of guide field on Hall magnetic reconnection by systematically varying an applied guide field in the MRX device. The reconnection rate is reduced with increasing guide field, because the in-plane Hall currents are reduced and guide field pileup at the downstream region produces an increased pressure. The quadrupole field, a signature of null-helicity Hall reconnection, is altered asymmetrically along with asymmetrical change of in-plane plasma potential profile, which results in decrease of electrostatic acceleration to ions near the separatrices toward the outflow direction.

Next, we have developed a novel and economical NBI system using a washer-gun plasma source for the first time. It produces a low-cost, maintenance-free, high power and low voltage ion beam, thus eliminating the need for the conventional filaments and water-cooling systems. By optimizing plasma formation, we successfully achieved beam extraction of up to 40 A at 15 kV and a pulse length longer than 0.25 ms. Its low-voltage and high-current pulsed-beam properties enable us to apply this high-power NBI into a high-beta compact torus plasma characterized by a low magnetic field.

The low-energy, high-current NBI was applied to an oblate FRC for the first time. The fast ions from the NB reduce growth rates of low-n modes dangerous for the oblate FRC, extending the FRC lifetime. The reduced loss power of 5 MW is ten times higher than the NBI power of 0.5 MW, indicating that the NBI not only heats the FRC plasma but also improves its stability and transport properties. The NBI also maintains higher pressure and current density profiles of the FRC, improving its flux and energy decay times by a factor of 2.

Finally, we demonstrated formation experiments of ultra-high-beta STs from an oblate FRC and a spheromak. Rapid ramp-up of external toroidal fields to the FRC results in the ultra-high-beta ST with its volume-averaged beta of 50%, toroidal beta of 100%, poloidal beta of 100%, and normalized beta of 20 for its duration of 50 microseconds. The high-beta ST is found to have a diamagnetic toroidal field profile in sharp contrast with the peaked toroidal field profile of the low-beta ST. Those high-beta STs often have absolute minimum-B profiles that can stabilize all interchange modes. Ramp-up of external toroidal field reduced the growth rates of low toroidal mode numbers, improving the energy decay time.

In conclusion, we successfully formed and sustained ultra-high-beta spherical torus plasmas by use of high power heating of magnetic reconnection and the newly developed NBI.

A8. シャックハルトマン法による小電流アーク内の二次元電子密度分布測定

稲田 優貴

Measurement of Two-Dimensional Electron Density Distribution over Low Current Arc Using Shack-Hartmann Method

By Yuki Inada

Shack–Hartmann type laser wavefront sensors were developed for measuring a two-dimensional electron density distribution over an arc discharge in an extinguishing phase from a single recording with high temporal and spatial resolutions.

A9. 大規模計算環境を活用するコンピュータゲームプレイヤの研究

浦 晃

Computer Game Players Utilizing Large-Scale Computing Environments

By Akira Ura

Large-scale computing environments such as computing clusters and cloud computing services have been getting commonly-used recently. To fully utilize such powerful environments, studies are needed for each of a wide variety of application areas. In this thesis, we propose methods to utilize large-scale computing environments in order to improve the strength of

computer game players. The targeted game is shogi (known as Japanese chess). Proposals aim to improve performance of two different processes required for computer shogi players: acquisition of knowledge to evaluate game positions and search for an appropriate move at a given position. Some of the proposals are proven to be effective through experiments on a reasonably large computing environment.

Computer game players use evaluation functions which estimate the chance of winning for given positions. Many studies have been conducted to find effective ways of tuning the parameters of evaluation functions using supervised approaches. Effectiveness of supervised approaches, in large part, depends on the number of training samples. However, the amount of high quality game records such as those of human experts is usually limited.

We propose an approach to generating additional training data using search results of computer game players. This approach consumes a great amount of time to perform deep searches for creating such training data, but the process can be easily parallelized on large-scale computing environments. We generated positions in three types of situations, namely, those appearing in self-play games, those at leaves of search trees, and those appearing in random games. We used a shogi program, Gekisashi. The generated training data were added to the game records of experts. Experimental results show that the generated data can improve the strength of computer players when leaf positions in search trees are added.

Training time becomes longer when the number of training positions increases. In order to shorten the training time, we apply a parallel training method to Gekisashi's evaluation function. Experimental results show that the parallel training method is effective for evaluation functions in shogi programs.

For increasing the search speed of computer players, our goal is to efficiently parallelize the alpha-beta algorithm utilizing large-scale computing environments. The alpha-beta algorithm significantly reduces the search space by pruning subtrees, but, given a search tree, at least one of the certain sets of subtrees must be searched to complete the search. Since such subtrees are yet to be known to the program when the search is started, prediction of such subtrees is made gradually, increasing its accuracy during program the search. Search in those subtrees judged to be unnecessary in early prediction may be judged necessary afterwards, and vice versa.

We propose a method to prioritize search in subtrees based on the possibilities of their necessities. Necessities of searching subtrees are predicted based on the results of search in related subtrees. During such search, the sizes of the subtrees predicted to be mandatory are limited. Dividing such search tasks into small fragments causes too much parallelization overhead and thus the abundant computing resources in large computing environments cannot be fully exploited. There are subtrees for which search necessities are yet to be predicted but may become known afterwards. It is beneficial to use surplus resources for speculative execution of such tasks. However, not all of them have the equal chance to be necessitated. Our proposal is to estimate the probabilities of search tasks to become necessary and prioritize them accordingly to control the speculation. Certain performance improvement is shown in simulations in which all tasks have the same cost. However, its effectiveness is not observed with actual search in shogi game trees.

To fully exploit the resources available in large computing environments, search in subtrees must be started based on prediction of their necessities before knowing search results of other subtrees which could have been obtained in the sequential search. The prediction should be dynamically updated using results of partially completed search. Game tree search is conducted in an iterative deepening fashion, that is, the tree is inspected incrementally deeper. The shallow search results should be promptly reflected to the prediction. We implement a parallel game tree search algorithm performing such dynamic updates on the prediction. Searches in two kinds of game trees are tried in performance evaluation: synthetic game trees and game trees generated by Gekisashi. On a computer cluster with more than 1,500 cores, the updates of the prediction actually show significant performance improvements, which are more apparent in game trees generated by the shogi program for which initial prediction is less accurate. The speedup nevertheless remains sublinear. A performance model built through analyses of the results reasonably explains the results.

A10. Q 値可変フォトニック結晶ナノビーム共振器の作製と光電子相互作用の制御に関する研究

太田 竜一

Fabrication of Tunable-Q Photonic Crystal Nanobeam Cavities for the Control of Light-Matter Interaction

By Ohta Ryuichi

Photonic crystal (PhC) nanocavities have been investigated as fascinating platforms to build integrated optical devices and to study fundamental physics of the light-matter interaction in cavity. Strong light confinement in both of real space and frequency space enable to dramatically enhance the overlap of the field distribution of cavity modes to nano emitters. In addition, emission rate and collection efficiency from cavity modes can be engineered by modifying PhC pattern. So far, PhC nanocavities are widely studied to enhance optical property of materials toward extremely efficient lasers and solar cells, and to construct quantum information system in solid.

Recently, dynamical control of the property of PhC has been of great interest because of their capability to improve the functionalities for integrated optical devices and open the novel field to study the light-matter interaction. In particularly, in-situ control of quality (Q) factor in PhC nanocavities is one of the promising objectives, since it enables photon trapping and releasing within a micrometer scale region, as well as tunable spectral filtering. The first demonstration of Q factor control and subsequent experiments to manipulate the light-matter interac-

tion had been reported by injecting local heat or extra carriers which modify the refractive indexes around the cavity. However, several problems still remain for realizing a larger tuning range of Q factor and resulting control of the light-matter interaction. The biggest problem is that the generated heat and carriers hardly degrade the controllability of Q factor and the optical properties of materials. Avoidance of this problem is essentially difficult in the conventional way. It is the time to break through the limitation by a new approach.

In this thesis, one dimensional PhC nanocavities, called PhC nanobeam cavities, in micro electro mechanical system (MEMS) is investigated to control their Q factors. Q factor of PhC nanobeam cavity is controlled by changing the gap distance between the cavity and an adjacent waveguide. The cavity and the waveguide are connected to MEMS actuators respectively, which separate the gap distance without any undesired effects including additional heating and generation of extra carriers. In this thesis, Q factor change from 3,500 to 14,000 with a voltage of 17 V is experimentally demonstrated. The combination of the wide range tunable-Q cavity and self-assembled quantum dots (QDs) enable to dramatically change the coupling between photon and exciton in the system.

In chapter 2, fundamental physics about PhC nanocavities, QDs and the light-matter interaction in the cavities are discussed. Based on Jaynes-Cummings model, two different regimes of the interaction in the QD-cavity coupled system are explained. It also indicates that one of the critical parameter, which governs the light-matter interaction in cavity, is Q factor of PhC nanocavities.

In chapter 3, design and fabrication procedure for high Q PhC nanobeam cavities without MEMS are explained. Demonstration of high Q PhC nanobeam cavities leads a wide range Q factor control by combination with MEMS actuators. Thanks to parabolic modulation of air-hole distances, intrinsic (calculated) Q factor of isolated PhC nanobeam cavity exceeds 107. After the careful optimization of fabrication process, Q factor of 44,000 is experimentally achieved in PhC nanobeam cavity incorporating QDs.

Measurement setup and fundamental characteristics of PhC nanobeam cavities are discussed in chapter 4. By tuning the resonant wavelength of the cavity mode to that of a single QD, vacuum Rabi splitting of 226 μeV is observed, which confirms the coupled system is in strong coupling regime. In weak coupling regime, low threshold lasing in PhC nanobeam cavity is also demonstrated. These experimental results indicate that the coupled systems of QD-PhC nanobeam cavity enable to dramatically change the light-matter interaction by control of its Q factors.

In chapter 5, design and fabrication techniques for electro mechanically controllable PhC nanobeam cavities are described. Fabrication procedure of electro mechanically controllable PhC nanobeam cavities becomes much complicated and difficult than that of isolated PhC nanobeam cavities. Especially, these movable structures are easily broken down in wet etching process due to the strong surface tension of water. However, optimization of each process and introduction of boiling technique drastically increase success rate.

In chapter 6, wide range Q factor control and modulation of the light-matter interaction are experimentally demonstrated. Q factor is continuously controlled from 3,500 to 14,000, which is the largest control range of Q factor in PhC nanocavities incorporating QDs. Modulation of emission lifetime of QD in a PhC nanobeam cavity is also observed by changing the Q factor. Furthermore, in-situ switching of the coupling regimes is discussed in this chapter.

Resonant wavelength shifts of the cavity mode are observed in the Q control operation, which induce a detuning between the QD and the cavity resonance. Therefore, novel designs to reduce the resonant wavelength shift with keeping a large tuning range of Q factor are expected for more complicated control of the light-matter interaction. For this purpose, theoretical analysis of coupled mode equations in cavity-waveguide system is investigated in chapter 7. Good agreement between theoretical model and FDTD calculations reveals that variations of Q factor and resonant wavelength of cavity mode are attributed to the coupling of waveguide modes. This finding indicates that the voltage dependence of Q factor and resonant wavelength shift can be manipulated by tailoring the dispersion of the waveguide.

Finally, conclusion of this thesis is presented in chapter 8. Significances of the results in this thesis and an outlook for future prospects are discussed in this chapter.

A11. 空調機器を可制御負荷として用いた短周期電力変動補償システムの設計手法及び実証検討

河内 駿介

Proposal of Control Parameter Designing Method and Actual Machine Test of Short Term Power Fluctuation Compensation System by Use of Heat Pump Air-Conditioning System as Controllable Load

By Shunsuke Kawachi

It is concerned that penetration of naturally fluctuating renewable energy sources such as photovoltaic cells and wind turbines on a large scale will cause shortage of LFC capacity and difficulty in stable operation of power grid. In order to compensate power fluctuations caused by loads and renewable energy sources, the concept of load control is proposed. In this concept, the power consumption of load equipments are controlled by grid operator. These loads whose power consumption can be controlled are called controllable loads.

This research focuses on use of heat pump air-conditioning system (HPACS) as controllable load in microgrid and following studies have been conducted.

1. Measurement of basic characteristics of HPACS
2. Proposal of new designing method to determine control parameters for microgrid including HPACS power consumption control

3. Verification of power fluctuation compensation control for microgrid by use of HPACS power consumption control in real microgrid testing facility
4. Analysis of contribution ability of microgrid with HPACS control to grid frequency control

In the measurement of HPACS's basic characteristics, efficiency characteristics, dynamic characteristics of power consumption, and dynamic characteristics of heat generation have been measured by experiment using real HPACS machine.

The proposed method to determine microgrid's control parameters calculates transfer function between microgrid's power fluctuation source and microgrid's tie line power flow. The frequency spectrum of microgrid power fluctuation is multiplied by value of transfer function in order to calculate frequency spectrum of tie line power flow fluctuation. Power spectrum density (PSD) is calculated from frequency spectrum and LSD is integrated in frequency domain to calculate tie line power flow's RMSE for fluctuation within frequency range that should be compensated. The fluctuation suppression ratio of microgrid is calculated using RMSE value of tie line power flow and original power fluctuation, The RMSE of battery's SOC fluctuation and HPACS's stored energy fluctuation are calculated in the same way using transfer function and PSD integration. By changing control parameters cyclopaedically, set of control parameter combination that gives Pareto-optimal combination regarding fluctuation suppression ratio, RMSE of battery's SOC, and RMSE of HPACS's stored energy is acquired. From the list of Pareto-optimal control parameter combination, the control parameter for microgrid can be determined depending on the allowable SOC fluctuation of battery, stored heat fluctuation of HPACS, or fluctuation suppression ratio.

The verification test is conducted using a microgrid testing facility with gas engine (GE), HPACS, NiMH battery, and loads. Experiments are conducted in several microgrid configurations combining GE, HAPCS, and NiMH battery. The results of experiment case in which both HPACS and NiMH battery are controlled shows that power consumption control of HPACS can reduce SOC fluctuation of NiMH battery on a large scale compared to case in which only NiMH battery is controlled. The loss of convenience caused by HPACS power consumption control is analyzed using room temperature calculation model and heat storage model. The results of analysis using room temperature model show that the temperature fluctuation caused by HPACS control is within range of 1 degree Celsius In case of analysis using heat storage model, the fluctuation of stored heat was with in range of normal heat storage capacity. The results of experiment case in which GE, HPACS, and NiMH battery are controlled shows that control of HPACS can reduce output fluctuation of GE compared to case in which only GE and NiMH battery are controlled. This indicates that by controlling HPACS's power consumption, larger proportion of GE in microgrid can be used as reserve margin.

The contribution ability of microgrid to grid frequency control is analyzed by using linear model of power grid. In the grid model, loads, renewable energy sources, base power plant, thermal power plant, hydro power plant, grid battery system, and microgrid are considered. The transfer functions between power fluctuation sources (Grid side load + grid side renewables and microgrid load + microgrid renewables) and output of grid side apparatuses(i.e. thermal power plant, hydro power plant, grid side battery) are calculated. The frequency spectrum of grid side apparatuses output is calculated by multiplying frequency spectrum of power fluctuation sources and value of transfer functions. The RMSE of power fluctuation that corresponds to LFC frequency region and compensated by grid side apparatuses is calculated from frequency spectrum of these outputs using PSD integration. RMSE of grid side battery's SOC fluctuation and RMSE of microgrid side battery's SOC fluctuation are also calculated in the same way using transfer function and PSD integration. The relation between microgrid's fluctuation suppression ratio and RMSE of grid side apparatuses' LFC output, RMSE of grid side battery's SOC fluctuation, and RMSE of microgrid battery's SOC fluctuation is analyzed. The analysis shows that there is a trade-off between LFC capacity and microgrid battery's SOC fluctuation, but there is no relation between microgrid's fluctuation suppression ratio and grid side battery's SOC fluctuation.

This research indicates the effectiveness and feasibility of power fluctuation compensation by use of HPACS in LFC region and will contribute to development of load control system in power grid.

A12. ガイド磁場磁気リコネクション実験における磁場揺動と静電揺動

桑波田 晃弘

Experimental Studies of Electromagnetic and Electrostatic Fluctuations during Guide Field Magnetic Reconnection

By Akihiro Kuwahata

Magnetic reconnection is a fundamental phenomenon which occurs in all magnetized plasmas. The sun shows explosive phenomena triggered by magnetic reconnection in the solar system: solar flares and coronal mass ejections (CMEs). These powerful events tremendously impact on our lives: damaging satellites, disturbing radio signal for communications, and involving wide-area electrical blackouts. How are these explosive events arisen in the sun? This question is the beginning of magnetic reconnection studies.

There is the huge gap of reconnection duration between theory and nature. For solar flares, typical time scale of magnetic reconnection in a theory based on simple magnetic dissipation is about 10^{14} s, while it in nature is about 10^{3} s. Why is magnetic reconnection in nature so fast in contrast to the theory? Various models such as Sweet-Parker model, Petschek model, and two-fluid model has been considered to fill the huge gap. However, there is not yet consensus on how fast reconnection is triggered during magnetic reconnection.

In order to verify the mechanism of fast reconnection, magnetic reconnection experiment was performed in the TS-3 Plasma

Merging Device.

This dissertation provides detailed studies of magnetic reconnection in the presence of a guide field in TS-3 Plasma Merging Device. When a guide field is applied in magnetic reconnection, it changes many reconnection conditions: electron parallel acceleration and asymmetric distribution of density, potential, and magnetic field, and so on. These conditions could drive waves and instabilities which can lead to fast reconnection. By using high spatial resolution 1-D scans of many probes such as magnetic probes, electromagnetic and electrostatic fluctuation probes, and Langmuir probes, detailed profiles of the plasma parameters have been obtained.

Large electromagnetic fluctuations were observed inside the current sheet during fast magnetic reconnection in the presence of a guide field. Amplitudes of fluctuations reached 10% of the reconnection magnetic field. The fluctuations had a clear peak frequency of 1.5 – 2 MHz, which was about 2 times larger than the local ion cyclotron frequency.

2-D measurement of the electron density shows that diffusion region was modified due to the effect of a guide field. This suggests that the Hall effect appeared around the diffusion region in the experimental regime.

Electromagnetic fluctuations were localized at the downstream region rather than X-point, which means that fluctuations might play an important role of ion and/or electron heating at the downstream.

The fluctuations were found to propagate to the parallel and perpendicular direction to the magnetic field. The parallel and perpendicular phase velocities were approximately 100 km/s and 50 km/s, respectively. These velocity were similar value of the local Alfv¥'en velocity (100 km/s). The fluctuations were left hand polarized to the wave number vector. Numerical calculation of dispersion relations for low frequency wave shows that the left hand polarized wave (kinetic Alfv¥'en wave: KAW) can propagate in the experimental regime, while the right hand polarized wave (Whistler wave) is evanescent. These characteristics suggest that the observed electromagnetic fluctuations were consistent with a dispersion relation of KAW in the experimental regime.

Both the fluctuations and the reconnection rate had dependency on the strength of a guide field. In the strong guide field case, large magnetic fluctuations and large reconnection electric field was observed. Normalized reconnection rate increased as the amplitude of the fluctuations. There is a positive correlation between the enhancement of reconnection rate and fluctuation amplitudes.

To investigate the generation mechanism of the fluctuations, the existence of fast electron was estimated by using a simple model. Electrons are expected to be accelerated to the 4400 km/s, which is about twice as large as the electron thermal velocity. The fast electron (electron beam instability) is most likely generation mechanism of the fluctuations. And then, the fluctuations could drive the fast reconnection due to the deformation of the current sheet.

Electrostatic fluctuations were also measured at the downstream region. However, a different characteristic between electrostatic and electromagnetic fluctuations was found, which indicates that electrostatic fluctuations include other waves or instabilities such as LHDI (lower hybrid drift instability).

In summary, the mechanism of fast reconnection focused on fluctuations during guide field magnetic reconnection has been experimentally investigated in TS-3 plasma merging device. Differently from a general understating, the experimental results show that reconnection rate increased with increasing the strength of a guide field. There is a positive correlation between the amplitude of electromagnetic fluctuations and the enhancement of reconnection rate. The scenario for fast reconnection suggested by in this dissertation is: (1) fast electrons accelerated by reconnection electric field drive electromagnetic fluctuations, (2) the fluctuations deform the current sheet, (3) fast reconnection finally occurs. We argue electromagnetic fluctuation that has the characteristics of KAW is one of the mechanisms for fast reconnection in the presence of a guide field.

A13. InP ハーフリッジ型偏波変換器を用いた光集積回路内偏波制御

財津 優

Polarization Control inside Photonic Integrated Circuits Using InP Half-Ridge Polarization Converters

By Zaitsu Masaru

The current optical communication systems, which are inevitable in the modern information society, have gained the transmission capacity by multiplexing data signals. Owing to further developments of the information technologies such as introduction of cloud computing, optical communication systems with large transmission capacity have been more and more important not only in core network but also edge network. Photonic integrated circuits (PICs), integrating a number of optical components into a small chip, have proved to be a promising technology to realize the advanced optical systems in a low-cost and a small-footprint. The PICs have adapted to wavelength-division multiplexing and coherent modulation technologies, and more recently a polarization-multiplexing technology has been introduced into the PICs. However, control polarization states of lightwaves inside the PICs is an important issue because planar lightwave circuits usually employ lightwaves with only a single polarization state.

Various types of polarization handling devices inside PICs have been proposed and demonstrated on several platforms such as InP, Si, and silica. However, most of them have a quite different waveguide structure compared with conventional photonic devices in PICs, especially with active photonic devices such as laser diodes (LDs) and semiconductor optical amplifiers (SOAs), and therefore the monolithic integration of the polarization handling devices is a challenging issue. Consequently, a fully-integrated polarization-multiplexed- (PM-) PIC has not been demonstrated yet. In such situation, polarization handling devices which can easily be integrated with active photonic

devices have been demanded in order to realize the fully-integrated PM-PICs with low-cost and small-footprint.

In this thesis, I present an integrated InP half-ridge polarization converter (PC) which is significantly suitable for the integration with other photonic components. This device features its simple, ridge-like asymmetric half-ridge structure which can easily be fabricated without any critical lithographic alignment and enable a smooth connection with InP ridge waveguides. I demonstrate the integration of the half-ridge PC with a SOA on InP platform.

Chapter 1 presents the background of this research topic. Following a brief introduction of current optical communication and photonic integration technologies, several types of polarization handling devices are referred.

Chapter 2 shows fundamental theories to analyze and design waveguide photonic devices with several example numerical results. Through a slab waveguide analysis and cross-section eigenmode analysis based on a finite-difference method, a concept of eigenmodes in dielectric waveguides is described. Descriptions of polarization states of lightwaves are also shown based on Jones vector, Stokes parameters, and Poincare sphere. Principles of a polarization conversion by using a birefringent medium are described.

Chapter 3 describes fabrication technologies of InP-based photonic devices. I express several fundamental fabrication procedures with some example results; crystal growth, lithography, deposition, and etching.

In Chapter 4 and 5, I present the integrated InP PC based on asymmetric half-ridge structure. Chapter 4 describes a design, principle, fabrication, and demonstration of the half-ridge PC. One side of the half-ridge PC is ridge structure and the other side is deeply-etched high-mesa structure. By employing an angled deposition, the half-ridge structure is fabricated without any precise lithographic alignment below sub-micron scale. More than 96% polarization conversion is achieved in a broad wavelength range covering C-band and quite low insertion loss below 1.0 dB using a small operating length of 150 μm. Also, the experimental results significantly agree with numerical characteristics. Based on detailed analyses of the fabricated PC, the half-ridge structure is optimized as shown in Chapter 5. By introducing a slope at the ridge side of the half-ridge PC, a fabrication tolerance in the width of the PC increases factor-of-two improvement. To fabricate the optimized structure precisely, I propose an improved fabrication procedure using a novel layerstack and hybrid etching processes.

In Chapter 6, I demonstrate the integrated of the half-ridge PC with a SOA. I employ an offset quantum well layerstack to integrate active and passive components monolithically. An incident transverse electric (TE) light is amplified by the SOA and then convert to a transverse magnetic (TM) mode by the half-ridge PC. Polarization conversion ratio of 99% is successfully achieved with the half-beat length of 70 μm.

Chapter 7 presents a proposal of a waveguide polarization modulator consisting of the half-ridge PC and a passive waveguide modulator. Since a refractive index modulation based on electro-optic effects depends on the polarization state, TE and TM modes, the birefringence of the symmetric waveguide can be controlled by an external voltage bias. An incident TE mode, assuming the output from an integrated LD, is converted to arbitrary polarization states by using two half-ridge PC with quarter-beat length and two symmetric waveguide modulators.

A14. 極低電圧 CMOS デジタル回路設計における遅延ばらつきの特性とモデリングに関する研究

高橋 亮

A Study on Characterization and Modeling of Delay Variations in Extremely Low Voltage CMOS Digital Circuit Design

By Ryo Takahashi

Temperature dependence of 256 within-die random gate delay variations in sub-threshold logic circuits is measured in 40-nm CMOS test chips. When the temperature is reduced from 25 degrees Celsius to −40 degrees Celsius, the sigma/average of the gate delay at 0.3 V increases by 1.4 times. A newly developed model shows that the sigma/average of the gate delay is proportional to 1/T for the first time, where T is the absolute temperature.

A15. 高信頼ソリッド・ステート・ストレージシステムに関する研究

田中丸 周平

Design of Highly Reliable Solid-State Storage System

By Shuhei Tanakamaru

Solid-state storage is escalating demands due to the expanding industry and applications from SD cards to data centers. Solid-state storage is mainly composed of NAND flash memories, which are the most cost effective non-volatile memory devices. This is because the memory cell transistor achieves the smallest size and multi-level cell technology is realized. To further reduce the chip cost of the NAND flash memory, scaling of the memory cell is continuously promoted. However, the reliability of the NAND flash memory is degrading due to the scaling. The memory cells are getting close, and thus the interference between the memory cells by such as cell-to-cell coupling is becoming strong. Moreover, the number of electrons stored in the floating gate is smaller in the scaled NAND flash memory. Therefore, the reliability of the NAND flash memory should be improved.

On the other hand, storage-class memories (SCMs) are attracting attention because SCMs show higher performance than NAND flash memory with non-volatility. Thus, the storage performance can be improved by combining low-cost NAND flash memories and high-speed SCMs. Phase-change random

access memory (PRAM), magnetic RAM (MRAM), and resistive RAM (ReRAM) are considered as SCMs. Similar to the NAND flash memory, the reliability of these SCMs also degrades during write/erase cycle. Thus, the reliability of the SCMs should also be improved.

This paper discusses the design of highly reliable solid-state storage starting from the problems of the reliability degradation of NAND flash memory, co-optimization of NAND flash memory and SCM, and reliability of SCM. As for the solutions, chip-level and system-level reliability enhancement techniques are proposed for NAND flash memories, chip-level techniques are proposed for ReRAMs (SCMs), and the system performance is evaluated.

Error-prediction low-density parity-check (EP-LDPC) scheme, page-RAID, error-masking (EM), and bits/cell optimization (BCO) are proposed as chip-level reliability enhancement techniques. Bose-Chaudhuri-Hocquenghem (BCH) error-correcting codes (ECCs) are widely used to correct bit-errors of the NAND flash memories. However, due to the degrading reliability of the NAND flash memory along with the scaling, LDPC codes are considered as the promising candidate for the next generation ECC due to their extremely high error-correction capability. However, the use of the LDPC codes has a fatal problem that LDPC codes require multiple read from the NAND flash memory to get precise VTH information, resulting in long read latency. Proposed EP-LDPC can achieve higher error-correction efficiency than BCH code while eliminating multiple reads.

Page-RAID creates a vertical parity in addition to the horizontal parity (ECC). As a result, even if there is an ECC failure, the page can be corrected by the vertical parity with page-RAID. EM corrects the errors which occurred in the previous read. The error location is stored in an error-location table in every read. The errors are corrected by bit-flipping the data stored in the error-location table. Both page-RAID and EM can effectively use ReRAM as a parity buffer to improve the reliability with no performance degradation. In BCO, triple-level cell (TLC) NAND flash memory is changed to multi-level cell (MLC) and single-level cell (SLC) according to the write/erase cycles.

Reverse-mirroring (RM), shift-mirroring (SM), error-reduction synthesis (ERS), and balanced RAID-5/6 are proposed as system-level techniques for NAND flash memories. RM, SM, and ERS improve the system-level reliability of the mirrored system (RAID-1). RM and SM intelligently allocate the data to improve reliability based on the error characteristics of the NAND flash memory. RM also uses ReRAM as a non-volatile buffer. ERS reduces bit-errors considering the error characteristics. Balanced RAID-5/6 improves the reliability of the RAID-5/6 system. RAID-5/6 is more cost effective method than mirroring (RAID-1) to improve the system-level reliability due to the significantly small storage overhead.

The chip-level reliability enhancement techniques for ReRAM are proposed such as flexible RRef (FR), adaptive asymmetric coding (AAC), and verify trials reduction (VTR). FR tracks the changing resistance of the ReRAM to reduce the BER during set/reset cycling. It is found that the dominant error direction (1→0 or 0→1 error) changes from 0→1 to 1→0 error during set/reset cycle. AAC reduces BER based on the dominant error direction. VTR reduces the verify trials and improves the set/reset latency by correcting the remaining errors by ECC.

A16. 合成開口レーダー干渉画像における歪みとその解消に関する研究

夏秋 嶺

Distortion and Its Reduction in Synthetic Aperture Radar Interferogram

By Ryo Natsuaki

Synthetic Aperture Radar (SAR) has been widely used for airborne and spaceborne radar observation which can only carry small antenna. Though the resolution of SAR image is lower than the optical observation, it can remotely observe phase and polarization information, while the optical one can only observe intensity.

Interferometric SAR (InSAR) uses two or more images taken from different places and / or at different times. Their phase differences are geometrically the same as the topography of the observation area. In particular, we need two complex-valued SAR data obtained by observing identical place, named ""master"" and ""slave."" An interferogram is a result of multiplication of the master and the conjugated slave. The height information is periodically “wrapped” in phase value of the interferogram.

Phase unwrapping process is required to generate DEM from interferogram. We have to solve the periodicity to recover the height information. As the interferogram corresponds to real landscape, its phase map has to be a conservative field. However, an unwrapping process is disturbed seriously by Singular Points (SPs), the non-zero rotational points existing in the phase map.

Many papers reported two origins of the SP generation. One is the landscape roughness. In this case, SPs are the evidence of the steep slope, and the SPs should exist there. The other is the low signal to noise ratio (SNR) in low coherence areas of the ground. To remove the latter SPs and create an accurate DEM, various filtering and unwrapping methods have been proposed.
In this thesis, we aim to generate more accurate SAR interferogram for landscape observation. Here, we made a hypothesis that there is a local distortion between master and slave, the third origin of SPs. That is, the slight difference in the observation orbit between the master and the slave causes the change of dominant scatterer, resulting in local phase distortion in the interferogram.

We firstly present the experimental results in anechoic chamber which simulates the generation of local distortion. Slight difference of incidence angle causes the change of dominant scatterer. This change is predictable as long as the scatterers and radar positions are accurately estimated. However, spaceborne SAR has several meter orbit error and in general, we do not know the scatterers’ position on the ground. In short, local distortion between master and slave is unavoidable.

Next, we propose the local sub-pixel scale co-registration method for master and slave which employs the SP number and the amplitude-implied phase gradient as the evaluation criterion (the SFS-SPEC method). One of the drawbacks of the SFS-SPEC method is that it uses the phase gradient in order to evaluate the co-registration result though the interferogram generally contains large phase ambiguity. To solve this problem, we propose the use of an interferogram generated with a large-number multilook as the reference in the evaluation process. This reference interferogram is used in the evaluation process to avoid the phase noise of which effect is large in the small-number multilook interferogram. That is, we calculate the phase difference between the co-registered pixel value and the pixel value of the reference interferogram. Without the distortion, no SP is expected through an appropriate co-registration of non-aliasing master and slave maps. Experimental results showed that the proposed method solve 90percent of SPs and increased 2dB in the SNR.

Finally, we present the results of research on statistical approach for filtering methods of SAR Interferogram. The removal of SP is also possible by filters. In this case, filters for interferogram must be compatible with phase information.

Recently a new filtering method based on complex-valued Markov random field (CMRF) model has been introduced. Its dynamics can be reduced to a simple and fast complex-valued correlation learning process, the CMRF filter.

This complex-valued correlation learning is compatible with complex-amplitude information of SAR interferogram. A complex number is represented by two real numbers. Thus, if the CMRF filter consists of N inputs and 4 outputs, we feed real 2N as input values and receive 8 as output values. In this sense, the N complex-valued correlation learning is similar to a 2N real-imaginary double-dimensional correlation learning. If the real-imaginary MRF (RI-MRF) filter can estimate correct phase values as same as the CMRF, it has possibility to calculate faster than the CMRF because it does not need to calculate complex number. At the same time, other image filters which can only compatible with amplitude are also be able to apply by separating complex-amplitude image into real and imaginary images. However, experimental results show that the RI-MRF filter creates interferogram presenting inappropriate anisotropy in the phase values whereas the CMRF filter generates accurate interferogram.

As written above, we proposed the idea of local distortion and solved with co-registration and filtering methods. Experimental results showed that the proposed method could generate more accurate SAR interferogram than conventional methods.

A17. III-V 族強磁性半導体 GaMnAs におけるバンド構造と強磁性

宗田 伊理也

Band structure and ferromagnetism in III-V ferromagnetic semiconductor GaMnAs

By Iriya Muneta

Conventional semiconductor devices use only the charge degree of freedom of electrons and holes, while the spin of carriers remains untouched. Spintronics on semiconductors is aiming to introduce spin-related functions to semiconductor devices by utilizing the spin degrees of freedom of carriers and atoms. The most widely studied materials to realize semiconductor spintronics are ferromagnetic semiconductors (FMSs), which have the properties of both semiconductors and ferromagnets. The most investigated FMS is the III-V ferromagnetic semiconductor GaMnAs, which has the zinc-blende crystal structure where a part (typically a few %) of the Ga atoms in GaAs is replaced by Mn. The Mn atoms act as both acceptors and localized spins. GaMnAs is known to show ferromagnetism with the Mn content over 1%. This Mn concentration is not enough to show the ferromagnetism by a direct exchange interaction between two neighboring Mn, but holes mediate the indirect exchange interaction, which induces the ferromagnetism in GaMnAs.

In Chapter 2, the survey of the recent research on the band structure and the ferromagnetism in GaMnAs is described. The problem in GaMnAs is that the band structure and the origin of the ferromagnetism are not understood. At the beginning, the holes were believed to be in the valence band, which is spin split by the p-d exchange interaction between the holes and 3d electrons. However, recent experiments have shown that the valence band is filled with electrons (no holes) and is highly ordered. These new findings raise three unsolved problems: (i) The position of the Fermi level, which is located in the impurity band in the band gap, contradicts the conventional understanding that in semiconductors doped with non-magnetic acceptors the Fermi level crosses over the valence band as doping concentration increases. (ii) The highly-ordered valence band is against the simple expectation that the heavy doping and p-d hybridization will result in the disordered valence band. (iii) The detail about the impurity band in GaMnAs is not understood at all because it was believed that the impurity band did not exist so far. The following three Chapters address these three problems, respectively.

In Chapter 3, the Fermi level position in GaMnAs is precisely determined. The Mn content dependence of the Fermi level position in GaMnAs are systematically investigated by using resonant tunneling spectroscopy in GaMnAs quantum-well heterostructures. The Fermi level position is estimated from the quantum-well-thickness dependence of the resonant levels. It is shown that the Fermi level in GaMnAs is always in the band gap above the valence band top, and that it becomes close to the valence band top as the Mn content increases in the paramag-

netic region, but it gets away from the valence band top at the onset of the ferromagnetism. These results indicate that the behavior of the impurity band in ferromagnetic GaMnAs is anomalous, and very different from that of non-magnetic acceptors.

In Chapter 4, the valence band ordering in GaMnAs is studied. The Mn content dependence of the valence band ordering in GaMnAs are systematically investigated by using resonant tunneling spectroscopy in GaMnAs quantum-well heterostructures. Our characterization of the valence band ordering shows that the valence band becomes disordered as the Mn content increases, but its ordering is restored by the onset of ferromagnetism. These results show that the p-d hybridization does not make the valence band disordered, but forms an additional band, which is the impurity band that induces the ferromagnetism in GaMnAs.

In Chapter 5, the anisotropy of the impurity band is studied. The anisotropy of the impurity band is characterized by measuring the tunneling anisotropic magnetoresistance (TAMR) in GaMnAs-based tunnel heterostructures. The TAMR in GaMnAs is considered to originate from the hole-bound states. It is natural to think that the hole-bound states inducing TAMR are the impurity states or impurity band in the ferromagnetic GaMnAs. In the measurement of TAMR, the symmetry of TAMR shows the complex dependence on the bias voltage. This result shows that the multiple impurity levels have the wave functions with different spatial anisotropies, indicating that the Fermi level position in the impurity band determines the magnetic anisotropy in GaMnAs.

In summary, this thesis investigates the Mn content dependence of the Fermi level position and the valence band ordering by means of resonant tunneling spectroscopt, and the anisotropy of the impurity band by means of TAMR. It was found that the detail of the band structure, such as the Fermi level position and the merging or separation of the valence and impurity bands, plays an important role in the magnetic properties of the prototype FMS GaMnAs, such as ferromagnetism, Curie temperature, and magnetic anisotropy. Comprehensive and deep understanding of the relationship between the band structure and ferromagnetism is necessary for FMSs to be utilized for semiconductor spintronics devices.

A18. 光導波・局在機能を有する三次元フォトニック結晶の設計と作製に関する研究

付 嘉鵬

Design and Fabrication of Three-Dimensional Photonic Crystal for Light Guide and Optical Localization

By Fu Jiapeng

Possessing spatial periodicity in the dielectric constant, photonic crystals (PCs) can prevent light from propagating in certain directions with specified frequencies. This frequency range is referred as photonic bandgap (PBG). In 1987, the concept of photonic crystal was brought into the optical research field. Many researches, by utilizing PC structures, have been conducted to improve the performance of optical components. Most of these researches focused on two-dimensional (2D) PCs, particularly the so-called 2D PC slabs, which consisted of thin dielectric plate with periodic arrangement of holes. Properties of the 2D PC slabs were developed with a rapid speed compared with three-dimensional (3D) PC because of the ease of fabrication. However, from the practical point of view, light gets loss to the third direction of 2D PCs easily because the dielectric constant only varies in two directions. On the contrary, the dielectric constant of 3D PCs varies in all directions. 3D PCs, which possess a complete photonic bandgap (cPBG), are possible to control light of all polarizations in all directions. Therefore, 3D PCs have a potential to operate light in a 3D structure. This potential, which allows us to realize 3D optical circuit, makes 3D PCs more meaningful to investigate.

However, the performance of optical components in 3D PCs is still far behind that in 2D PCs. For instance, single mode operation bandwidth of 3D PC waveguide (PCW) still needs to be expanded. The quality factor (Q) of 3D PC nanocavity is also expected to be improved further because it is still far behind that of 2D PCs. Thus, in order to fully utilize the advantages of 3D PCs, researches on these issues discussed above are strongly expected.

Aiming to address these issues, original research work on designs of PCW and nanocavity in 3D PCs are presented in this thesis. Experimental work to demonstrate the usefulness of our design is also presented.

After a brief introduction of the research background and objectives of the research in Chap. 1, basic physics of PCs that are necessary for understanding the research are introduced in Chap. 2. Types of PCs that classified by dimensionalities are introduced. After the introduction of several types of 3D PCs, the woodpile structure, one of the 3D PCs, is described in details as it is the basic structure of all the work in this thesis. Then, varies of fabrication methods of 3D PCs are discussed. Finally, the way of manipulating light with PCs, introducing defect into PC structures, is discussed.

The fundamentals of plane wave expansion (PWE) and finite-difference time-domain (FDTD) methods, which are computational methods used in this thesis, are described in Chap. 3. By using these two computational methods, how to obtain important characters of PC structures are discussed. For instance, calculation on band diagram of PC structure, frequency of cavity mode, Q and mode volume of nanocavity structure are discussed.

In Chap. 4, a design of silicon 3D PCW is reported. Tuning the width of the line defect allows the waveguide to support two guided modes, which enable single-mode propagation ~98.7% of the complete photonic bandgap. In addition, we demonstrate that the frequency ranges for single-mode propagation can be extended to almost the entire range of the cPBG by further tuning the thickness of the layers. The wide ranges of available frequencies for single mode propagation enable flexible design of 3D PC components and would provide a route towards future

3D photonic circuits.

A nanocavity is designed to improve the Q of 3D woodpile PC in Chap. 5. The Q of the nanocavity embedded in a vertically mirror-symmetric woodpile structure, which can be realized by changing the stacking sequence of layers above the cavity layer of an ordinary woodpile structures, is discussed. A Q of 1.7×105 of the nanocavity embedded in the mirror-symmetric structure can be obtained. This is ~3.6 times as high as the maximum Q of the same size of the nanocavity embedded in an ordinary woodpile structure. Compared with other designs of 3D PCs at same level of Q, our design can improve the Q with a smaller structure volume.

Finally, in Chap. 6 experimental work for investigating the effect of mirror symmetric woodpile structure on cavity Q as discussed in Chap. 5 is presented. Both of nanocavity structures in a mirror symmetric woodpile and an ordinary woodpile are fabricated by using micromanipulation technique. A square-shaped defect cavity embedded in the mirror symmetric woodpile structure with 25 layers exhibits a cavity mode with Q ~4,000, which is larger than that of the nanocavity design in the ordinary woodpile (~3,100).

At last, the main achievements presented in this thesis are summarized. The outlooks for future research are also given in Chap. 7.

The results obtained in this thesis provide an important step towards the complete manipulation of light in nanostructures.

A19. 確率的ポーズ推定法を用いた移動ロボットの位置同定支援手法に関する研究

ジャヤセカラ ペシャラ ゲハン

Study on Localization Assistance for Mobile Robot Navigation using Probabilistic Pose Estimation Tecniques

By Peshala Gehan Jayasekara

This thesis puts forward the notion of assistance for autonomous mobile robot navigation. The conventional approach to autonomous navigation is to make the robots as intelligent as possible to tackle with the environment. Such a strategy can often run into pitfalls as there is no way to program the robots for all scenarios that can arise. Humans tend to depend on some assistance, sometimes unintentionally, to save both the effort and time spent on navigation. This human behavior can be imitated in autonomous navigation for mobile robots, which motivates us to design a proper robot assistance scheme. Such an assistance system can act as the missing building block to provide fully autonomous capabilities for mobile robots to navigate in real, complex environments.

The main concepts of the proposed localization assistance scheme are as follows: i) The mobile robots that need assistance are detected, tracked and managed by an agent acting as the “assistant”. ii) Tracked data is transformed into localization information and is relayed back to the mobile robots as “localization assistance” using communication devices. iii) The mobile robots perform continuous self-localization to deal with absence of localization assistance. iv) The assistant can either be stationary or mobile. v) To deal with uncertainties in sensing, actuating, and system modeling etc., probabilistic methods have been employed.

In the first stage, a stationary assistant is proposed for real, populated indoor environments. The stationary assistant senses the environment using a laser range finder (LRF) and camera based sensor unit while the environment modification is kept at minimal. Using Rao-Blackwellized particle filter (RBPF) technique, the robots that need assistance are continuously tracked. RBPF makes sure the data association problem is handled robustly. A novel method to track only the mobile robots in crowded environments by changing the LRF placement and by making a modification at the robot platform is proposed. The proposed method can detect mobile robots even in complex environments. Two mobile robots were simultaneously navigated in given trajectories successfully using real-time assistance data, which shows the validity of the proposed scheme for simultaneous localization assistance for multiple mobile robots.

In the second stage, mobile assistance is proposed when the environment is large (e.g. outdoor terrains) since the coverage of a stationary assistant is limited. Two key aspects of mobile assistance are tackled: improvement to self-localization of assistants and, cooperative localization assistance for multiple robots in outdoor terrains.

A novel state variable extension (SVE) method is proposed by combining terrain point clouds with rover kinematics to improve the self-localization of assistants. SVE establishes a connection between state variables of full 6-DOF pose of an outdoor rover. With this approach the number of effective state variables to be estimated has been reduced. This reduction allows the particle filter to maintain a lesser number of particles. The proposed method assures the validity of the estimated 6-DOF poses on a give terrain, through SVE method. In other odometry techniques (e.g. visual odometry), the resulting estimations are not guaranteed to be valid poses on a given environment. The results show that when the 2D state variables (x, y, yaw) are known, the 2D state can be extended to its 3D state (x, y, z, roll, pitch, yaw) successfully. Finally, the proposed SVE method is employed in a particle filter to determine the 2D state variables, which in turn results in achieving the full 6-DOF position tracking of the rover.

As a mobile assisting mechanism a novel simultaneous localization and mapping (SLAM) technique called “Cooperative Positioning SLAM (CPSLAM)” is proposed by incorporating landmarks to the original “Cooperative Positioning System (CPS)”, while landmark initialization uncertainty is reduced by a tethering mechanism. The results show that CPSLAM outperforms CP significantly. The notion of “virtual loop closing” is introduced for two navigation scenarios of planetary rovers. It is shown that localization error in worksite exploration can be reduced when two rovers take different routes, meet up and swap their routes. Next, it is demonstrated that the merits of virtual loop closing can be experienced when two rovers start from two different locations and move towards the each others

origins while meet somewhere in the middle. Finally, a motion strategy named “simultaneous adjacent motion”, which uses covariance intersection method for data fusion, is proposed to minimize localization error when two rovers navigate towards a common goal, side-by-side.

A20. Si プラットフォーム上 III-V ロジック LSI のための InGaAs-On-Insulator MOSFET に関する研究

金 相賢

Study on InGaAs-On-Insulator MOSFETs for III-V logic LSI on Si platform

By Sanghyeon Kim

Conventional device scaling strategy to enhance device performance become confronting the fundamental physical limit. Therefore, the introduction of new principle and new material become more important for the further improvement of the metal-oxide-semiconductor field-effect transistor (MOSFET) performance. InGaAs, one of III-V compound semiconductors is being considered as the promising channel materials for the next generation MOSFETs thanks to their small effective mass and high electron mobility. Moreover, extremely-thin body (ETB) InGaAs-on-insulator (InGaAs-OI) structure is strongly needed to achieve both of good short channel effect (SCE) control and high on-performance. However, there are three main technological issues to realize high performance InGaAs-OI MOSFETs, which are source/drain (S/D) formation for a low resistance, channel engineering to enhance electron transport, and channel formation on Si wafer. Therefore, in this thesis, we suggest the possible solutions for each issue and have realized the high performance InGaAs-OI MOSFETs.

For the S/D formation, we have suggested the metal S/D structure using Ni-InGaAs alloy formed by the direct alloy reaction between Ni and InGaAs. We have found that Ni-InGaAs has a low sheet resistance and Schottky barrier height for electron and Ni can be selectively etched by HCl solutions without etching of Ni-InGaAs. Utilizing these favorable characteristics, we have fabricated self-aligned metal S/D InGaAs-OI MOSFETs, for the first time. Also, we have systematically investigated all the components of the S/D parasitic resistance (RSD) in InGaAs MOSFETs with Ni-InGaAs metal S/D and have developed a technology to reduce all components of RSD. The increase of Indium content in the channel was found to decrease the interface resistance between Ni-InGaAs and InGaAs channel. Therefore, by increasing Indium content up to 100 %, the interface resistance was significantly decreased to the theoretical limit of the interface resistance. Moreover, contact resistance between metal pad and Ni-InGaAs was reduced by developing surface cleaning technology. Finally, we have demonstrated high performance InAs-OI MOSFETs with Ni-InGaAs metal S/D structure by employing these technologies.

Channel engineering includes two parts, which are quantum well (QW) channel engineering by introducing MOS interface buffer layer and strain engineering. Firstly, we have introduced InGaAs layer with a lower Indium content than that of channel InGaAs as the MOS interface buffer layer at the both interface with top gate dielectric and buried oxide and increased the Indium content in the channel layer. This makes the change of the electron distribution in the channel layer, resulting the enhancement of electron mobility. Finally, therefore, we have demonstrated a high peak mobility of 3180 cm2/V•s in our InAs-OI MOSFETs, which were fabricated on Si substrates with MOS interface buffer layers. The scattering mechanisms for the electron mobility in InGaAs-OI MOSFETs are systematically analyzed and identified. We conclude that the increase of the Indium content enhances phonon-limited mobility, whereas the use of the MOS interface buffer enhances thickness-fluctuation-limited mobility through the suppression of thickness fluctuation at the MOS interface.

Also, we have strained In0.53Ga0.47As MOSFETs on both of bulk III-V substrate and In0.53Ga0.47As-OI substrate. 1.7% highly strained In0.53Ga0.47As-OI structures are fabricated on Si substrate. Fabricated devices are systematically analyzed with different channel strain values. Strained In0.53Ga0.47As-OI MOSFETs with Ni-InGaAs S/D have been operated with high on-current (Ion)/off-current (Ioff) ratio of 105 and good current saturation in output characteristics. MOSFETs with 1.7% tensile strain exhibits 1.65 times effective mobility (μeff) enhancement against In0.53Ga0.47As MOSFET without strain. We found that this μeff enhancement is attributed to the increase in mobile free electron concentration under tensile strain, which leads to the lowering in the conduction band minimum (CBM) and the increase in the energy difference between CBM and the Fermi level pinning position due to a large amount of interface states by Hall measurements.

Moreover, using QW-OI channel structure, we have fabricated deeply scaled InGaAs MOSFETs. QW-OI structure provided us large on-performance enhancement and better electrostatic control than InGaAs-OI without QW structure. In addition, from the simulation study, we have found that further vertical scaling and back biasing techniques can improve the control of short channel effect in InGaAs-OI MOSFETs. By hinted from these simulation results, we have investigated the effects of vertical scaling and the tri-gate structure on electrical properties of ETB InAs-OI MOSFETs. It was found that body thickness (Tbody) scaling provides better SCEs control, whereas Tbody scaling causes the reduction of the mobility limited by channel thickness fluctuation (δTbody) scattering (μfluctuation). To achieve better SCEs control, the thickness of channel layer (Tchannel) scaling is more favorable than the thickness of MOS interface buffer layer (Tbuffer) scaling, indicating necessity of QW channel structure. Also, the Tri-gate ETB InAs-OI MOSFETs shows significant improvement of SCEs control with small μeff reduction. As a result, we have successfully fabricated sub-20-nm-channel length InAs-OI MOSFETs with good electrostatic. Furthermore, we have demonstrated wide-range threshold voltage (Vth) tunability in Tri-gate InAs-OI

MOSFETs through back bias voltage control.

Finally, we have proposed the new concept of III-V integration on Si wafer using improved direct wafer bonding (DWB) techniques using Si donor wafer. By changing donor wafer from III-V to Si, this technique can offer 300 mm and/or larger wafer scalability.

A21. 励起子共振器ポラリトンの実現に向けた空隙/III 族窒化物半導体分布ブラッグ反射型垂直微小共振器の作製に関する研究

陶 仁春

Fabrication of Air/III-Nitride Distributed Bragg Reflector Vertical Microcavity for Exciton Cavity Polariton

By Tao Renchun

Semiconductor distributed Bragg reflector (DBR) microcavities (MCs) have been widely used for III-nitride optoelectronic devices, among which exciton polariton devices, such as polariton lasers, are of special interests. Exciton polaritons are quasiparticles resulting from the strong coupling between excitons and cavity photons. Because of the peculiar physical properties of polaritons, polariton devices have unique performances. For example, polariton laser is of ultralow threshold (or thresholdless). Besides, polaritons in microcavity is also a good platform to study Bose-Einstein condensation and superfluid at high temperature and so forth.

Polariton lasing has been realized in polar III-nitride DBR MCs at room temperature. However, for polaritons in III-nitride, non-polar nitride MCs would be a better option, because the absence of a built-in electric field leads to an enhancement of the electron/hole wave-function overlap, consequently resulting in a higher exciton binding energy and a large Rabi splitting in polariton devices. However, there are very few works published on non-polar nitride DBR MCs.

It is also well known that conventional monolithic DBR MCs made with nitrides suffer from a low refractive-index contrast. In order to have III-nitride MCs with efficient photon confinement, a large number of epitaxially grown DBR layers are usually necessary. Practically, however, the fabrication of such DBRs is very difficult, because growth conditions vary with time and effects of strain or defects in lower layers can accumulate and propagate to later grown upper layers. As a result, instead of monolithic DBR MCs, hybrid nitride/dielectric DBR MCs and all-dielectric DBR MCs are often employed. Hybrid MCs, of course, still suffer from a narrow stop band determined by the bottom nitride DBRs and all-dielectric DBR MCs usually involve complicate membrane lift-off and bonding process.

Air-gap structures are one promising option to overcome the low refractive index contrast in conventional III-nitride DBRs. Previously, many different wet etching and dry etching methods have been tried to fabricate air-gap nitride DBRs. But each of these methods has certain drawbacks of its own. Consequently, no complete air/nitride DBR MCs have been reported to date. Recently, a newly developed technology employing the thermal decomposition of GaN has shown great potential for the fabrication of nitride air-gap nanostructures. This technique, based on a dry process, is easier and faster, allowing the fabrication of complicated multilayer structures.

This thesis presents the original research work on the growth, fabrication and characterization of air/III-nitride DBR MCs and their application to exciton cavity polaritons.

Chapter 1 is the instruction to this thesis, including basic concepts and application of exciton polariton, the advantages, disadvantages and current research status of III-nitride DBR MCs to exciton polariton applications. As for the disadvantages, we came up with the idea of air/III-nitride DBR MCs.

Chapter 2 describes the transfer matrix method, the basic theoretical tool to simulate DBR MCs. By simulation, the high efficiency of air/III-nitride DBR MCs and their difference from conventional DBR MCs were revealed.

Chapter 3 gives growth optimization for structures grown on m-plane free-standing GaN substrates. Growth temperature was found to be one key parameter affecting the surface morphology of epitaxial AlGaN layer. Grown at the same temperature, InGaN single quantum well (QW) seems good enough for serve as a cavity emitter for our initial samples. With some special considerations in design, complete structures were grown.

Chapter 4 describes the detailed fabrication process of air/III-nitride DBRs MCs by using thermal decomposition of GaN method. Two types of DBR cavities have been grown. Images taken by scanning electron microscope and atomic force microscope revealed their good structure quality.

Chapter 5 presents optical characterization for the fabricated non-polar air/III-nitride MCs by micro photo-luminescence measurements at room temperature. A Q factor of 1600 was estimated and anisotropic optical properties have been investigated. Especially, to analyze the optical anisotropy, $k \cdot p$ method based theoretical calculation was performed, whose results are in good agreement with experimental measurement.

Chapter 6 describes the application of air/III-nitride DBR MC to exciton cavity polariton. Firstly, a non-local dielectric response theory was given to describe exaction-cavity strong coupling semi-classically. Secondly, GaN/AlGaN QWs were grown, and optimized to have a narrower emission line width in the aim of satisfying strong coupling criteria. Micro photo-luminescence was measured to demonstrate strong coupling phenomena.

Finally, Chapter 7 summarizes this thesis, indicating possible prospect researches base on the results presented in it.

A22. 光相関領域法による光ファイバ中のブリルアンダイナミックグレーティングの分布測定における空間分解能に関する研究

山下 健二 ホドリーゴ

Research on the Spatial Resolution in Optical Correlation Domain Distributed Measurement of

Brillouin Dynamic Grating along Optical Fibers
By Yamashita Rodrigo Kendy

Tunnels, bridges and aircrafts are submitted to various environmental changes and heavy loads during its lifetime. Detection of cracks, overloads and displacements in those structures is vital to keep the safety in their usage, preventing big collapses and accidents that may take many lives. Fiber-optic sensing is one of the most promising technologies to realize that monitoring due to its small size, light weight, flexibility and immunity to electro-magnetic interference. In this thesis, the focus was on the enhancement of spatial resolution of Brillouin optical correlation domain analysis (BOCDA), a fiber-optic sensor system developed by Hotate laboratory, when measuring the distribution of strain and temperature simultaneously, based on Brillouin dynamic gratings (BDGs).

The BOCDA system has been developed to measure the fiber distribution of Brillouin frequency shift (BFS), which has strain and temperature dependence. Later, it was found that it can also measure the birefringence distribution along a polarization maintaining fiber, which also has strain and temperature dependence. By those two measurements, BFS and birefringence, it is possible to determine both the strain and temperature distribution. However, the spatial resolutions of the two measurements are different by an unknown reason. For the BFS measurement, BOCDA is acknowledged as the highest performer in spatial resolution, with reports of mm-order resolution. But for the birefringence distributed measurement, the highest resolution reported with BOCDA was 10 cm. Therefore, this research has the goal of enhancing the spatial resolution of the system, creating a stable and accurate sensor system.

The first step for enhancement of spatial resolution is to understand what determines the spatial resolution, also to understand why the spatial resolution for BFS measurement is worse than that of birefringence measurements. The first approach was to calculate the acoustic wave complex amplitude created by the x-polarized waves in the PMF and consider the scattering of y-polarized light by that acoustic wave. From that calculation, it was possible to evaluate the effective length of the BDG after localization in correlation domain. The result was that the BDG works as a reflector in a region that extends beyond the nominal spatial resolution of BOCDA.

According to the theoretical analysis of BOCDA, the intensity of stimulated Brillouin scattering (SBS) is proportional to the beat power spectrum of the pump-probe lightwaves, which is a function of both position and frequency. In the BOCDA used in this research pump and probe waves are under sinusoidal frequency modulation (FM), applied by direct modulation of the current injection of the distributed feedback laser diode. To evaluate the spatial resolution of BOCDA, both the intensity of the beat power spectrum and its spectral broadening are considered. However, in this thesis, I formulated the hypothesis that this logic does not work for the BDG spectrum, because the y-read lightwave, which is launched to read the BDG, is under the same FM as the x-polarized waves. Therefore, its spectrum is broadened and it is reflected by all the BDG length, including the side lobes on the sides on the main correlation peak. So, to enhance the spatial resolution, it is necessary to suppress the correlation peaks, what can be realized by applying a proper intensity modulation (IM) synchronized with the FM applied to the laser source. Experiments showed the IM has the effect of spatial resolution enhancement, and under the conditions of the experiment, the observed enhancement was from 75.0 cm without the IM scheme to 17.5 cm with the proposed scheme.

To develop a stable high spatial resolution system, it is important to guarantee a good signal to noise ratio and avoid all sources of noise. A technique that has been developed to extend the measurement range of BOCDA is called temporal gating, which is based on pulse modulation of pump and probe waves. Although its efficiency in elongating the measurement range has been demonstrated, a solid theoretical analysis was not held. I assumed that the total beat power spectrum when two types of modulation are applied is the convolution of the beat power spectrum of each modulation. Based on that, it was possible to theoretically predict the optimum synchronization between the FM and the pulse modulation in a temporal gating scheme. Also, when spatial resolution is short and the signal coming from this tiny length of fiber is small, considerations about the signal acquisition scheme are necessary. The best solution for the strain-temperature simultaneous measurement BOCDA system was the beat lock-in detection.

By a cooperative research with a construction company, the proposed system was used to measure temperature and strain on a fiber glued to the surface of a concrete block. It is expected that the system can be adjusted to realize smart structures, detecting cracks in concrete in their early stage by accurate distributed sensing.

A23. 量子化ノイズの抑圧とモデルベース摩擦補償を用いたモーションシステムのサーボ性能の改善

朱 洪忠

Servo Performance Enhancement of Motion Systems via Quantization Noise Suppression and Model-Based Friction Compensation
By Hongzhong Zhu

Mechatronic systems, such as industrial robots, NC machine tools and exposure systems, often require high-performance motion control to improve the productivity and product quality. As the advancement in industry fields such as information technologies, biotechnology, electro-optics, automotive and aerospace where the required control accuracy is submicron order or nanometer order, high-speed and high-precision control systems are increasingly demanded. However, nonlinearities, such as the quantization in I/O signals and friction in mechanical components, play a vital role in control performance degradation, such as the limit cycle oscillations, torque ripples and so

on. Perfect suppression of the negative effects has attracted a great deal of attention both from the theory and real applications. In this dissertation, several easy-to-use novel solutions are provided to reduce these effects for enhancing the control performance.

The main work of this dissertation is divided into two parts. In first part, the methods for suppressing the effects of quantization noise by (a) output reconstruction method using convex optimization and (b) dithering techniques combined with Kalman filter, and the methods for suppressing the effects of nonlinear friction by model-based friction compensation are proposed from the theoretical perspective. In second part, on the other hand, the applications of the proposed methods on real systems are studied via simulations and experiments from the practical perspective. The main contributions of this dissertation are summarized as follows.

1. An output reconstruction method utilizing both observer techniques and curve fitting approaches is proposed for quantized systems to reconstruct the quantized output. By fitting the quantized measurements with polynomials in a moving horizon manner, a smooth signal is reconstructed via solving a convex optimization problem with some model-based constraint conditions. According to the proposed method, the degree of the polynomials can be automatically determined and the reconstruction error can be guaranteed to be within the quantization step. The convex optimization problem is a simple quadratic programming problem so that it can be solved very efficiently and accurately.

2. The combination of dithering techniques and Kalman filter is proposed for quantized systems to recover the real output. Firstly, two dithered systems including the subtractively dithered system and nonsubtractively dithered system are designed to whiten the quantization noise. In the design, optimal dither signals (“optimal dither”, evaluated from the perspective of probability, is the dither that can minimize the level of total measurement noise) can be theoretically designed by taken into account of the probability characteristics of the sensing noise. Then, Kalman filter is designed to estimate the real output signals from the dithered measurements. Since the variance of the total measurement noise is theoretically determined according to the proposed dithering methods, Kalman gain can be designed analytically.

3. An simple friction model and friction compensation strategies in zero-speed region are proposed for a high-precision ball-screw-driven system by considering the mechanical deformations in micron scale. In many mechatronic systems, servo performance is significantly degraded in low-speed area especially in zero-speed region owe to the inaccurate velocity measurement (caused by quantization noise), the limited bandwidth of feedback control, and the insufficient friction compensation. In this study, firstly, the elastic deformation characteristics of the system are analyzed. It is obtained that the mechanical deformation characteristic of the system in high acceleration/deceleration differs from the deformation characteristic in low acceleration/deceleration, and therefore friction compensation should take the motion conditions into account. Based on this observation, a simple friction compensation model and the compensation law are proposed for low acceleration/deceleration motions in zero-speed region including the non-reverse motions. Additionally, a friction compensation strategy for high acceleration/deceleration reverse motions is presented by taking into account of both the elastic deformation and nonlinear friction. The proposed methods can save much trouble in design and maintenance, and are particularly suitable for control purposes.

All the proposed methods are examined and verified by using real motion systems. Their outstanding effectiveness on improving the control performance shows that the proposed methods are not only developed from the theoretical considerations, but also very useful and practical in real situations.

Owe to the rapidly development in industry fields, low-cost and high-precision control systems will be increasingly demanded for improving the productivity and product quality. Therefore, authors believe that the proposed methods in this dissertation will attract increasing attention not only for their theoretical novelty but also for the easy-to-use properties.

A24. 自閉症児における脳ネットワークの発達異常に関する MEG 研究

段 放

MEG Study on Abnormal Development of Brain Network in Autism Children

By Duan Fang

This thesis studies the brain network of children with autism spectrum disorder (ASD). Magnetoencephalography (MEG) data were recorded to analyze the brain function due to its characteristics friendly with children. Popular research technique in brain network analysis, namely graph theory, is introduced to study the network development of ASD children. Our focus is to find insight by the graph indices of brain graphs to understand the development tendency of functional networks of ASD children. The artifacts removal method for obtaining high quality MEG data is shown in Chapter 2. After that, the brain graphs of broadband MEG of ASD and typically developing (TD) children are compared in Chapter 3-5. The Kaufman Assessment Battery for Children (K-ABC) is employed as a cognitive performance index to describe the network development. In Chapter 3, network level analysis is performed on TD children and finds a baseline of network development viewed in our free video watching task. In Chapter 4, the atypical network development of ASD children in the frontal area is observed by nodal and edge level indices. We propose a cross area index in Chapter 5 to describe the sub-graph interaction in the whole graph. By the cross area index, we interpret how strongly the whole graph can disturb the sub-graph interaction. In Chapter 6, we apply the network, area, nodal and edge level indices on the band-passed MEG data to search the atypical network development rhythms based on the reference of the simultaneous processing scale that is one of the K-ABC scales. In Chapter 7, we

employ the characteristics of brain graph of ASD which were found in previous chapters as neuromarkers to classify ASD and TD children. We find that these neuromarkers can assist the diagnosis of ASD.

A25. ＭＥＭＳ可変メタマテリアルのテラヘルツフィルタ応用に関する研究

韓 正利

A Study on MEMS Reconfigurable Metamaterial for Terahertz Filter Applications

By Zhengli Han

This work deals with a study on MEMS reconfigurable metamaterial for terahertz filter applications. A novel MEMS reconfigurable metamaterial have been proposed and demonstrated on a low loss quartz substrate for tunable terahertz band stop filter applications. The designed structure implements a reconfiguring RF-MEMS (radio frequency – micro electro mechanical systems) capacitor embedded within each split ring resonator (SRR). By electrostatically controlling the suspension height of the RF-MEMS cantilever structures, meanwhile the capacitance within the SRR, the tunable ability for the SRR resonance and thus the terahertz transmission of metamaterial device was controlled. Since a high transmission and low loss material of quartz was used as substrate, the device further shows a terahertz switch with high contrast ratio at the frequencies of the SRR resonance, which presents a potential prospect for high efficiency transmission terahertz device, such as Fresnel zone plate.

Chapter 1 reports the introduction of this work from the tunable terahertz metamaterial view. Usually, metamaterial is composed by two-dimensional array of metallic micro or nanoscopic structures much smaller than the wavelength, for instance the SRR, on a dielectric or semiconductor substrate to form a functional material or device. The main benefit of metamaterial is in the ability to tailor electromagnetic wave propagation from the designed structures rather than the material composition from nature. Most natural materials inherently have very small electromagnetic interaction with terahertz light in the frequency range between 100 GHz and 10 THz, resulting in the lack of functional device, where metamaterial as a promise candidate shows the ability to control terahertz wave propagation. Recent studies have reported the realization of terahertz wavelength modulator and filter based on the tunable terahertz metamterial by using voltage, photo excitation, temperature, and magnetic field. On the other hand, geometry reconfiguration of SRR pattern by using micro electro mechanical system (MEMS) technique shows dramatic changing in the transmission performance of metamateiral devices. In this work, we demonstrate a novel MEMS reconfigurable metamaterial on a low loss quartz substrate for terahertz filter applications.

Chapter 2 deals with the device design and simulation with a commercial software package, High Frequency Structure Simulator (HFSS). The square SRR pattern is formed on a fused quartz wafer (thickness 300 μm). In the center of SRR lattice, a cantilever together with a disk made of gold and silicon oxide layered structure is suspended over an air gap above the bottom disk with bilayer composition of gold and silicon oxide, thereby forming the MEMS capacitor within the SRR. Other parts of SRR metallic pattern also work as the feed electrodes for the MEMS capacitor, where a design of DC/RF decoupling structure was used.

The resonance tunability of the SRR can be achieved by controlling the cantilever suspension height above the bottom disk, associated with changing the capacitance within SRR. When applying voltage to the two electrodes beyond the pull-in voltage, the suspended disk will be brought down into contact with the bottom disk, where insulator layers of SiO2 with both the top disk and the bottom disk become laminated between the two metal electrodes, avoiding the electrical short circuit. Consequently, the closed air gap increases the capacitance of the SRR compared with the original OFF-state, resulting in a lower resonant frequency for the ON-state. Therefore a tunable terahertz band stop filter for particular frequencies is obtained from the tuning transmission spectrum. At particular frequency, the spectrum also suggests a switch with high contrast ratio.

Chapter 3 deals with the manufacture process of the MEMS reconfigurable SRRs by the surface micromachining technique. The fabrication procedure begins with sputtering 10-nm-chromium (Cr) / 220-nm-gold (Au) / 10-nm-chromium three stacked layers on quartz wafer. After the bottom electrode patterning by normal photolithography and wet etching, a thin layer silicon oxide (SiO2 200nm) is sputtered on the wafer for the purpose of avoiding electrical short circuit during MEMS actuation. After that, a 2 μm photoresist as sacrificial layer is spin coated and patterned by photolithography. Next, the top structure layers of SiO2 / Cr / Au (240 nm / 10 nm / 230 nm) are sputtered sequentially on the device and followed by wet patterning. Finally, the sacrificial photoresist was removed by oxygen (O2) ashing to finish the fabrication of SRR device. The scanning electron microscope (SEM) images of the developed device showed that the SRR cantilever tilted up a little after releasing, which we thought it was due to the residual stress.

Chapter 4 reports the mechanical and terahertz characteristic of the developed MEMS SRR array.

Laser Doppler Vibrometer (LDV) was used to quantitively investigate the SRR cantilever's mechanical performance. The MEMS drive voltage with triangle wave at a frequency of 1 kHz and a peak of±40 V was applied through the lateral connections to each parallel disk of a test element group (TEG) of 4 × 4 MEMS-SRR array. Electrostatic pull-in motion of the cantilever was found at a voltage of ±33.5 V. The cantilever remained in contact with the bottom electrode until the voltage was lowered to ±1 V, after which the cantilever was released to the damped oscillation.

Terahertz transmission performance was characterized by terahertz time domain spectroscopy (THz-TDS). The SRRs have an array of 60×60, in an area of 6mm×6mm, where the terahertz wave with a beam waist smaller than 5mm encounter the device area with a proper holder. For the ON-sate, we used a symmetric

square wave voltage with a frequency of 1 kHz and amplitude of ±35 V to pull the SRR cantilever array down to contact with the bottom disk. After the ON-state measuring, on the other hand, no voltage was applied to the MEMS-SRR array during the TDS measurement for the OFF-state. Both transmission spectra of the ON-state and OFF-state were normalized with the air reference. The HFSS simulation results matched well with the measurement results. Therefore a tunable terahertz band-stop filter was demonstrated. It is worthy to point out that the MEMS SRR device also worked as a high contrast ratio terahertz switch at the resonant frequencies both for SRR ON-state and OFF-state, which is an advantage compared with the conventional tunable terahertz metamaterial devices.

Chapter 5 discusses the key points during experiments and the originality and contribution of this work. The developed SRR cantilevers have issues of stiction, charge up, etc., which were solved by the optimization from the comparison of several cantilevers designed in different structure and size, together with drive voltage actuation by using a shaped waveform. The DC/RF decoupled structure was discussed from the SRR working principle with the fundamental electromagnetic coupling to a metallic pattern. Based on the independent properties of SRR, the influence of the device yield on the terahertz performance was also discussed.

Chapter 6 summarizes this work and proposes the related future research on terahertz optic components. In conclusion, we proposed and demonstrated a novel MEMS reconfigurable metamaterial on a low loss quartz substrate for tunable terahertz band stop filter and terahertz switch applications. Based on the high contrast ratio terahertz switch at SRR resonant frequencies, it presents a potential prospect for high performance transmission terahertz device, such as Fresnel zone plate.

A26. Ｇｅ／Ｓｉヘテロ接合を用いたトンネルＦＥＴに関する研究

金 閔洙

Study on Tunneling Field-Effect Transistors with Ge/Si Heterojunctions

By Kim Minsoo

In this thesis, tunnel field-effect transistors (TFETs) using band-to-band tunneling are investigated as a prospective solution of low power applications. Device structures and fabrications processes are suggested to achieve the steep subthreshold swing (SS) lower than 60 mV/dec which allow a supply voltage reducing, i.e. power consumption scaling. Tunneling probability of the TFET is strongly depends on the energy band gap of materials. narrow energy band gap materials (Ge, InAs...) have a potential to obtain a large tunneling current than that of wide energy band gap materials (Si, GaAs...). However, the tunneling current at an off-state can be also enhanced by the increased tunneling probability with narrow energy band gap materials. Therefore, in this study, Ge and Si heterojunction TFETs, which can enhance the tunneling current at on-state due to the narrow energy band gap of Ge while suppressing the leakage tunneling current at off-state due to wide energy band gap of Si, with simple structure are proposed and demonstrated. To enhance the device performance, pure Ge-source and thin body silicon-on-insulator (SOI) substrates are used. Low power phosphorus ion implantation is investigated for drain formation for thin body devices fabrication. Optimized 3 keV acceleration energy with phosphorus ion dose of 5×1014 cm-2 is used. Pure-Ge layer is successfully grown on drain-formed SOI substrate by extremely low temperature MBE. To guarantee the interface between Ge and Al2O3 gate oxide, ECR oxygen plasma post oxidation is carried out. The uniform interface of Ge/Al2O3 is confirmed by TEM images.

The effects of doping concentration of Ge-source on device performances are investigated. Highly boron doped Ge/Si heterojunction device shows improved device performances than those without boron doping. Although high on/off current ratio of 6-orders of magnitude with the low leakage current and good on current saturation are obtained, SS factor as high as 161 mV/dec.

The impact of the interface state density, which exist in both of Ge/Al2O3 and Si/Al2O3 interfaces, on device performances Ge/Si heterojunction TFETs are investigated. The low Dit values in the optimized Ge/Al2O3 interfaces are revealed by conductance method using nGe MIS capacitors. The high Dit values in the Si/Al2O3 interfaces decrease as the PMA temperature increases, resulting in the improvement of on/off current ratio and SS of Ge/Si TFETs. Fabricated TFET devices show high on/off current ratio over 6 orders of magnitude and steep SS of 58 mV/dec are obtained after PMA at 400 oC. Through the temperature dependence of I-V characteristics, it is confirmed that the tunneling current is the dominant currents in present devices. It is revealed that Dit between Al2O3 and Si in the channel region of the present Ge/Si TFETs is a critical factor to realize low SS and high on/off current ratio of the proposed TFET structure and, thus, the proper thermal treatment is important for the enhancement of electrical properties.

Channel strain engineering effects on TFET's performances are investigated using different strain values in Si channel. Unstrained Si and two kinds of different biaxial tensile strain with 0.8, 1.1 % Si substrates are used and the strain values are confirmed by Raman spectra. The high Ion/Ioff ratio is obtained after 400 oC PMA, which amounts to 4.4, 2.2 and 3.7x107 for the unstrained, 0.8 and 1.1 % strained Ge/SOI TFETs, respectively. Moreover, steep minimum SS (SSmin) of 55, 49 and 29 mV/dec at room temperature are obtained after 400 oC PMA for the unstrained, 0.8 and 1.1 % strained Ge/SOI TFETs, respectively. It is confirmed that strain engineered Ge/Si hetero-junction which has advantages of reduced effective energy band gap (Eg.eff) shows high on/off current ratio with low leakage current and steep SSmin. The dominant tunneling current in device operation is confirmed by non-dependent temperature and channel length properties.

The back bias effect on device performances of Ge/sSOI(0.8 %) TFETs are investigated. It is found that the device performances can be further improved with back biasing.

Steeper SSmin can be obtained by negative back biasing at small VG region. However, the opposite direction of VB to VG cause inefficient band bending of channel resulting in the decrease of drain current. With positive back bias voltage, significant increase in Ion and decrease averaged SS (SSavr) in middle ID region are obtained. The improvement of drain current and SSavr might be attributed to enhanced by gate electrostatics by identical direction of positive VB as double gate operation. However, the Ioff increases due to the increase in the ambipolar current and this increase of the ambipolar current is attributable from un-optimized drain junction and further improvement is expected by process optimization.

The demonstrated Ge/Si hetero-junction TFETs with strain channel show high Ion/Ioff ratio with steep SSmin and favorable SSavr in comparison with other results.

Hence, in this study, we have confirmed the feasibility of Ge/Si hetero-junction and strain engineering of channel on the enhancement of TFET performances.

A27. 人間環境で働くロボットの人間親和性に関する研究：モビリティ，マニピュレーション，リハビリテーションの観点から

金 潤河

Human-friendliness of Robots in Human Environments: Mobility, Manipulation, and Rehabilitation Perspectives

By Yunha Kim

This dissertation presents a novel definition, an evaluation criterion, requirements, and design suggestions for the human-friendliness of robots of the immediate future in human environments, from mobility, manipulation, and rehabilitation perspectives. Securing human-friendliness is an essential prerequisite for the realization of the human-robot coexisting society.

With cutting-edge technologies being implemented, robots have increasingly been commercialized and launched onto the market. The demands for robots, who can help, for example, clean the house, communicate with people, carry heavy things, and work in dangerous environments with or instead of humans, are expected to increase rapidly in the immediate future, given the fact that the average population of many societies is getting old, and the working conditions and perimeters of human activities are changing and expanding.

These robots of the near future greatly differ from the ones that we have known so far in terms of that they share the same time and space with humans, and continuously interact with them in physical, psychological, or other ways. As they are coming into our society, guidelines regarding safety for robots and ourselves must be set to prevent problems of any kind. However, the main stream of the robot research and development has been mostly focused on, and dedicated to improving the performance of the conventional robots. Consequently, most endeavor has been given to making robots stiffer, faster, more efficient, more precise, and more robust, while paying relatively little attention to the human-friendliness of robots.

Ever since Asimov first devised the Three Laws of Robotics in 1942, the guidelines regarding human-robot relationship have been discussed and amended over the last seventy years in sociological domains. And finally in 2006, the British government sponsored a speculative paper suggesting that robots one day might demand equal rights to humans, which marked the first government-level action on the issue. In the following year, also the government of the Republic of Korea came to announcing that it would draft a Robot Ethics Charter to address and prevent ``robot abuse of humans and human abuse of robots.'' However, in contrast to the development of the argument in sociological domains, the discourse concerned with human-robot interactions and safety in the engineering domain still stays local and in its infancy.

To our relief, recently in 2014, a new international standard (ISO) governing the safety issues of the service robots has been published to catch up with the changes of demands and expectations. However, it is no more than setting a foundational guideline in human-robot interactions, barely mentioning that ``robots should be inherently safe.'' One can also find a few research works on the issue only to find that each of them postulates different conditions and concepts, and that the discourse has not reached any consensus yet, despite its importance. That being said, now it is timely and significant to address how robots should treat humans and vice versa -- the human-friendliness of robots in engineering terms.

A wide spectrum of issues involving robots' body and mind has to be addressed for safe and dependable human-robot interactions. Among many, in this dissertation, the body components which involve robot design and control, concerned with the physical portion of the interactions, are mainly focused on and dealt with, based on the fact that the supreme priority falls on the physical aspects of the safety. And the principle that this dissertation makes is simple and clear: ``Robots have to be compliant.''

In this work, the human-friendliness of robots is newly defined by adopting the concept of the lumped compliance. Then, a criterion to evaluate the human-friendliness is formulated. And while answering the questions such as how should robots be designed, how should they be controlled, and what human aspects should be considered, the requirements and suggestions that lead to improvements of the human-friendliness are provided and verified theoretically and experimentally. Three laboratory-made robots are used for the experiments, to postulate, respectively, mobility, manipulation, and rehabilitation, which form the basis of most of the robotic applications we expect to face in the near future.

In Chapter 1, an overview of the history involving robots and humankind is given. From the overview, the relationship between humans and robots and, the trends in it with regard to the physical distance and interactions are explained. Based on the aspects of the change and the forecast demands and expectations, we will see the problems that we are facing now in preparation

for the human-robot coexisting society, where we find the motivation and justification of this work. Based on it, three robotic applications are introduced in the following three chapters, to specify the requirements and conditions that robots of the near future should meet, and eventually to draw a conclusive philosophy in Chapter 5.

Firstly in Chapter 2, a future mobility platform, CIMEV, is introduced. By adopting compliant mechanical elements -- caster wheels here -- in the system, it is clearly shown that the lumped compliance (the human-friendliness) of the whole robot improves. In addition, it is also shown that introducing compliant control algorithms, such as a disturbance observer, helps robots to perceive and adapt themselves to the changes of the surrounding environments. Moreover, mobile robots working in human environments are required to have high maneuverability and controllability, which are realized by utilizing the characteristics of caster wheels in CIMEV.

In Chapter 3, biologically inspired manipulators, including JUMPBiE, are introduced. The systems' high compliance, that animal's musculo-skeletal structures (in this dissertation, to be specific, the bi-articular muscles) provide, enables safe and human-/environment-friendly motion in robot manipulation. The homogeneity in stiffness distribution and output force characteristics of the bi-articular actuation helps to improve the performance of the robots in human environments. It is also shown that the use of compliant mechanical elements (springs, here) also helps to enhance the human-friendliness of robot manipulators.

In Chapter 4, a novel type exoskeleton for rehabilitation, H-FEX, is introduced after a thorough consideration on the human bio-mechanical characteristics. Based on a study on human body kinematics and muscle activation, a novel algorithm to estimate the muscle group activation rates during gait is formulated. Then, the estimation result leads us to the implementation of an advanced design and control for exoskeletons for rehabilitation, by specifying the deteriorated muscle groups, where to assist. Moreover, the viscoelastic characteristics of human muscles opens a way to the extensive use of springs and dampers, which eventually enhance the human-friendliness of the devices.

In Chapter 5, based on the findings and observations from the robotic applications introduced in the previous chapters, a novel definition and a criterion are formulated to tell how human-friendly a robot is. The new definition of human-friendliness, in this dissertation, adopts the concept of the lumped compliance, whose derivation and application methods are also elaborated. Then, the design requirements and suggestions for enhancing the human-friendliness are provided both hardware-wise and software-wise, which are implemented in designing and controlling the robots introduced in Chapter 2, 3, and 4.

Finally in Chapter 6, the findings and contributions of this work and, some open issues for future work are explained and discussed.

Now we are entering a new era of the human-robot coexistence. Many robotic applications are working together with us already, and in the immediate future, we will see many more robots sharing our daily lives together with us. In this dissertation, robots' human-friendliness itself is extensively studied. A novel definition of it, requirements for it, and suggestions to enhance it are given, and they are backed by theoretical and experimental verifications using laboratory-made robots, from mobility, manipulation, and rehabilitation perspectives. Regarding that those three applications are the basis for most robotic systems, the findings and suggestions provided in this work must be helpful and inspiring the next `human-friendly' robots of the future.

A28. 走行ルートの動的な車両別変更によって都市道路交通網における車両走行時間の短縮を図るルート案内システム

リャン　ジールー

Route Guidance System for Reducing Travelling Time by Personalized Rerouting of Vehicles in Urban Road Trac Network

By Liang Zilu

Urban road traffic congestion has been a severe problem for years. This research proposes a novel preventive route guidance system (RGS) with personalized rerouting to tackle the problem of traffic congestion in urban areas. The mechanism of the proposed RGS is to provide route guidance to drivers when traffic congestion is predicted, and differentiate the route guidance that is given to vehicles to prevent triggering secondary congestion on detour routes. Three major technical issues, i.e., short-term traffic amount prediction, average speed estimation, and vehicle ranking, are addressed in this research in order to achieve the final goal of reducing average travel time. Firstly two urban traffic amount prediction models and one average speed estimation model are proposed based on a microscopic modeling approach, which are suitable for the studies in urban traffic network and distinctly differ from existing models that are based on a macroscopic modeling approach. Real traffic data are used to evaluate the prediction or estimation accuracy of the proposed models by comparing them with existing models. The results demonstrate that both of the proposed traffic amount prediction models significantly reduce prediction error by up to 52% and 30% in the best cases. The first model works better when guidance update interval is not long, while the second one demonstrate opposite feature. Therefore, the former is more suitable for the proposed RGS and thus is used in the implementation of the proposed RGS afterwards. As to the travel speed estimation model, it consistently leads to lower errors than the widely used Greenshields' Model (GM). By properly selecting the tuning parameter, the proposed model successfully reduces estimation error by more than 50% in the studied urban traffic network. On the other hand, the proposed model also satisfies the practical requirement of speed estimation, as its relative errors are constantly lower than 20%. Furthermore, it was also noticed that GM had the tendency of overestimation, especially when traffic amount on a link was high, which could

give a distorted picture of the traffic conditions. The proposed speed estimation model is used in the implementation of the proposed RGS, while the GM model is used by the existing RGS that is taken as the baseline for comparison. In order to effectively realize the personalized rerouting, the vehicles that need to be rerouted should be ranked according to their potential contribution to the reduction in average travel time. The vehicles with higher ranking would be rerouted first and thus have the chance to enjoy better alternative routes. Six ranking criteria are proposed based on three categories of rationalities. The proposed RGS is constructed with the proposed traffic amount prediction model, the average speed estimation model, and a ranking criterion implemented in corresponding module in the system. The evaluation of the vehicle ranking was conducted in line with the performance of the proposed RGS on the system level, as the measures on the effectiveness of the ranking criteria are also the measures of the systematic performance of the whole RGS. The effect of tuning parameters, including congestion threshold , selection level l, and guidance update interval c, are investigated first to decide the proper values for these parameters. The results show that = 0:7, l = 3, and c = 60 is a set of proper values for the parameters in the studied scenario, as they not only leads to satisfactory performance of the proposed RGS in terms of reducing travel time, but also offer good trade o among other potential benefit, such as travel distance and rerouting frequency. It is also noticed that ranking vehicles according to their distance to the destination generally yields good outcome in all cases. With the above values of parameters and the ranking criterion, the performance of the proposed RGS is then compared to an existing one on both macroscopic and microscopic level. On the macroscopic level, the proposed RGS not only successfully reduces the average travel time by 22%, but also leads to shorter average travel length. In addition, 40 % less vehicles are involved in rerouting in the proposed RGS, and the average number of reroutings for each rerouted vehicles is reduced from 6.8 times in the existing RGS to only 1.6 times in the proposed one. Performance analysis on microscopic level further indicates that the advantages of the proposed RGS over the existing one may primarily come from the vehicles that are rerouted in both RGS and the vehicles that are rerouted in the existing RGS but not in the proposed one, which in total takes up 77% of all the vehicles. It is also found that most of the rerouted vehicles are benefited from the personalized rerouting in the proposed RGS, especially if they would also have been rerouted in the existing RGS. Some of the non-rerouted vehicles in the proposed RGS are also benefited from the rerouting of other vehicles, especially if they would have been rerouted in the existing RGS. The travel time of each individual vehicle in the proposed RGS is also compared to that of the same vehicle if no route guidance is given. The results show that 77% of the vehicles save travel time when they follow the personalized route guidance, and in total 66% of the vehicles save more than half of their travel time. In other words, among all the vehicles that save travel time, 85% of them in fact save more than half of their travel time. The personalized route guidance also has strong impact on the distribution of travel time of all vehicles in the traffic network. Compared to the distribution of travel time in the case where no guidance is given, the distribution of travel time in the proposed RGS is more centered to the left, which means that if a driver follows the personalized route guidance received, there is high probability of spending less time traveling and arriving earlier to the destination. This benefit may give incentive to drivers to comply with the personalized guidance that they receive from the proposed RGS.

A29. 複数バージョンのあるソフトウェアの自動検証・検査 – 複数バージョン管理時代のソフトウェアの品質向上 –

馬 雷

Automatic Verification and Testing for Software with Multiple Versions -- Improving Software Quality in the Era of Multiple Versions --

By Lei Ma

The verification and testing of software systems to improve the software quality are two major significant activities in the software development cycle. However, while their significance is widely known, it is also known that they occupy large parts of the cost in software development and maintenance. A software system has to be continuously changed to increase its functionalities, to fix bugs, and to adapt to new requirements over its lifecycle. Such changes are released as a series of updated software versions that share many commonalities among multiple versions. As the wide adoption of revision control system, Software Product Lines, more and more similar version variants are produced. This brings new challenges for conventional verification and testing techniques, which are only able to analyze one single version.

Separate verification and testing for each individual version would cause many redundancies in analyzing the same code. The results from separate analysis processes are also difficult to be shared among multiple versions. Sharing common knowledge is important to improve the overall analysis results and achieve better quality assurance guarantee such as code coverage. Therefore, there is a strong demand to create and design novel verification and testing techniques for multiple versions, improving the overall quality guarantee for all versions efficiently. However, the simultaneous analysis of multiple versions is inherently challenging, especially for managed languages like Java, and platforms designed to handle a single version.

In this thesis, we first propose a general framework project centralization to manage multiple versions. Project centralization shares commonalities of multiple versions as much as possible while preserving the behaviors of each version. We formalize the version conflict problem and propose a graph representation for all versions of products under analysis. Based on this representation, we transform the project centralization problem into a graph-coloring problem, where existing solutions

can be applied to calculate both the optimal and near-optimal solutions. We implement our differently proposed techniques and compare their effectiveness in code sharing. We can conclude that our proposed heuristic algorithm is both efficient and effective to calculate the near optimal solution. Based on this framework, we perform consecutive of studies, implement many software verification and testing tool chains, and show that our tools are useful for improving software quality and correctness of general multiple version software.

Distributed systems are typical complicated software examples that are operated with multiple versions. Based on project centralization, we further propose process centralization techniques for such challenging software quality assurance, where large combinational states, interactive network communications, and concurrency are involved. With combined project centralization and process centralization approaches, we have successfully verified some practical distributed applications with multiple versions, demonstrating the effectiveness of our technique in revealing bugs that are unable to be detected by using existing techniques.

In additional to verification, testing is also a major approach for detecting software defects and improving software quality. Among various testing techniques, random testing is easy to use, robust and scalable. It has been proved to be useful in finding bugs and improving software quality. However, conventional random testing techniques suffer from low code coverage. They only support to handle a single product. We propose a novel program analysis enhanced testing approach and a centralization based approach for multiple products with different versions.

Our program analysis enhanced random testing technique automatically performs program analysis on the software under test to extract domain knowledge to guide testing. It combined both static analysis and run-time guidance for testing. Our design and implementation outperform the current most advanced fully automatic random testing tool Randoop after many strict and thorough evaluations on more than 30 widely used benchmarks and by researchers on the collection products inside Software Competence Center Hagenberg. To support the automatic testing for multiple versions, we further refine our project centralization to the method-level and design novel testing strategies for multiple versions. Our techniques on real-world benchmarks demonstrate that the reuse of analysis results can improve the overall performance.

In summary, this thesis focuses on the issues to improve software quality, specifically on proposing novel techniques for the management, verification and testing multiple versions in the era of many coexisted version variants.

We summarize the main achievements of our proposed concepts, techniques and implementations from our consecutive studies on the management, verification and testing to improve software quality for multiple versions. Our work successfully makes steps further and solves important problems for multiple version related analysis: (1) manage multiple version variants, sharing common code while preserving the behavior of each version. (2) The verification of distributed application, with multiple version coexisted and running on multiple peers. (3) Improving automatic testing techniques and design novel testing approach for multiple versions.

A30. ストークスベクトルに基づく偏波合成開口レーダ地表分類

尚 方

Stokes Vector Based Polarimetric SAR Land Classication

By Shang Fang

Imaging radar has established itself as a capable and indispensable earth remote sensing instrument in the past two decades. At present, synthetic aperture radar (SAR) is intrinsically the only viable and practical imaging radar technique to achieve high spatial resolution. Fully polarimetric SAR (PolSAR) collects the full information of scattering matrix (HH, HV, VH, and VV) at every observed pixel. It is widely used in land classification fields.

Conventional classification algorithms for fully PolSAR data focus on analysis parameters for targets, such as scattering (S) matrix and coherency/covariance (C/T) matrix. Among these methods, the C/T based methods are the most active ones, since C/T matrix carries the important depolarization information of the targets. Although, the C/T matrix based classification methods are effective in many cases, there are still two main factors restricting their performances. Firstly, the C/T matrix is a parameter for target, not for scatted wave. It means that, partially polarized scattered wave information actually cannot be extracted physically from C/T matrix. To represent such depolarization information, in model-based decomposition methods, researchers introduce a volume scattering model. The expression of the model is switched according to the values of practical data to ensure high adaptability for various land situations. Nevertheless, depolarization phenomenon is caused in so many cases that finite number of volume models are not enough for all the situations. Then, sometimes, the depolarization information cannot be reasonably estimated. Secondly, In C/T matrix based decompositions, the averaged scattering mechanism described by the C/T matrix is decomposed as the sum of several elements. Such decomposition processes can hardly be unique, complete, and physical, simultaneously. For example, the H/A/α decomposition, a mathematical process, uniquely and completely decompose the T matrix. However, the decomposition results are not convenient to understand in physical way. On the contrary, the model-based decompositions, physical processes, decompose the T/C matrix into several elements corresponding to physical scattering models. However, since the models are not totally independent, such physical decomposition processes are usually not unique or complete.

Based on these considerations, developing an advanced algorithm which can use fully PolSAR data more sufficiently and effectively is a necessary topic. In this thesis, we propose Stokes vector based PolSAR land classification algorithms. Different from conventional ones, the proposed algorithm focus on the

analysis parameters for scattered wave, the Stokes vector, directly. It is more powerful for dealing with the generally existing depolarization information. Therefore, the proposed algorithms have higher classification performance.

Firstly, we proposed the method of analyzing the averaged Stokes vector for PolSAR data. We show that the averaged Stokes vector can be calculate from PolSAR data. To calculate the averaged Stokes vector, certain polarization state of the incident wave needs to be supposed. With the change of the polarization states of the incident wave, we can have different averaged Stokes vector. By employing the Born-Wolf wave decomposition, the averaged Stokes vector can be expressed by three independent physical components: the total scattered intensity, the degree of polarization, and the completely polarized wave component. To illustrate the features of the three components, we observe the three components for a sample window of PolSAR data. The total scattered intensity and the degree of polarization are scalars varying with the polarization state of the incident wave, whereas the completely polarized wave component is a 3×1 vector varying with the polarization state of the incident wave. We can select special values, such as the maximum and the minimum values, of the scalar components to construct discriminators for classification. However, the application of the vector component is difficult. Then, the application method of the completely polarized wave component has been proposed. The completely polarized wave component can be expressed as a point on the Poincare sphere. With the change of the polarization state of the incident wave, the points will cover the whole Poincare sphere. Two special routes are selected to express the features. They are the zero orientation route and the zero aperture route. We prove that these two routes can be approximated by the ideal routes, and have observed the ideal routes for several typical geometries of targets. To make the principle of the Stokes vector based PolSAR land classification clear, we discuss the relationship and difference between the averaged Stokes vector and other widely used parameters. We show that, the averaged Stokes vector takes much more information than conventional C/T matrix. Especially, it is more powerful for dealing with generally existing depolarization phenomenon. Moreover, our averaged Stokes vector based process is very different from the Co/X-polarization power based process.

Secondly, based on the analysis of the three components of the averaged Stokes vector, we propose supervised Stokes vector based PolSAR land classification algorithm. The total scattered intensity is very sensitive to topography. This feature may cause difficulties in classifying the targets correctly. Especially, in a supervised process. Therefore, in this supervised algorithm, we temporarily ignore the total scatted intensity component, and construct analysis parameters by only degree of polarization and completely polarized wave components. By representing the Stokes vector on/in the Poincare sphere geometrically, we construct two analysis parameters to describe the feature of a pixel in test area. They are, the position vector showing the averaged polarization state, and the variation vector presenting the polarization-state fluctuation in a small area centered on the pixel. We name the position vector and the variation vector together the Poincare sphere parameters. For analyzing the Poincare sphere parameres, we employ neural networks. The neural networks have high capability on dealing with fluctuation data. Moreover, they are very effective on the fusion of different types of analysis parameters. Because of the fluctuation of the Poincare sphere parameters and the fusion requirement of the position and variation vectors, the neural networks are expected to be a suitable analyzing tool. Using a real-valued feedforward neural network, we obtained successful classification results. Considering the multi-dimensional feature of the Poincare sphere parameters and the fact that, for the phase-sensitive remote sensing systems, the performance can be improved by employing complex-valued neural networks, we expect that the result of the classification in Poincare-sphere-parameter space can be also improved by using higher dimensional algorithms. With this idea, we use quaternion feedforward neural network. In experiments, we train the neural network with a set of teaching data for lake, grass, forest and town areas selected from the Fujisusono area. Then, by using the trained neural network, we generate successful classification results not only for the Fujisusono area, but also other test areas, such as the Suruga Bay area. In comparison with C/T matrix based methods, the proposed method has higher classification performance, especially on detecting forest and town areas. Moreover, the method is sensitive only to the polarization state of the reflected wave. Then, the result is not influenced by height information. With these advantages, the proposed classification method can, therefore, be used for complicated terrains.

Thirdly, we proposed unsupervised Stokes vector based PolSAR land classification algorithm. Unsupervised methods provide automatically interpretation for PolSAR data. However, strictly speaking, they are not complete classification processes. Therefore, for unsupervised algorithm, a more appropriate word interpretation is used instead of classification. We propose a method to extract discriminators from the averaged Stokes vector. Actually, we can have many different discriminators. In the proposed algorithm, we select five important ones for use. They are averaged intensity, averaged degree of polarization, perimeter degree, inclination degree, and arc asymmetry degree. The first two discriminators describe the averaging value of total scattered intensity component and degree of polarization component. The last three discriminators present the spatial attitude of the zero orientation and zero aperture routes of completely polarized wave component. Then, based on the extracted discriminators, we have built four physical interpretation layers with ascending priorities: the basic layer, the low coherence targets layer, the man-made targets layer, and the low back scattering targets layer. The four layers together finally serve as the interpretation result of PolSAR data. In each layer, we focus only on targets with one certain physical feature. The information provided in each layer has unequal priority. The four layers together are already the interpretation results which can be used in the further classification process. Moreover, we can generate an intuitive final image by stacking the four layers according to priority order. A layer with higher priority is

stacked on a layer with lower priority. We can find that, if a pixel is identified (colored) on several layers, the color in an upper layer will cover the color in a lower layer. It means that, only the information with highest priority is shown in final image. In this way, we obtain final interpretation image for Suruga bay Area. We also test the performance of the proposed unsupervised algorithm for Ebetsu city area and Tokyo harbor area. The results show that the proposed method has high interpretation performance, especially for skew aligned or randomly distributed man-made targets as well as isolated man-made targets. The origin of the strength of the proposed method for detecting man-made targets lies in the fact that it focuses on target structures rather than only scattering mechanisms themselves.

Finally, we briefly discuss the method of using Stokes vector for PolInSAR system. We show that, the Stokes vector can be also introduced into PolInSAR system to improve the performance.

In summary, in this thesis, a new classification algorithm system for fully PolSAR data is construct based on the Stokes vector. The proposed algorithms have high classification performance.

A31. メモリと制御ソフトウェアの統合設計によるソリッド・ステート・ストレージシステムの高性能化

孫 超

High Performance Solid-State Storage Systems with Memory-Aware Software Design

By Chao Sun

The market of the solid-state drives (SSDs) is expanding due to SSDs' higher performance and endurance while lower power consumption, compared with the hard disk drives (HDDs). The continuously decreasing cost of the NAND flash memory, thanks to the scaling and multi-bit technologies, is another key driving force. Since there is no seek time for the data access in SSDs, the read performance of the SSDs is higher than HDDs. Moreover, SSDs also have a significant sequential write performance advantage over HDDs. However, due to the "erase-before-write" characteristics and endurance problems of the NAND flash memory, the SSDs have little or even no advantage in random write performance than the HDDs. Therefore, the SSD write performance should be improved.

In this dissertation, research is carried out to improve the SSD performance and endurance, reduce its energy consumption and cost. The solution is the memory-aware design in the storage stacks, including the memory device layer, flash translation layer (FTL), operating system (OS, kernel) layer and the application layer.

In the memory device layer, the design guidelines of the storage class memory (SCM) and NAND flash memory are provided for the proposed three-dimensional through-silicon-via (TSV) SCM/NAND flash hybrid SSD (Hybrid SSD). From the experimental results, the required SCM capacity will be dependent on the application speed requirement, workload characteristics, data management algorithms like SCM wear leveling and SCM latency parameters. Strategies to configure the required SCM and NAND flash capacities are presented to achieve the low cost. In addition, the SCM chip design examples are provided, which meets the system speed requirement with a low SCM chip cost. Lastly, the sensitivity of the NAND flash organization, block and page sizes, on the system performance is discussed.

In the FTL, a write cache buffer replacement algorithm, cold data eviction (CDE), is proposed for the Hybrid SSD. According to a 50 ns HfO2 ReRAM measurement results, the NAND like interface (I/F) is proposed for ReRAM. Frequently accessed (hot) data and random data are stored in ReRAM, which reduces the data traffic to the NAND flash and decreases the SSD data fragmentation issue. When ReRAM is almost full, the CDE algorithm aggregates and evicts the cold and less fragmented data to the NAND flash memory. Then the ReRAM space can be reclaimed for the new writes. Combined with the page-level address mapping scheme, 12.6-times performance improvement, 92.8% energy consumption reduction and 9.7-times endurance enhancement are achieved for the financial application.

In the OS layer, a NAND flash aware middleware, LBA scrambler, is proposed to improve the SSD performance by minimizing the garbage collection (GC) overhead, which is the bottleneck of the SSD random write performance due to many page-copy operations. The concept of the LBA scrambler is to intentionally write data to the fragmented pages in the next erase block. As a result, the page-copy overhead can be minimized. To achieve this, the recommended writing page information is sent from the SSD controller to the LBA scrambler. With these hints, the LBA scrambler maps the logical block address (LBA) from the write requests to the scrambler LBA (SLBA) and send the new write requests with SLBA to the SSD controller. With the LBA scrambler, 17%-400% performance improvement, 23%-60% energy consumption reduction and 9%-55% endurance enhancement are achieved. The SSD issues due to the unaligned writes are eliminated as well.

Moreover, since file system (FS) in the OS manages the file storage and access, the effect of the FS on the SSD performance is evaluated. By analyzing the SSD workload characteristics under different FSs, it is proved that the success of NAND flash aware FSs in improving the SSD performance is realized by grouping the random writes into sequential and reducing the metadata updates. The proposed middleware LBA scrambler presents the effectiveness to improve the SSD performance even for the NAND flash aware FS.

In the application layer, a storage engine assisted SSD (SEA-SSD) is proposed for the database applications. It is based on the idea that upper layer in the host contains more rich information of the data activity, which is useful for reducing the GC overhead. By passing several hints from the SE to the SSD controller, data with similar activity are identified, clustered and aggregated the in the same block of the NAND flash. As a result, maximum 24% SSD performance improvement, 16% energy

consumption reduction and 19% lifetime extension are achieved.

A32. 単一自己組織化 InAs 量子ドットにおける量子準位構造のテラヘルツ分光に関する研究

張 亜

Terahertz spectroscopy of sublevel structures in single self-assembled InAs quantum dots

By Ya Zhang

Terahertz (THz) wave is a powerful tool for exploring electronic properties of nanostructures. However, the long wavelength of the radiation prohibits THz wave efficiently interacting with nanostructures. We focus our work on THz spectroscopy of single nanostructures, and aim at bringing a breakthrough in the study of nanoscale physics. We have chosen InAs self-assembled QDs as our research target due to their unique properties and great interests in device applications. For device applications, it is of great importance to precisely characterize the electronic structures of InAs QDs and clarify the interaction dynamics with THz electromagnetic wave through THz spectroscopy.

For an introduction of the work, in Chapter 1, we reviewed these important previous works. The electronic structures of InAs QDs were extensively studied by interband photoluminescence and transport measurement. The research on THz spectroscopy of sublevel structures in InAs QDs is, however, still at a preliminary stage. Due to the great mismatch between the size of the QDs and the wavelength of THz radiation, the absorption of THz wave by single QDs is extremely small. Both ensemble QDs spectroscopy and single QDs spectroscopy by scanning probe microscope suffered from broad linewidths and low single-to-noise ratio, hindering detailed discussions on the physics of intersublevel transitions. Therefore, in this work we try to fill this gap, i.e., propose a novel method for THz spectroscopy in single QDs and systematically study the intersublevel transitions in InAs QDs.

In Chapter 2, we described the basic principles of single electron transistor (SET). We described the single electron tunneling theory within the framework of the constant interaction model. Discussions on how to obtain the information on sublevel structures and the charging energy from the Coulomb stability diagram. Based on this, we discussed the photoexcitation mechanism and the selection rule in the QD SET.

In Chapter 3, we first described how to use the SET geometry to overcome the great mismatch between the size of the QDs and the wavelength of the THz electromagnetic wave. We used a solid immersion lens and the nanogaps electrodes integrated with a bowtie antenna to tightly focus the THz field on a single QD. By doing this, we can strongly enhance the effective THz field on a single QD. The other problem is that the THz absorption by a single QD is too small to be measured. We did not perform the absorption/transmission measurements; instead, we used the QD-SET itself as a THz detector. We detected the intersublevel transition as THz-induced photocurrent in the SET. Furthermore, we could vary the electron number in the QD by using the backgate. Then, we described the sample preparation. Particularly, we explained how to align a nanogap with antenna on a single QD. We tried three different fabrication methods; i. e., random fabrication, selected fabrication, and QDs mapping fabrication. The first method has an advantage of protecting the sample surface during the process. The second method has high fabrication yield. The third allows us to select the individual dot and achieve a high fabrication yield.

In Chapter 4, we presented the results of the THz photocurrent measurements. When the QD-SET sample was illuminated by a wideband THz radiation, an electron in the lower energy states absorbs a THz photon and makes a transition to the upper energy state and, then, tunnels out to the electrodes. When an electron in the electrodes tunnels into the ground state, the QD-SET returns to the initial state. This process is called “N,N-1 excitation”. However, the photocurrent distribution with respect to the Coulomb diamonds indicates that there is another mechanism for the photocurrent generation, which allows the photocurrent to flow even when the upper energy state is below the Fermi levels of electrodes. The total energy calculation shows that, after one electron is photoexcited to an upper sublevel, another electron in the electrode can subsequently tunnel into the lower empty state. Once the lower empty energy state is filled by another electron, all the energy levels are pushed up by EC and the photoexcited electron goes above the Fermi levels and tunnels out, producing a photocurrent. During this photoexcitation process, the electron number changes between N and N+1. Thus, we call this process the “N,N+1 excitation”, which agrees with the observed photocurrent distribution. For a deeper understanding of the photocurrent generation processes, we performed numerical calculations with rate equations, and found critical conditions for efficient photocurrent generation.

In Chapter 5, we presented the intersublevel transition spectra measured in QD-SETs within the few-electron regime. We observed sharp photocurrent peaks, whose linewidths are consistent with the tunnel coupling with the electrodes. When the p shell is fully occupied, we observed rather simple photocurrent spectra induced by p,d/2s shell intersublevel transitions. The selection rule for the intersublevel transition allows three intersublevel transitions; namely, p-,d-, p-,2s, and p+,d+, recalling the fact that the THz electric field is polarized along the direction of nanogap electrodes. Having this in mind, we decomposed the observed photocurrent peak into three peaks (p-,d-, p-,2s, and p+,d+) by numerical fitting. The intensity change of photocurrent peaks with VG agrees with the numerical calculation, suggesting the different Coulomb repulsion between the electrons in different energy states. However, when the p shell is half filled, the photocurrent spectra exhibited rather complicated behavior as a function the gate voltage, most likely due to the fluctuation in electron configuration when the empty p state is filled back from the electrode.

Furthermore, we measured the temperature dependence of the

intersublevel transition spectra. Surprisingly, even at 150 K, we could observe the photocurrent spectra for the sublevel energy spacing of about 13 meV. At low temperatures (< 30 K), the linewidth shows a weak temperature dependence, while at higher temperatures (30-150 K), the linewidth increased rapidly with increasing temperature. The linewidth broadening and the photocurrent reduction are most likely to result from the thermal fluctuation of the electron population in the QD.

In Chapter 6, we performed THz spectroscopy on single self-assembled InAs quantum dashes (QDHs) in the many electron regions. We observed large energy differences between the excited state energies determined from THz spectra and that from transport measurements. We discussed manybody effects in the QD(H)-SETs. Electron-electron interactions give rise to the energy splitting in the QD(H). The transport measurements (i.e., Coulomb stability diagram) tend to measure the lowest excited state, whereas the intersublevel transition spectroscopy takes place only between the ground state and a specific excited state allowed by the selection rule. Therefore, the excited states determined from the stability diagram are systematically smaller than those by the THz spectra. In the many electron regions, the observation of multiple excited states is possible. From careful comparison, we found, for almost every photocurrent peak in the THz spectra measured on a QDH-SET, there was a corresponding excited state in the Coulomb stability diagram.

In the last chapter of this dissertation, we summarized the whole work in this thesis and also gave a comment on future prospects. We systematically studied the intersublevel transition spectra in single self-assembled QDs. We think the knowledge we have obtained from this research will be useful for both developing devices and understanding fundamental physics. The technology we developed for the coupling between THz wave and single nm-scale structures may also be applied to other fields, such as nano-chemistry, pharmaceutical science and even molecular biology.

A33. オンおよびオフ状態高電圧ストレスによる PFET のしきい値電圧シフトと信頼性に関する研究

ヌルル イザイラ アリアス

Study on Threshold Voltage Shifts and Reliability in PFETs by High-Voltage ON-State and OFF-State Stress

By Nurul Ezaila Alias

In recent decades, electronics have made much progress thanks to the scaling of silicon CMOS LSIs. Now dimensions of state-of-the-art MOSFETs are already as small as tens of nanometers. The size of metal-oxide-semiconductor field effect transistors (MOSFETs) in large scale integrated circuits (VLSI) has been rapidly scaled down for more than forty years for higher performance, lower power consumption, and higher integration. In such aggressively scaled MOSFETs, the short-channel effects and variability have large impact on the behavior of devices, and other problems are arising.

It is well known that the random variability is caused by the statistical nature of dopant atoms in the transistor channel which is called as random dopant fluctuation (RDF). The number and position of impurity atoms in the channel depletion layer in determining the Vth of the transistor is randomly distributed. It is well known that the variability of transistor characteristics is one of the most critical challenges in VLSI. In particular, the instability in static random-access memory (SRAM) cells due to the variability of individual transistors in the cells is known as a serious problem that will prevent further device integration and supply voltage lowering. Therefore, the analysis of cell unbalances at the transistor level is needed for better understanding of SRAM stability at low supply voltage (VDD) operation, which leads to a severe yield loss of SRAM. The large variation leads to the instability in SRAM cells. Hence, the suppression of this large variation is strongly required in order to reduce the instability in SRAM cell. In particular, some of SRAM cells fail due to cell unbalance caused by individual transistor variability.

Recently, a new concept of post-fabrication self-improvement technique of SRAM cell stability has been demonstrated. The self-improvement scheme in SRAM is used to improve cell stability after chip fabrication. This technique simply applying stress voltage to the VDD node, when VDD is raised to high voltage, stronger pFETs is stressed by ON-state stress, |Vth| is increased and selectively weakened by self-improvement scheme indicating self-improvement mechanism works. On the other hand, the weaker pFETs is stressed by OFF-state stress, |Vth| is decreased and selectively strengthened by self-improvement scheme which is favorable for self-improvement technique. As a result SRAM cell stability is self-improved.

In this work, experimental study on |Vth| shift and reliability in pFETs by high voltage ON-State and OFF-State Stress are intensively investigated. Variability of |Vth| shift by ON-state and OFF-state stress for post-fabrication SRAM cell stability self-improvement technique is experimentally investigated. The variability of |Vth| shift is controllable, with proper choice of stress voltage and stress time, larger shift can be obtained with less variability. Sigma variability does not depend on the stress voltage nor stress time, but it depends on the average of |Vth| shift. The magnitude of |Vth| shift in pFETs by high voltage ON-state and OFF-state stress are also very important because the magnitude of |Vth| shift is varies for different transistor. Some transistor has large |Vth| shift and some transistor has small |Vth| shift. The maginitude of |Vth| shift by high voltage ON-state and OFF-state stress itself has variability. From the experimental result, it shows that |Vth| shifts are process and transistor size dependence.

In terms of reliability, recover behavior of |Vth| shift by high-voltage ON-state and OFF-state stress under SRAM self-improvement technique also an important issue. This is because after stress application, |Vth| shifted, but after some relaxation period, |Vth| shift tend to move back to its initial state, but how much the |Vth| shift is recover and become permanent

part has been throughly discussed in this dissertation. Even though there is a sudden recovery just after the stress is removed, from long-time recovery measurements, it is found that the permanent part (|Vth| shift) are certainly exist even after 2 to 3 months relaxation period. From the experimental results, it is also newly found that |Vth| shift in pFETs by high voltage ON-state and OFF-state stress for SRAM cell stability self-improvement technique has no critical recovery issue.

One of the major concerns in SRAM self-improvement technique is the reliability issue. The transistors particularly pFETs are stressed by high voltage, and, therefore, the reliability may be degraded. Hence, the realiability measurements of pFETs under the post-fabrication SRAM self-improvement technique has been performed. NBTI degradation and NBTI lifetime estimation of pFETs under this technique are compared with fresh pFETs. It is found that although the NBTI lifetime of pFETs is slightly shorthened by the application of self-improvement technique, the lifetime difference is just a little, indicating the self-improvement cheme has no critical issues in reliability.

In conclusion, the experimental study on |Vth| shift in pFETs by ON-state and OFF-state stress for SRAM cell stability self-improvement scheme have been investigated through this study. The experimental results that have been obtained in this dissertation show important information on the |Vth| shifts and their variability behaviors in pFETs by high voltage ON-state and OFF-state stress for post-fabrication SRAM cell stability self-improvement scheme. It is found that the reliability of pFETs under this technique has no critical reliability issue. This is an important step for the realization of this self-improvement technique. These measurement data provide clear device design guidelines for the post-fabrication self-improvement scheme of static random access memory (SRAM) cell stability.

電子情報学専攻

A34. 不安定な GPS 測位環境下における都市空間の世界座標系での３次元形状モデル化

アシュワニ クマール

3D Geometric Modeling of Urban Structures in World Geodetic Coordinates under Unstable GPS Conditions

By Ashwani Kumar

3D models are widely used in many computer vision and computer graphics applications viz. digital preservation of heritage sites, geological survey, autonomous navigation and driving simulators in intelligent transport systems. Several methods are employed for reconstruction of such models which scan 3D structures with 3D scanners and align them into common coordinate system. However, there are some issues which need to be addressed for reconstruction of accurate large-scale 3D models. Among all, issues of high computational cost and error accumulation involved in alignment of huge number of range images are quite common in large-scale modeling. Another issue arises when the application needs the 3D model to be aligned in world coordinate system. Such an issue becomes even worse in urban scenario because the accuracy of GPS is not sufficient for many applications.

The work in this thesis handles the issue of computational cost and error accumulation by aligning range images in local coordinate system using a fast simultaneous alignment method. Several partially overlapping scans of the structure to be modeled are taken with a laser range scanner. A laser range scanner scans the surrounding geometric environment as a point cloud with coordinates of each point wrt. center of scanner. As each scan has its coordinates in individual coordinate system, these scans are brought into common coordinate system which is usually the center of first scan using fast simultaneous alignment method. As a result, a unified point cloud is obtained consisting of point clouds from each scan.

The issue of global alignment into world coordinate system is addressed by measuring world positions of scan centers using GPS and removing outliers based on statistical inferences drawn on confidence of GPS. The confidence of GPS is obtained using information from GPS receiver as well as from range scans. Several measurements are taken at each scan position to have statistically significant data. The measurements having number of visible satellites and their geometric dilution of precision less than empirically chosen thresholds are discarded and k-means clustering followed by inter-quartile range is used on rest of measurements to obtain a set of inliers. As a result, a subset of measurements is obtained as inliers at each scan position. Out of all the scan positions, an optimal set of positions with high confidence of GPS position estimation is chosen with RANSAC like approach and Hill Climbing optimization. After obtaining the optimum set of positions with high confidence of GPS accuracy, 3D transformation is obtained between locally aligned scan centers and their world positions as non-linear least squares solution using Levenberg-Marquardt algorithm. Global adjustment of 3D model is done into world coordinate system using estimated 3D transformation. Evaluation based on orientation of building facades, positioning on aerial photos, world distance between reference points and overlapping of neighboring regions etc. confirm the accuracy of global alignment.

Towards another independent approach, reflected GPS signals are identified using 3D range scans and are excluded from position estimation calculation because such signals create an additional path difference due to reflections leading to position estimation errors. A transformation between locally aligned scan centers and their world positions obtained from refined GPS positions is used for global adjustment of 3D model. 3D models of huge structures in Hongo campus and Komaba-II campus of The University of Tokyo have been reconstructed using the proposed approach with coordinates of each structure in world geodetic coordinate system. A significant improvement in global alignment of reconstructed 3D model validates the applicability and feasibility of proposed approach to 3D modeling under unstable GPS conditions.

A35. ソーシャルセンサとしてのマイクロブログを利用したリアルタイムイベントへの世論の識別と要約

モハンマド アシフ ホッセン カン

Identifying and Summarizing Public Opinion to Real-time Events Using Microblogs as Social Sensors

By Muhammad Asif Hossain Khan

Twitter has become an ideal platform for getting access to first-hand responses from its users in real-time about various social events, for example, popular public events such as Super Bowl, Academy Awards, presidential debates etc., social movements such Arab Spring, natural disasters such as earthquakes, tsunamis etc., outburst of epidemics such as seasonal flu and so on. With its 200 million monthly active users posting over 500 million tweets per day, Twitter offers a means to harness collective distributed opinion of the crowd regarding various social issues. It is as though a huge network of social sensors have been deployed, where individual sensors gets activated and communicates with other sensors whenever it perceives some social signals from the segment of the society where it is embedded. However, the sheer volume of these real-time status updates presents a great challenge in identifying, filtering, distilling and summarizing tweets pertinent to any particular event. Moreover, the 140 character length restriction imposed by Twitter on individual posts, forces its users to use unstructured language, non-grammatical sentences, abbreviations and out of dictionary words. This makes the aforementioned challenges even more complicated as many of the tools and techniques developed for standard text processing in the field of Natural Language Processing, cannot be readily imported in the domain of Twitter.

In the first part of this dissertation we propose a method for identifying tweets relevant to any particular event using Bag-of-Word classifiers. We investigate a special scenario where the training set is not carefully annotated (e.g. when “hashtags” are used as class labels). Although, it alleviates the need for manual labeling of training instances, thus saving time and cost, it presents several challenges. One of the challenges we tackled is the identification and removal of “confounding outliers”, i.e. training instances from a class which are outliers in their own classes and are also very similar to instances from other classes. Evaluation shows that their removal together with our proposed feature selection method can improve the classification accuracy. The proposed method can also improve classification accuracy when the training set contains limited training instances and the inter-class distances are very narrow.

In the second part of the thesis, we propose an unsupervised method for automatically summarizing tweets related to a particular event. The proposed method can produce a journalistic summary for those events which are pre-scheduled, take place within a limited time span, possibly televised and cause upsurge of traffic in Twitter. The proposed method tries to optimize three objective functions: maximize information content, minimize redundancy and maximize topical diversity. It optimizes the objective functions independently; i.e. in succession. At first, it performs topical clustering of the tweets; i.e. cluster the tweets according to their discussion topics. It performs a hard clustering of the tweets in the collection. Then, salience scores of the tweets in each topic cluster are calculated independently. Next, a set of highly salient tweets from each cluster are incorporated in the summary for that cluster. However, to avoid redundancy, tweets similar to the already selected tweets in the summary are not included in the summary. Finally, tweets in the summary of each cluster are aggregated to produce the summary of the whole corpus. Evaluation performed on thousands of relevant tweets generated during a real-world event reveals that, the summary produced by the proposed model could delineate the proceeding of the event with high precision and recall and could significantly outperform two intuitive and competitive baseline methods.

In the third part of the thesis, we propose another unsupervised method for automatically summarizing even-related tweets. However, instead of optimizing the objective functions independently, we model the optimization problems using Integer Linear Programming (ILP) and jointly optimize them using Lagrangian relaxation and dual decomposition techniques. Instead of trying to perform a hard clustering to tweets in the collection, we try to identify the inclination of each tweet toward the prominent discussion topics. As there are no topic clusters now, we calculate salience scores of the tweets in the whole collection instead of doing it per cluster basis. Two intermediate summaries are produced for the tweet collection: one trying to maximize topical diversity and the other trying to maximize salience score. However, the one trying to maximize salience score performs sequential selection of tweets in the summary and uses maximum marginal relevance (MMR) to penalize the salience score of a tweet in proportion to the already incorporated tweets in the summary. Finally, Lagrangian heuristics are used to find an agreement between the two optimizers to produce the final summary. Evaluation performed on the same data set used in the second part shows that the joint optimization approach significantly outperforms the sequential optimization approach that we proposed earlier.

Thus, the thesis as a whole presents a framework for identifying and summarizing people's opinion expressed in their tweets about public events. Twitter users post over two billion queries each day looking for real-time status updates on different events. However, the sheer volume of tweets pertinent to a particular event is formidable for a search user to go though even a fraction of them. On November 2013, Twitter introduced a new tool called the “custom timelines” that allows its users to manually select tweets returned by Twitter's search interface in response to an event related query to construct custom lists of tweets on their topic of interest. This substantiates that the proposed framework for automatically generating summary of an event by identifying tweets with popular discussion points among the set of pertinent tweets is highly significant and would satisfy the

information need of a large user group.

A36. 並列データ処理系におけるアウトオブオーダ型実行方式に関する研究

山田 浩之

A Study on Out-of-Order Execution in Parallel Data Processing Systems

By Hiroyuki Yamada

In parallel data processing systems, making sequential scans is thought to be an efficient way to access data, and a lot of sophisticated algorithms have been invented to achieve high scan throughput. This approach is supposed to be very reasonable because, from the 1980's to now, areal density of hard disk drives has increased exponentially every year, whereas it's latency has only reduced by 5% per year. Thus, the approach is widely seen both in the current open-source and commercial data processing systems such as Hadoop, Netteza and Vertica. As a matter of course, a sequential scan is not always the best approach. In general, when accessing a large portion of a file, scanning the file sequentially is very reasonable. However, when accessing a small portion of a file, making selective accesses by looking up a portion of the file through some structured data such as an index is very reasonable. Although some commercial parallel data processing systems implement such data structures and the access methods, to the best of my knowledge, not only the effectiveness of the approach has not been discussed sufficiently, but also the approach is not fully utilized, especially in analytical data processing. The volume of data to be handled by parallel data processing systems tends to be increasing dramatically, it is therefore sometimes unrealistic to read all the data. Furthermore, to make some evidence-driven decisions, it is highly required to process data interactively and ad-hoc, and look deeper into the data than some conventional BI tools normally do. Hence, it is very natural to think that making selective accesses is going to be much more effective and attractive.

In this paper, I propose an out-of-order execution method in parallel data processing systems. With the out-of-order execution, selective accesses are dramatically accelerated in parallel data processing. I also describe the design and implementation of Hadooode, a prototype of a Hadoop-based parallel data processing system empowered by the out-of-order execution principle, and verify the performance benefit by showing our experimental results in a 128-node cluster.

In the current parallel data processing systems, the dataset is sometimes composed of a lot of attributes, but queries to the dataset do not necessarily need all the attributes to make a result. Rather, in some analytical queries, only small number of attributes are needed to make a result. Hence, it is widely seen that a dataset is laid out in a column-oriented fashion instead of a row-oriented fashion so that queries can touch only needed attributes. This column-oriented data layout is seen as an optimized data layout for some expected queries, it is therefore not always the best strategy to query over a column-oriented data layout. For example, when a query needs to construct row-oriented tuples from columns that laid out in a column-oriented fashion, a lot of I/O accesses might be needed to stitch the separate columns together, especially when projecting many attributes. In addition to the case above, there are many opportunities which out-of-order execution might accelerate the query processing performance on a column-oriented data layout.

In this paper, I also propose an out-of-order execution method in column-oriented parallel data processing systems. I also describe the design and implementation of a prototype of a column-oriented parallel data processing system empowered by the out-of-order execution principle, and verify the performance benefit by showing our experimental results.

A37. X-Wall：個人写真リポジトリ用の画像可視化

呉 志鵬

X-Wall: Image Visualization for Personal Photo Repository

By Zhipeng Wu

Recent development in information science and multimedia technology not only makes the acquisition of digital images as free as air, but also brings new challenges to us. In our study, we propose X-Wall, a system that focuses on novel image visualization for personal photo repository. X-Wall is composed of three parts: FriendWall, MangaWall, and PicWall, focusing on different visualization challenges, respectively.

We propose FriendWall for social networking oriented image annotation and visualization. Motivated by the observation that photos come from social networking websites always contain rich information (e.g. relation with social friends, geo-locations, multiple tags and descriptions), we introduce 'social attributes', which simply refer to a set of intrinsic labels such as {Who, When, Where, What}. To effectively annotate social attributes, we obtain training images from social networking websites. Both of the visual features and metadata are extracted from the images and further imported into the graph-learning based annotation framework. A variance optimization-based post-processing step is proposed to refine the annotation results.

We propose MangaWall to help the user better interact with the images. Motivated by recent advances in computer graphics, which allow rich user interactions with images and enable a wide variety of expressive styles for digital art, our MangaWall system allows the user to interactively convert the input image into sketch, cartoon, painting, or manga. Besides, MangaWall can further combine the artistic effects with real-word images. Such 'half-real' image always provides an extremely intriguing sense of art. And the introduction of user interaction makes the visualization process much more creative and interesting.

We propose PicWall in order to cope with web-scale data and meet the requirements on various devices and platforms. PicWall advances previous works in generating real-time collages

for large amount of input images. It tightly packs the input images while keeping their visual contents, aspect ratios, and orientations unchanged. Besides, we introduce several extensions and applications for PicWall. For instance, we propose 'shake & show' for image visualization on mobiles. We contribute 'VideoWall' for video summarization and visualization. In 'rainbow collage', we propose content-aware collage. And in 'high-light collage' and 'interactive collage', the user can interactively edit the output collage.

All the methodologies and approaches presented in this thesis are well implemented and demonstrated in the proposed X-Wall prototype system.

A38. 多様なセンサを用いる歩行者ナビゲーションと位置同定に関する研究

党 聡維

A Study on Pedestrian Navigation and Localization Using Various Sensors

By Congwei Dang

Against a background of the fast increasing usage of modern mobile phones throughout the world, research topics relevant to phone-based navigation and localization have currently attracted a great deal of attention. In this thesis we present our research efforts that are organized as two parts related to pedestrian navigation and pedestrian localization respectively.

In the former part, we first present a multi-factor cost model that is used to fuse sensor data of heterogeneous environmental factors. This model takes a cost-based approach to assess the effects of the environmental factors on pedestrian's comfort level. Aggregation formula is derived on the basis of a set rules of substitution induced from the observations of the behaviors of pedestrians. Then we propose a framework for constructing pedestrian navigation systems for comfort in time varying environments. We apply data warehouse and data forecasting techniques in the framework and also design a set of path planning algorithms that select paths in time varying networks. In the evaluations sensor data from the real world are used and simulations are also performed to generate the necessary data. The results prove the effectiveness of the proposed methods.

In the later part of this thesis, we first propose an adaptive inference approach for pedestrian localization using phone-based inertial sensors. Places with salient geographical or physical features are used as the ground truth to trigger the online learning phase, which plays a central role in which location data as well as system parameters are refined. Then we enhance the system by incorporating sensor data of environmental signals. We design a sparse particle filter in order to reduce the computation burden when fusing the various phone-based sensors. Evaluation results show that the system can perform localization with high robustness, much higher efficiency, and only slight loss of accuracy compared to traditional method.

A39. 3 次元画像の高画質化・高機能化に向けた解像度変換処理の研究

中島 諒

Resolution conversion techniques for enhancing quality and functionality of 3-D image synthesis

By Ryo Nakashima

3-D images are rapidly becoming popular and widely-used for a variety of applications, because they can provide a higher sense of reality by giving perceptions of depth. The goal of my research is to enhance quality and functionality of a given 3-D image using resolution conversion techniques, where a given image is resized into another resolution in an intelligent way. Examples of resolution conversion techniques include super-resolution (SR), where a resolution of a given image is increased, and image retargeting, where an image is resized into a different aspect ratio with preserving the content of the image. This dissertation particularly addresses the following two problems: super-resolved free-viewpoint image synthesis (SR-FVS) and stereo image retargeting.

The former problem, SR-FVS, aims to generate a high-resolution image that would be observed from a novel viewpoint is synthesized from a set of low-resolution multi-view images. Although the generated image itself is a 2-D image, this process can be regarded as 3-D image generation because the viewpoint can be chosen arbitrarily. Free-viewpoint image synthesis generally consists of two steps: (1) estimating 3-D structure of the scene, and (2) texturing the estimated structure. In SR-FVS, SR algorithms are used in the texturing step to improve the resolution.

Among several SR approaches, reconstruction-based SR, where multiple images are combined to improve the resolution, is mostly used for SR-FVS, because multi-view images are given as the input. Therefore, I first study the performance of reconstruction-based SR, where camera arrangement mainly determines the quality of the synthesis. I formulate the SR reconstruction process in the frequency domain, where the camera arrangement can be independently expressed as a matrix in the image formation model. Then, the condition number of the matrix is evaluated to quantify the quality of the SR reconstruction. I clarified that when the cameras are arranged in a regular grid, there exist singular depths in which the SR reconstruction becomes ill-posed and the quality of the synthesized image is severely degraded. I also determined that this singularity can be mitigated if the arrangement is randomly perturbed.

The above theory reveals that the performance of reconstruction-based SR varies according to the depth of the scene. Such variation is not desirable for the reconstruction of the entire 3-D scene. To mitigate this problem, I integrate another SR approach, learning-based SR, into the framework of SR-FVS. Learning-based SR methods synthesize a high-resolution image by reproducing image features learned from a massive amount of natural images. Therefore, even if reconstruction-based SR is not very effective, learning-based SR can help improve the quality of the synthesis. I adopt sparse coding super-resolution

as a learning-based SR method and combine it with an existing SR-FVS method. Through experiments, I demonstrated that the proposed method improve the quality of the synthesis by utilizing reconstruction-based and learning-based SR in a complementary manner.

I also developed a system that performs SR-FVS in real-time. An array of 25 cameras is used as the input device. From a set of images captured by this camera array, this system generates a high-resolution free-viewpoint image in real-time. I implemented an SR-FVS algorithm in graphics processor unit (GPU) for speeding up. Also, I proposed a new matching cost for depth estimation to improve robustness against occlusions. This system is capable of synthesizing a high-resolution (320×240 pixels) free-viewpoint image from 9-view low-resolution (160×120 pixels) around 40 ms.

The latter part of this dissertation considers the problem of stereo image retargeting. Retargeting is the process of fitting the image size to various display devices with different resolutions and aspect ratios. Most retargeting methods aim to do more than simply scaling or cropping images. Instead, these methods add/remove non-salient regions to/from the given image while preserving as much of the salient regions as possible. However, most retargeting studies have focused on monocular images and videos and only a few studies have been conducted on stereo images.

Retargeting of stereo images poses a new challenge because pixel correspondences between the stereo pair should be preserved to keep the underlying scene structure unchanged. To meet this challenge, I proposed stereo correspondence constraint, which encourages preserving stereo correspondences, and integrated this constraint into the retargeting process. Among several retargeting methods, I adopt shift-map image editing, which formulates retargeting problem as an energy minimization whose objective function encodes pixel saliencies and size constraints. I define a new energy term that represents stereo correspondence constraint and integrated this term into the objective function of shift-map image editing. The modified objective function can be optimized similarly to the original one, which is an advantage of my formulation. I confirmed the effectiveness of our method through experiments using various stereo images.

A40. 画素適応処理による立体映像表示・自由視点画像合成の高画質化の研究

浜田 宏一

Image quality enhancement based on pixel adaptive processing for stereoscopic display and free-viewpoint image synthesis

By Koichi Hamada

In recent years, pixel adaptive image processing methods have begun to be used in consumer products. The development of the semi-conductor technology and the enhancement of the signal processing technology enable us to use high-cost image processing methods such as pixel adaptive image processing. This dissertation focuses on the image quality enhancement based on the pixel adaptive processing. I propose pixel adaptive methods which improve the image quality for stereoscopic display and free-viewpoint image synthesis . The realtime or fast implementation of the methods is also proposed.

First, this dissertation introduces a field-sequential stereoscopic display system with a 42-inch diagonal HDTV DC-type plasma display panel (PDP). This system uses an LCD shutter stereoscopic eyeglass, synchronized with the left and right pictures on the display by infrared signals. The light-emission scheme with twelve sub-fields for stereoscopic display and a signal-processing method for improving grayscale expression are developed. The effectiveness of the signal-processing method is confirmed by subjective evaluation. Though the stereoscopic images are displayed on the PDP using the proposed light emission scheme and grayscale signal processing, it is found that crosstalk impairment is incurred due to leakage between light to the left and right images. We calculate the amount of crosstalk as a function of phosphor decay time and estimated the desirable decay time for a field-sequential stereoscopic display system. This enables us to develop a signal processing method for reducing the crosstalk impairment with pixel adaptive processing, and a subjective evaluation confirms the effectiveness of the method. This system becomes the prototype of the 3D PDP television which is available today.

Second, the image quality enhancement of free-view point image synthesis is proposed. Free-viewpoint image synthesis refers to the process of combining a set of multi-view images to generate an image from a new viewpoint where no camera is actually located. The reconstruction-based super-resolution technology is used in combination with the synthesis. A fast GPU (graphic processor unit) implementation of the super-resolved free-viewpoint image synthesis is proposed. To speed up the super-resolution reconstruction process, an efficient and compact matrix representation that is suitable for parallelization using a GPU is proposed. I also modifies the initial image and regularizer for the reconstruction process to reduce the iteration time until convergence. As a result, I achieve a speed up of about 70 times compared to the original CPU-implemented algorithm, requiring only 130ms for synthesizing a 320x240 pixel free-viewpoint image from 160x120 pixel input images. In order to improve the image quality, I also propose a super-resolution method which is robust for registration errors. The super-resolution processing requires precise registration of low-resolution images and the registration error degrades the resulting high-resolution image. In order to handle inaccuracies in registration, the robust super-resolution methods have been proposed. I propose an adaptive pixel weighting method which uses pixel weighting variables for the input pixels. The proposed method is the extension of the conventional pixel selection type robust super-resolution. The cost function which includes the regularization term for the weighting variables is defined and the cost function is minimized against the weighting variables and the resulting high-resolution image simultaneously. The proposed adaptive pixel weighting method can define the weight properly without

knowing how to define it. This is a large contribution in practical use of super resolution. The effectiveness of the proposed method is confirmed with super-resolved free-viewpoint image synthesis.

The methods proposed in this dissertation realize the image quality enhancement in the field of stereoscopic display system and the super-resolution technology. I hope the pixel adaptive image processing are widely used in consumer products and people enjoy high quality images with the methods.

A41. ID レス生体認証における安全性と利便性の最適化に関する研究

村上 隆夫

A Study on Optimization of Security and Convenience in Biometric Identification

By Takao Murakami

Biometric identification, which recognizes an individual based only on physiological or behavioral characteristics, is nowadays used for commercial applications such as computer login, physical access control, and time and attendance management. It has a potential to provide the best authentication solution with regard to security and convenience because it does not require a user ID, password, nor card but recognizes a user based on his/her biometrics (i.e. something you are). In biometric identification, however, the following factors cause problems with security and convenience, and become serious as the number of enrollees increases: (1) false accepts; (2) wolves and lambs who cause false accepts against many others; (3) false rejects; (4) the number of biometric inputs; (5) response time. False accepts, wolves, and lambs are factors which affect security, while false rejects, the number of inputs, and response time are factors which affect convenience. They are related to each other, and have prevented biometric identification from being applied to large-scale applications. The goal of this study is to optimize security and convenience in biometric identification in terms of these factors. Firstly, we make an attempt to optimize false accepts, false rejects, and the number of inputs. We focus on MSPRT's (Multi-hypothesis Sequential Probability Ratio Tests), multi-hypothesis tests which can minimize the average number of observations, and propose two sequential fusion schemes in identification: the PPSI (Posterior Probability-based Sequential Identification) scheme and the LRSI (Likelihood Ratio-based Sequential Identification) scheme. The PPSI scheme is based on MSPRT and can minimize the average number of inputs (referred to as ANI), while the LRSI scheme is a simpler one which can be carried out quickly. Then we prove that the LRSI scheme can also minimize ANI by proving that this scheme is equivalent to MSPRT. We also discuss the conditions to achieve the optimality, and show the effectiveness of the two schemes through experimental evaluation using the NIST BSSR1 Set1, a multi-modal score dataset (one face and two fingerprints). Secondly, we make an attempt to further optimize response time. To this end, we turn our attention to metric space indexing methods which have been developed in the area of similarity search, and focus on pseudo-score based indexing schemes which compute, for each object in the database, a pseudo-score which is easily computed and highly relevant to a score (distance or similarity), and compute scores in order of the pseudo-score. We first propose the PPS (Posterior Probability-based Search) scheme which normalizes each pseudo-score to the posterior probability of being in the answer to the range query. We proved that the PPS scheme has an optimal property with regard to the number of score computations and the expected number of retrieval errors. We also showed that it outperforms the two state-of-the-art schemes: the standard pivot-based indexing scheme and the permutation-based indexing scheme, through experimental evaluation using various kinds of datasets from the Metric Space Library. We then make an attempt to combine metric space indexing and sequential fusion, and propose the PPSS (Posterior Probability-based Sequential Search) scheme, a modification of the PPS scheme to use not only pseudo-scores at the current input but past pseudo-scores and scores as information sources. We also propose a technique which optimizes the number of pivots (biometric templates selected from the database to compute pseudo-scores) with regard to retrieval errors. We demonstrate that our proposals significantly reduce the number of score computations of the PPSI scheme while keeping false accepts, false rejects, and the number of inputs, using a large-scale multi-modal dataset (1800 enrollees; one face and two fingerprints) obtained by combining the NIST BSSR1 Set3 and the CASIA-FingerprintV5. Finally, we attempt to optimize the trade-off between security against wolves and lambs and convenience in terms of the number of inputs and false rejects. To clarify our target, we first introduce a taxonomy which classifies wolves into three categories (zero-effort wolves, non-adaptive spoofing wolves, and adaptive spoofing wolves) and lambs into two categories (zero-effort lambs and spoofing lambs). Then, we propose the MLRSV (Minimum Likelihood Ratio-based Sequential Verification) scheme as a sequential fusion scheme in verification. We prove that this scheme has security against wolves and lambs, except for adaptive spoofing wolves, and minimizes ANI and false rejects under some conditions. We also discuss the conditions to achieve the security and optimality, and propose an input order decision scheme based on the KL (Kullback-Leibler) divergence to further reduce ANI in the case where the KL divergence differs from one modality to another. We finally demonstrate the effectiveness of our proposals using a multi-modal (one face and eight fingerprints) dataset obtained by combining the NIST BSSR1 Set3 and the CASIA-FingerprintV5.

B. 大学院修士課程論文リスト
Masters' Dissertations

電子情報学専攻

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池島 純	出力特徴量の状態識別と長時間特徴量を用いた区分的線形変換による声質変換	Jun Ikeshima	Voice conversion using piecewise linear transformation with long-span features and state discrimination of the target speaker
石黒 祐輔	為替ニュース記事を用いた SVM による株価動向予測	Yusuke Ishiguro	Using news articles on foreign exchange to predict trend of stock prices by SVMs
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アムガランガンバト	ClusterNap: グリーンコンピュータクラスタと クラウドのための汎用電力コントローラ	Amgalan Ganbat	ClusterNap: A Generic Power Controller Interface for Green Clusters and Clouds
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高 成源	多数のセンサーを用いたサッカーにおける運動状態検出システム	Go Seongwon	Analysis of Gait and Actions on Soccer Using Multiple Sensors
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鈴木 恵介	大規模データベースシステムにおける SSD を使用した問い合わせ処理高速化に関する研究	Keisuke Suzuki	A Study on Acceleration Techniques for Query Processing of Large Database Systems on SSDs
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中谷 翔	シェルコマンド群による分散処理のためのストリーム処理系	Sho Nakatani	A Stream Processor for Distributed Computing by Shell Commands
中村 哲也	クライアントサイドにおける異なるメディアストリームの再生タイミング同期技術	Tetsuya Nakamura	A Client Side Technology of Timing and Synchronization between Different Media Streams
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	に着目した漏洩電磁界低減手法と形状の変更が可能な無線給電シート		and Cancellation Mechanism of Electromagnetic Leakage for Wireless Power Transmission Using Magnetic Resonance
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三浦 俊祐	3 次元構造データを活用した都市部における GPS の測位精度改善に関する研究	Shunsuke Miura	Improvement of GPS accuracy utilizing 3D structure data of urban canyon
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栗原 俊明	テキストデータにおける予定変更情報および影響の獲得	Toshiaki Kurihara	Obtaining Information of Schedule Changes and Their Impact in Text Data
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山口 哲哉	災害時における携帯電話の電子メール配送遅延改善手法	Tetsuya Yamaguchi	Improving delivery delay of cellular phone e-mails in a disaster
周 磊杰	可視光通信プロジェクタにおける動的制御可能なフレームワークの研究	Leijie Zhou	Dynamically Reconfigurable Framework for Pixel-level Visible Light Communication Projector

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大野 仁嗣	微細トランジスタにおけるランダム・	Hitoshi Ohno	Statistical Analysis of Random Telegraph Noise

	テレグラフ・ノイズの統計分布解析		in Scaled MOSFETs
倉持 美沙	III-V CMOS フォトニクスに向けたマルチバンドギャップ III-V on Insulator 基板の研究	Misa Kuramochi	Research on Multi-bandgap III-V on Insulator Wafer for III-V CMOS Photonics
髙井 栄輔	対話型進化計算を用いた遺伝子制御ネットワークの構築	Takai Eisuke	Building Gene Regulatory Networks Using Interactive Evolutionary Computation
三浦 良平	フォトニック結晶ナノビーム共振器と結合した架橋単層カーボンナノチューブの顕微フォトルミネッセンス測定	Ryohei Miura	Photoluminescence microscopy on air-suspended carbon nanotubes coupled to photonic crystal nanobeam cavities
高 博シン	ラングミュアプローブによるガイド磁場下でのリコネクション拡散領域と電子加熱の検証	Gao Boxin	Investigation on Diffusion Region and Electron Heating in Guide Field Magnetic Reconnection by Using Langmuir Probes
石井 晃博	架橋単層カーボンナノチューブにおける励起子拡散とそれに伴う励起子緩和過程	Akihiro Ishii	Exciton diffusion and related decay processes in air-suspended single-walled carbon nanotubes studied by photoluminescence spectroscopy
石井 智章	ケルビンプローブフォース顕微鏡による Cu(In,Ga)Se2 太陽電池の物性評価	Ishii Tomoaki	Characterization of Cu(In,Ga)Se2 solar cells by Kelvin probe force microscopy
板持 貴之	木探索の部分結果を利用したモンテカルロ囲碁のシミュレーション方策の動的調整	Takayuki Itamochi	Dynamic Tuning of Simulation Policies Utilizing Partial Results of Tree Search in Monte-Carlo Go
伊藤 篤義	高性能有機トランジスタの溶液プロセスによる作製を目的とした自己組織化単分子膜の改質	Shigeyoshi Ito	Modification of Self-Assembled Monolayers for Fabricating High-Performance Solution Processed Organic Transistors
伊藤 成顕	THz 波発振に向けた MOVPE 法による窒化物共鳴トンネルダイオードの製作、解析	Naruaki Itoh	Fabrication and analysis of nitride resonant tunneling diodes by MOVPE for THz oscillation
井上 雅典	同時送信型フラッディングを用いた大規模無線センサネットワークの性能評価	Inoue Masanori	Performance Evaluation of Large-Scale Wireless Sensor Networks using Concurrent Transmission Flooding
井上 裕貴	グレースケール画像に対する画像の分解と曲線の抽出	Yuki Inoue	Clustering and Extraction of Curves for a Grayscale Image
今井 克樹	CF3I ガス及びその混合ガスの放電特性と絶縁媒体としての適性	Katsuki Imai	Discharge characteristics and suitability as insulation medium of CF3I and its mixture
今泉 宏之	ペプチド・レパートリー分布を考慮した T 細胞抗原認識モデルの構築	Hiroyuki Imaizumi	Modeling of T-cell-antigen recognition under the consideration of peptide-repertoire distributions
井本 翼	酸化亜鉛ナノロッドを用いた電極反応に対するドレスト光子効果の検証	Tsubasa Imoto	Study on the dressed-photon effect in a nanoscale electrode reaction using ZnO nanorod electrode
大島 浩資	部分回路への接続と論理の変更によるハードウェア設計の自動デバッグ手法	Kosuke Oshima	Automatic Debugging Method for Hardware Designs Based on Correction of Logic Function and Connection of Sub-circuits
岡崎 成晃	拡張現実感を用いた擬似傾斜提示が歩行者に与える影響の検証	Shieaki Okazaki	Investigation of the Effect of Virtual Slant on Pedestrian in Augmented Reality Environment
岡村 直柔	Ce@C82 金属内包フラーレンを用いた単一分子トランジスタにおける電子伝導	Naoya Okamura	Electron transport in Ce@C82 endohedral metallofullerene single molecule transistors
小原 知也	アドホックネットワークにおける TCP 通信のグッドプットを改善する早期再送	Tomoya Ohara	Early Re-transmission for Improving TCP Goodput over Ad Hoc Networks
角谷 太郎	住宅へのダブル発電導入に伴う社会厚生の改善と最適システムの設計に関する研究	Taro Kakutani	Study on Optimal System Design and Social Welfare Improvement of Houses Introducing Fuel Cells and Photovoltaics
蟹江 教佳	効用関数に基づく無線通信方式の選択手法	Noriyoshi Kanie	Utility Function Based Selection of Wireless Communication Method
菊田 和孝	折りたたみフィンによる小型・超広帯域テーパスロットアンテナ	Kazutaka Kikuta	Small ultra-wideband tapered-slot antennas having folded fins
菊池 優人	真空中の絶縁破壊現象における粒子挙動が与える影響	Yuto Kikuchi	Motion observation of metallic particles between electrodes and breakdown phenomena in vacuum

河野 健太	テラヘルツ帯メタマテリアルへのイオン液体電気二重層ゲートの応用	Kenta Kohno	Applications of electric double layer gating with ionic liquids for THz metamaterials
佐々木 大輔	強磁性半導体(In,Fe)As 薄膜における歪み、量子閉じ込め効果、バンド構造、および磁性に関する研究	Sasaki Daisuke	Research of strain, quantum confinement, band structure and magnetic properties in ferromagnetic semiconductor (In,Fe)As thin films
佐藤 正寛	パワーモジュール封止用シリコーンゲル中における部分放電現象	Masahiro Sato	Partial discharge phenomena in silicone gel for encapsulation of power modules
佐藤 美沙	照応詞と先行詞の文脈的な置換可能性を考慮した共参照解析	Misa Sato	Coreference Resolution Considering Contextual Substitutability between an Anaphor and its Antecedent
施 英漢	MEMS 技術を用いた音波の熱的な検知に関する研究	Shi Yinghan	A Research on Thermally Detect of Acoustic Wave using MEMS Technology
茂渡 修平	ワイヤを有する月惑星縦孔探査ロボットに関する研究	Shigeto Shuhei	Study on vertical hole exploration robot with tether wire on the moon or planets
柴田 優一	重イオン線照射による FPGA のソフトエラーの実測に基づく宇宙機用レゾルバの角度エラーの推定	Yuichi Shibata	Estimation of the angle errors in the resolver for spacecrafts by measuring soft errors in FPGAs with heavy-ion irradiation
赤尾 拓朗	Ru と RuO2 のナノ摩擦現象の TEM 観測	Akao Takurou	TEM observation of nanoscale friction of Ru and RuO2
瀬能 未奈都	超高集光太陽光発電への応用に向けた III-V 族化合物半導体モノリシック集積直列接続太陽電池の開発	Minato Seno	Fabrication of monolithic integrated series-connected III-V compound solar cells for ultrahigh concentrator photovoltaics
高橋 優斗	再生可能エネルギーを考慮した電力市場の価格決定方式の解析	Yuto Takahashi	Analysis of Electricity Market Auctions with Renewable Power Plants
瀧 勇也	水の電気分解用電極触媒 CaMn2O4・xH2O の合成と評価	Taki Yuya	Synthesis and Evaluation of CaMn2O4・xH2O electrocatalyst for Oxygen Evolving Electrode of Water-splitting
武 直矢	パリレン絶縁膜を用いた有機トランジスタのフリッカー雑音	Naoya Take	Flicker noise of organic transistor with a parylene-insulator
田尻 武義	<110>層状ダイヤモンド構造を有する三次元フォトニック結晶ナノ共振器の設計と作製に関する研究	Tajiri Takeyoshi	Design and Fabrication of Three-Dimensional Photonic Crystal Nanocavities in <110>-Layered Diamond Structures
樽茶 友昭	空間スキャン型 CO2 レーザ干渉計の開発	Tarucha Tomoaki	Development of CO2 Laser Interferometer with Spatial Scan
坪田 亮	太陽光発電の導入によって発電機の同期化力の受ける影響についての基礎的な検討	Tsubota Akira	Fundamental Investigation into Effects of Photovoltaic Energy installation upon Synchronizing Power
丁 天本	複素ニューラルネットワークによるフェージングチャネルの予測	Ding Tianben	Fading channel prediction based on complex-valued neural networks
寺川 雄貴	極薄ポリマー温度センサに関する研究	Yuki Terakawa	Polymer Based Thin-Film Thermal Sensor
寺田 博	GaMnAs 薄膜およびそのヘテロ構造の磁気光学効果と磁気抵抗効果	Hiroshi Terada	Magneto-optical effect and magnetoresistance of GaMnAs thin films and their heterostructures
寺村 理	INTERCEPT:ライブマイグレーションを用いた高インタラクションサーバ型ハニーポット	Satoru Teramura	INTERCEPT:High-interaction Server-type Honeypot based on Live Migration
内藤 駿弥	量子ドット太陽電池への異なる Si ドーピング手法による太陽電池特性への影響	Shunya Naitoh	Study on the effect of Si doping methods on quantum dot solar cells
永井 宏和	光コヒーレンストモグラフィのための分散チューニングレーザのパルス変調による性能の向上	Hirokazu Nagai	Improvement of dispersion tuning laser for optical coherence tomography by using pulse modulation
中村 亮裕	分極制御による水分解窒化物光電極の新規構造	Akihiro Nakamura	A Novel Nitride Photoelectrode for Water Splitting Based on Polarization Engineering
中村 陽二	LSI セキュリティ対策のための表面磁界観測による電流値推	Yoji Nakamura	Estimation of wire current utilizing surface magnetic field
成川 弘樹	知識ベースを利用した教師あり薬物間相互作用抽出の改善	Hiroki Narukawa	Improving Supervised Extraction of Drug-Drug Interaction Utilizing Knowledgebases

野尻 悠平	プラズモニック InP 光導波路デバイスのための金属グレーティングカプラの設計と作製	nojiri yuhei	Design and fabrication of metallic grating coupler for plasmonic InP optical waveguide devices
長谷川 雄大	能動・受動モード同期光ファイバレーザの特性の数値シミュレーションに関する研究	Hasegawa Yuta	Numerical simulation of the characteristics of the active and passive mode-locked fiber laser
平方 健太	ナノ秒パルス電源を用いた非熱平衡プラズマによるガン細胞およびマウス皮下腫瘍へのアポトーシス誘導	Hirakakta Kenta	Apoptosis induction of murine skin cancer cell and mouse subcutaneous tumor by non-thermal plasma using nanosecond pulsed power generator
深見 友也	超小型衛星用高速通信システムの開発と地上受信機における並列処理に関する研究	Tomoya Fukami	Development of high-speed communications system for nano satellite and study on parallel processing for ground receiver
藤井 裕大	衝撃吸収専用脚を用いた着陸機構の研究	Hiroki Fujii	Research on touchdown mechanism with a landing leg for shock absorption
保坂 航太	CMOS-MEMS 技術による電気的接触検出機能付き高精度プローブカード	Hosaka Kota	The high precision measurement probe card with electrical contact sensing function by CMOS-MEMS technology
星野 英二郎	SOI アナログ位相同期回路の SET 耐性	Hoshino Eijiro	SET Tolerance of SOI Phase-Locked Loops
松井 裕明	環境電波発電向け整流回路の最適化と出力電圧正規化曲線の提案	Hiroaki Matsui	Optimization of Rectifiers for RF Energy Harvesting and Proposal of Output Voltage Universal Curves
松岡 大	二重周波数変調法と位相変調法によるブリルアン光相関領域リフレクトメトリの性能向上	Ora Matsuoka	Performance Improvement of Brillouin Optical Correlation Domain Reflectometry Based on Double Frequency Modulation and Phase Modulation
松久 直司	伸縮性導体の高性能化と伸縮性有機トランジスタ集積回路	Matsuhisa Naoji	Improvement of elastic conductor and stretchable organic transistor integrated circuit
松本 豪	単一レーザによりポンプ・プローブ・リード光を時分割発生させる BOCDA システムによる温度と歪の分離・分布測定	Matsumoto Tsuyoshi	Discriminative and distributed measurement of temperature and strain by BOCDA system with time-division pump-probe-read light generation by single laser diode
丸尾 徳	SF6 ガス中における GIS モデルスペーサの直流帯電現象	Toku Maruo	Charge accumulation on GIS model insulator under dc field in SF6 gas
水野 陽二郎	太陽光発電大量導入時における電力系統の基礎的電圧特性に与える負荷特性と電 圧制御の影響	Mizuno Yojiro	Fundamental characteristics on voltage stability by load characteristics and voltage control in power system with PV large penetration
宮崎 耕太郎	U-VHF 帯スペクトルのワンショット取得向けフロントエンド回路の設計と評価	Koutarou Miyazaki	Design and Evaluation on Front-End Circuits for One-shot U-VHF-Band Spectrum Aqcuisition
宮田 洋佑	熱制御を考慮した小天体探査ローバの移動メカニズムに関する研究	Yosuke Miyata	Study on Locomotion Mechanism for Small Body Exploration Rover Considering Thermal Control
森 雄章	電源のアンビエント化に向けたリニアレギュレータと無線電力伝送に関する研究	Kazuaki Mori	Research on Linear Regulators and Wireless Power Transmission toward Ambient Power Supply
柳原 裕貴	CMOS バック・コンバータ及びブースト・コンバータの高効率化の研究	Yuki Yanagihara	Research on Improving Efficiency of CMOS Buck Converter and Boost Converter
吉岡 和顕	エネルギー効率向上に向けた 極低電圧トンネル FET デジタル回路の研究	Yoshioka Kazuaki	Research on Extremely Low-Voltage Digital Circuits based on Tunneling FET's for Energy Efficiency Improvement
米川 慧	高速デマンドレスポンス向け需要家デバイス状態管理機構の設計と評価	Kei Yonekawa	Design and Evaluation of Demand-side Device Management for Fast Demand Response
和田 直樹	コヒーレントフォノン制御によるバルク Si-LED の発光スペクトルの形状制御と発光機構の解明	Naoki Wada	Controlling the shape of the EL spectrum of bulk Si-LED by manipulating coherent phonons and clarification of its mechanism
渡邉 圭寿	災害時における情報通信のモデル化と分析	Watanabe Keiju	Modeling and Analysis of Telecommunication during Disasters

渡邉 翔一郎	直流電気鉄道の電力流を考慮した省エネルギー運転手法の研究	Shoichiro Watanabe	Research on Energy-Saving Operation Method Considering Power Flow in DC-Electric Railway
渡辺 隆嗣	横磁束形リニア波力発電機の応答曲面法を用いた高速最適設計とその評価	Ryuji Watanabe	Rapid design optimization using response surface methodology and its evaluation of transverse flux type linear wave generator
アシク ムスタファ	電力系統の需給バランスのための住宅用 PV-EV システムの評価	Aachiq Mustapha	Evaluation of Residential PV-EV System for Supply and Demand Balance of Power System
韓 在勲	プラズマ後窒化を用いた high-k/SiGe MOS 界面の研究	Jaehoon Han	Research on high-k/SiGe MOS interface using plasma post-nitridation
全 晟豪	レーザー距離計を組み込んだＭＥＭＳ光スキャナによるインタラクティブ・レーザー描画ディスプレイ	Jeon Sungho	AN INTERACTIVE LASER PROJECTION DISPLAY BY A MEMS OPTICAL SCANNER WITH A BUILT-IN LASER RANGE FINDER
姜 明	架橋単層カーボンナノチューブのフォトルミネッセンスにおける交流ゲート電圧の影響	Ming Jiang	Alternating gate-voltage effects on photoluminescence of air-suspended single-walled carbon nanotubes
亢 健	Ge 酸化膜パッシベーションによる Ge MSM 受光器の暗電流削減に関する研究	Kang Jian	Study on Dark Current Suppression for Germanium Metal-Semiconductor-Metal Photodetector by GeOx Passivation
カンチャナウィローグンパリット	サブミリ波用バーストモード CMOS パルス発生器	Kanjanavirojkul Parit	Burst-Mode Pulse Generation for Sub-Millimeter Wave on CMOS Technology
キッアカラコーシン プリンパット	PSO アルゴリズムによる過度安定性を考慮したグリーンフィールドでの最適な送電系統の設計	Primpat Kitakkarakosin	Design of Optimal Transmission System Configuration on Greenfield Considering Transient Stability by Using PSO-based Algorithm
コカテ ニシャド ヴァサント	細胞操作・観察のための透明薄膜トランジスタアレイつきマイクロ流体チャネル に関する研究	Kokate Nishad Vasant	A Study on Micro Fluidic Channel Devices with Transparent Thin Film Transistor Array for Biological Cell Manipulation and Observation
李 智守	タンパク質の結合能力を測るカンチレバーバイオセンサー -アルツハイマー病診断を目指して-	Jisu Lee	Cantilever biosensors for detecting attachment of proteins -Toward the diagnosis of Alzheimer's disease-
ニン バン クオン	リニア駆動都市鉄道の高性能化の研究 --ATO の活用とリニア誘導モータの二次側構造改良による省エネルギー化--	Cuong Ninh Van	Enhancing the Performance of Linear Metro Driven Railway-- Energy-saving through ATO Running-curve and Improvement of Secondary Design of Linear Induction Motor --
玉 成眞	LTE における QoS を考慮した資源の割り当て	Ock Seongjin	QoS aware resource allocation for LTE
サクデーシャヨン ティラット	圧縮センシングの省資源無線システムへの応用に関する研究	Theerat Sakdejayont	Applications of Compressed Sensing in Resource-Limited Wireless Systems
ウェーヴィタプラディーパラクマル	電源運用計画のための分散型風力発電の短期出力予測および統計的出力変動に関する研究	Pradeepa Lakmal Wevita	STUDY ON STOCHASTIC OUTPUT FLUCTUATIONS IN DISTRIBUTED WIND POWER GENERATION AND SHORT-TERM WIND POWER FORECASTING FOR POWER SYSTEM OPERATION
禹 泰城	導体による MR 信号消失を回復するための RF パルスの設計及び評価	Taeseong Woo	Design and evaluation of RF pulses to recover the MR signal loss due to conductive sample
ユビョンホ	多層 ZnO:Al 錯体塗布膜とその発光デバイスの特性	Yu Byung Ho	Characteristics of multi-layered ZnO:Al and its device
江 柏村	シリコンナノピンセットと Microfluidic デバイスによる DNA 損傷のリアルタイム測定 ～放射線損傷と制限酵素切断の影響～	Po-Tsun, Chiang	Real-time Measurement of DNA Degradation by Silicon Nanotweezers Coupled with Microfluidic Cavity ~Effect of Radiation Damage and Restriction Enzyme Digestion~
モラレス エスピノサ カルロス エマヌエル	大気混濁係数に基づいた複合現実感のための空気遠近法レンダリング	Morales Espinoza Carlos Emanuel	TURBIDITY-BASED AERIAL PERSPECTIVE RENDERING FOR MIXED REALITY
佐藤 弘之	環境音を利用した近隣モバイル端末推定手法の設計と評価	Hiroyuki Satoh	Co-Location Detection of Mobile Devices using Ambient Sound

米澤 和也	仮想平面を利用した飛行ロボット操作システムの提案と評価	Kazuya Yonezawa	Proposal and Evaluation of Flying Robot Manipulation System Using a Virtual Plane
崔明	消光比改善に向けた 1×N ナイキストサンプル光フェーズアレイシリコンスイッチ	Cui Ming	1×N Nyquist-sampling optical phased-array silicon switches with improved extinction ratio
ドアン ドゥック ヴァン	省エネルギーおよび車上エネルギー蓄積素子最小化の観点からの列車運転最適化 - 非接触給電電気車のケーススタディ -	Van-Duc Doan	Optimizing the Train Operation with Considerations of Saving Energy and Reducing the Capacity of Energy Storage Devices -- For a Train powered by Contactless Power Transmission --
傅 宇峰	III-V-on-Si レーザに向けたシリコン基板上 InGaAs マイクロディスクキャビティの設計、作製と特性評価	Fu Yufeng	Design, fabrication and characterization of InGaAs microdisk cavities on silicon substrates toward III-V-on-Si lasers
劉 俊安	イオン性ポリマー・金属複合材料による人工繊毛マイクロアクチュエータに関する研究	Junan Liu	A Study of Artificial Cilia Micro Actuators based on Ionic Polymer-Metal Composites
エドゥアルド パウカル ブラヴォ	順列による単変量および多変量時系列の予測	Eduardo Paucar Bravo	Predicting scalar and multivariate time series through permutations
パウデル サロジュ	表面探査ロボットとジャンピングロボットによる火星協調探査手方に関する研究	Paudel Saroj	Study on Cooperative Exploration Scheme on Mars using Ground Rover and Jumping Robot
シーウィセート ワリッタポン	光熱 AFM を用いた CIGS 太陽電池における非発光再結合特性の解析	Srivises Warithapol	Non-radiative Recombination Property in CIGS Solar Cells Investigated through Photothermal Atomic Force Microscopy
タナキットルンアン ワナシット	クラウド記憶におけるキーワード検索のための安全な索引	Wanasit Tanakitrungruang	Secure Indexes for Keyword Search in Cloud Storage
ゴドフロワ ヴァレ	STEM による生体現象のその場観察を目指した能動素子集積化 MEMS 液体セル	Godeffroy Valet	MEMS liquid cells with integrated active components toward in-situ observation of bio phenomena in STEM
王 安斉	球状トカマク合体実験 UTST における電流シート磁場構造の高分解計測	Anqi Wang	High Resolution Measurement of Current Sheet Magnetic-field Structure in UTST Spherical Tokamak Merging Experiment
ヤンワチラークン ワラーコン	高集光下での InGaAs/GaAs/GaAsP 多重量子井戸太陽電池におけるキャリア輸送	Yanwachirakul Warakorn	Carrier Transport in InGaAs/GaAs/GaAsP Multiple Quantum Well Solar Cells under High Concentrated Sunlight