TOSHIBA FELLOWSHIP PROGRAMME

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Leading Innovation

INNOVATION IS A JOURNEY, NOT A DESTINATION... JOIN OUR JOURNEY!

What is the Fellowship Programme?

The Toshiba Fellowship Programme offers outstanding scientists an annual opportunity to apply to join Toshiba's research and development laboratories in Japan for up to two years, on a Research Fellowship Contract.

The Toshiba Fellowship Programme is a unique opportunity for recently qualified PhD level scientists, mainly from science, computing and mathematics disciplines. It offers a chance to journey alongside Toshiba into innovation, discovering a new world of research and development, as well as exploring and living a new cultural experience in Japan.

Toshiba Fellows nurture cross-cultural understanding between the UK, Europe and Japan whilst benefiting from working in our highly innovative and research-centred organisation, in a country renowned for its world class technology. Every Toshiba Fellow has a real possibility to contribute to our future technologies. Participating in our scheme leads to both career development and personal growth.

The Programme has successfully operated for over 25 years, enjoying a strong and long-running collaboration with the EPSRC (Engineering and Physical Sciences Research Council) as well as fostering and developing the relationship between Japanese industry and UK academia. The successful Fellow receives a generous package, including a fixed salary and relocation assistance to and from Japan, together with support and advice prior to and during their stay.

Would I be eligible to apply?

Candidates must:

- Be a PhD-level researcher
- Be of EU nationality
- Be based in a UK academic or Government institution at the time of application (studying or working)
- Have no more than 10 year's post-Doctoral experience
- Have completed their PhD by the time they begin working for Toshiba in Japan.

What would the job be like?

Toshiba Fellows usually remain in their team for up to two years. The type of work carried out depends mainly on which team the Fellow joins and the research project area.

A normal working day is standard eight hours, Monday to Friday.

So that they can settle in and feel at home in their work and a new country, Toshiba assigns a mentor to assist the Fellow in and outside of the workplace.

Would I cope with the language barrier?

Many Fellows enjoy the experience of learning a new language skill, at the same time as the challenges of their research project work. A basic grasp of Japanese helps Fellows fully appreciate the time spent in Japan. Toshiba offers Japanese language courses to all Toshiba Fellows during the Programme. And of course, Toshiba staff also like to practice their English skills with you!

What would I research?

Research topics and project areas generally fall into the following categories:

- Wireless and Network
- Human Interface and Digital Media
- Software
- Hardware and Mechatronics
- LSI and Storage
- Nano Materials and Devices
- Systems and Environment

Applicants may also submit their own research project proposals, provided they are relevant to Toshiba's areas of interest and future technology.

Where would I live?

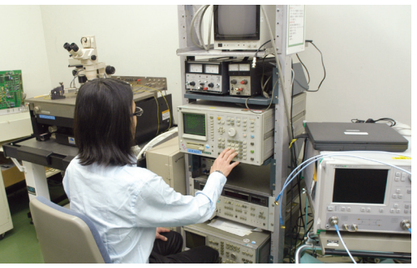
Toshiba Fellows are always offered a choice between Toshiba company accommodation or private accommodation. Toshiba supports the Fellow with advice and support to find whichever home they will feel most happy in during their stay in Japan.

What would my stay be like?

Toshiba Fellows work in one of the Toshiba's research labs in Tokyo. The Toshiba Corporate R&D Center (RDC) is based in Kawasaki, Japan's prosperous 'Silicon Valley', located just 20 minutes from Tokyo city centre by train. Kawasaki is the prime location for advanced R&D operations for many multi-national computer and electronics companies.

As a Toshiba Fellow, you could regularly enjoy a diverse mix of cultural and leisure pursuits. There is a whole new world of temples, shrines, food, museums, theatre and shopping to discover.Peaceful lakes and shrines in Nikko are simply beautiful during the Autumn season.

Japan's land area of 1432 square miles covers a diverse geography of mountains, lakes, hot springs, forests and islands. It is the perfect environment to relax or enjoy something more active - whatever takes your fancy!



"The Toshiba Fellowship Programme is ideal for researchers with a little curiosity for Japan. The research facilities are excellent and Toshiba has excellent relations with universities, so you will probably also be in touch with researchers from Japanese universities working in your field. For me, joining the Fellowship has allowed me to move into a new area of research. Of course, the learning curve was steep, but people have been very helpful and supportive. Japan is a very different country and culture, but it is an experience of a lifetime."

Dr Sven Meier, Water Treatment Technology, Toshiba Fellow 2007

"I love exploring the different areas around Tokyo, and the big cities further afield. Last summer I hiked up Mount Fuji, which was an amazing experience. As a snowboarder, I have taken full advantage of the fantastic snow conditions over the winter and the easy access to ski reports. One of my most fun experiences in Japan is flying down a field of fresh powder on a crisp winter's morning in the Japan Alps..."

Dr Jamie Shotton, Computer Vision, Toshiba Fellow 2006

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What happens afterwards?

Future career

The Programme provides scientists and researchers a chance to stimulate their career with valuable industrial experience. It can open the door to a wide variety of employment prospects: past Fellows enjoy globally diverse careers in academia, government and industry.

Toshiba Fellowship Alumni

A Toshiba Fellow is a Fellow for life! We operate an Alumni programme and remain in close contact with our members throughout their career. We like to maintain and nurture our links with our Alumni, establishing a contact network, exchanging information, knowledge and encouraging the networking of all Fellows. A reunion event is hosted each year, usually in London.

How can I apply?

- Visit the Toshiba Fellowship Programme website: **www.toshiba.eu/fellowship**
- Look at the current year's research topics
- Register your interest online by completing the initial application questions
- Eligible applications are then sent an application form
- You must apply by sending the paper application form by the application closing deadline (as shown on the website)
- You are also invited to attach up to two of your own research papers
- You must also submit two references to complete your application

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TOSHIBA FELLOWSHIP PROGRAMME

RESEARCH TOPICS 2015

Energy and Social Infrastructure Research Topics

Device simulation for ultra high efficiency solar cells

Explanation
Candidates will design an ultra high efficiency solar cell, whose efficiency is 30% or more, by using a multijunction structure and/or concentration PV technology, and examine its feasibility using device simulation. Furthermore, they will identify suitable absorbers for ultra high efficiency solar cells from various semiconductors including the CIGS. To carry out a realistic simulation, they will measure the current-voltage measurements of CIGS tandem solar cells.

Toshiba is promoting its photovoltaic generation business globally. Efficient solar cells are expected to become future worldwide core products.

Knowledge and Skills required
Candidates should have expertise in semiconductor physics and experience of device simulation. More specifically, they should understand the band structure of semiconductors, and have the ability to explain their optical and electrical properties. They should also have a keen interest in solar cells.

Related Papers
Nakagawa, N et al. (2013). Feasibility Study of Homojunction CIGS Solar Cells. *Photovoltaic Specialists Conference (PVSC).* IEEE 39th, pp.2023-2025, June 2013.
Hiraga, H. et al. (2013). Photovoltaic properties of homojunction CIGS solar cells using various divalent n-type dopants. 28th *European Photovoltaic Solar Energy Conference and Exhibition (EUPVSEC)*, pp.2299-2301, Oct. 2013.

Numerical analysis for droplets-steam multiphase flow in a direct contact type condenser

Explanation
Direct contact type condensers, which enhance contact between droplets of cooling water and exhaust steam from turbines, are widely used in geothermal power plants. To create added value in our geothermal condensers, R&D activities such as performance improvement, downsizing and so on are in progress. Although these processes require an understanding of physical phenomena, such as the motion of droplets and condensation performance in the condenser, there are limitations for evaluating the phenomena using an experimental approach because of complex multiphase flow with condensation. The aim of this programme is to clarify the phenomena using a thermo-fluid analytical approach, and to explore a new development plan for the condenser.

Toshiba is one of the top suppliers of geothermal power plant systems in the world. Therefore, this programme plays an important role in Toshiba's technological competitiveness in the global geothermal market.

Knowledge and Skills Required
Candidates should possess expertise in thermo-fluid dynamics and large-scale numerical simulation because the computations will be carried out with Toshiba's in-house HPC (High Performance Computer).

Related Papers
Osamu, F et al. (2012). Experimental study of direct contact condensation of droplets in mixture of saturated steam and non-condensable gas. *Baumann Centenary Wet*

Steam Conference 2012.
Fujisawa, T. (2012). Experimental study of direct contact condensation of droplets in mixture of saturated steam and non-condensable gas. *Baumann Centenary Wet Steam Conference 2012.*

Fault diagnosis and knowledge discovery for efficient plant operation using image data

Explanation
This research programme aims to develop algorithms for fault diagnosis and knowledge discovery from time-series image data acquired from social infrastructure plants such as water treatment plants and urban drainage plants. The programme covers the development of prototype algorithms for diagnosis and knowledge discovery and their implementation and evaluation. The programme's target is the development of particular feature extraction, classification and reasoning algorithms from multivariate time-series data acquired by Web camera and/or ITV (Industrial Television) camera for plant monitoring and through a SCADA (Supervisory Control And Data Acquisition) system. The algorithm should detect abnormal incidents/faults and categorise them into several classes where each class should be interpreted by plant operators or should have a label related to plant efficiency and safety.

Knowledge and Skills Required
Candidates are required to have a deep knowledge of at least one of the following: signal processing, machine learning or multivariate statistics. They should also possess expertise in system engineering with MATLAB or C programming skills.

Related Papers
Yamanaka, O. et al. (2012). A Monitoring Technique Using Multivariate Statistical Process Control Method for Performance Improvement with Application to Wastewater Treatment Plant Operation. *In Proc. of IFAC SYSID 2012*.
Yamanaka, O. et al. (2012). A Knowledge Discovery Assistance Method Using Multivariate Statistics for Efficient Wastewater Treatment Plant Operation. *Journal of Water and Environment Technology* 10(2), 87-99.

Modelling and simulation of building energy usage under uncertainties

Explanation
This research intends to quantify uncertainty arising from the use of computer simulators and to combine information from simulator runs and associated sensor observations. In particular, statistical (e.g. Bayesian) tools for computer model validation, calibration and prediction methods will be investigated. Although these statistical methods are popular in ecology and bionomics, we are investigating whether they are applicable to the domain of building energy simulation.

Toshiba operates business from energy generation to energy consumption in homes and buildings. Recently, managing energy usage in homes and buildings is a key focus. Toshiba has BEMS (Building Energy Management System) and HEMS (Home Energy Management System) businesses. The priority is to establish a building energy model (BEM). The BEM must consider the uncertainties of architecture, electricity usage and occupant behaviours. By combining the BEM under uncertainties with current Toshiba systems, we can establish a platform for smarter communities.

Knowledge and Skills Required
Candidates should possess expertise in statistical theory, especially Bayes based estimation methods. Candidates should also have computer simulator implementation experience.

Related Papers
Otsuki, T., Aisu, H., Tanaka, T. (2011). A Search-Based Approach to Railway Rolling Stock Allocation Problems. *Discrete Math., Alg. and Appl.* 3(4): 443-456.
Hiraishi,K., Choe, S., Torii, K., Uchihira, N., Tanaka, T. (2012). Modeling of complex processes in nursing and caregiving services. *SMC 2012*: 1449-1454
Sueda, N., Iwamasa, M (1995). A Pilot System for Plant Control Using Model-Based Reasoning. *IEEE Expert* 10(4): 24-31.

Preventive maintenance technology for infrastructure utilising acoustic signal processing technology

Explanation

Improvements in computational capability and sensor technology have allowed non-destructive inspections using acoustic emission (AE) to be applied to structural health monitoring (SHM) of bridges or other social infrastructure. However, appropriate health diagnostics technology and accurate deterioration models, especially in the early stages of damage, should be developed in order to progress from breakdown maintenance to preventive maintenance. The aim of this programme is to develop preventive maintenance technology for infrastructure based on an understanding of the relationship between AE signals and defect growth mechanisms of the structure, leading to a novel structural deterioration model.

Toshiba is focussing on Infrastructure Health Monitoring as part of its agenda for Creative Growth and Innovation. Toshiba started field testing in underground tunnels in the UK in collaboration with Cambridge University this spring and has also started to develop a SHM system in Japan through national funding.

Knowledge and Skills Required

Candidates should possess expertise in the theory of material mechanics and fracture mechanics on civil structures. In addition, candidates should possess expertise in the structural analysis of large scale architecture such as bridges or tunnels.

Related Papers

Omori, T. et al. (2013). Large-Scale Damage Path Simulation for Solder Joints in a BGA Package. *ASME International Conference*, IPACK2013-73161.
Hirohata, K. et al. (2013). Prognostic health monitoring method for fatigue failure of solder joints on printed circuit boards based on canary circuit. *ASME International Conference*, IMECE2013-65317.

Safe runtime dynamic software updating technology for embedded Linux

Explanation

This research theme focuses on dynamically updating a Linux kernel on an embedded system in a safe way. On embedded systems not only must performance requirements be satisfied but the correct operation must also always be guaranteed. However, when updating a kernel dynamically it may occur that some operations fail. Therefore, we are looking for technology that can handle these situations without affecting the performance and stability of the system.

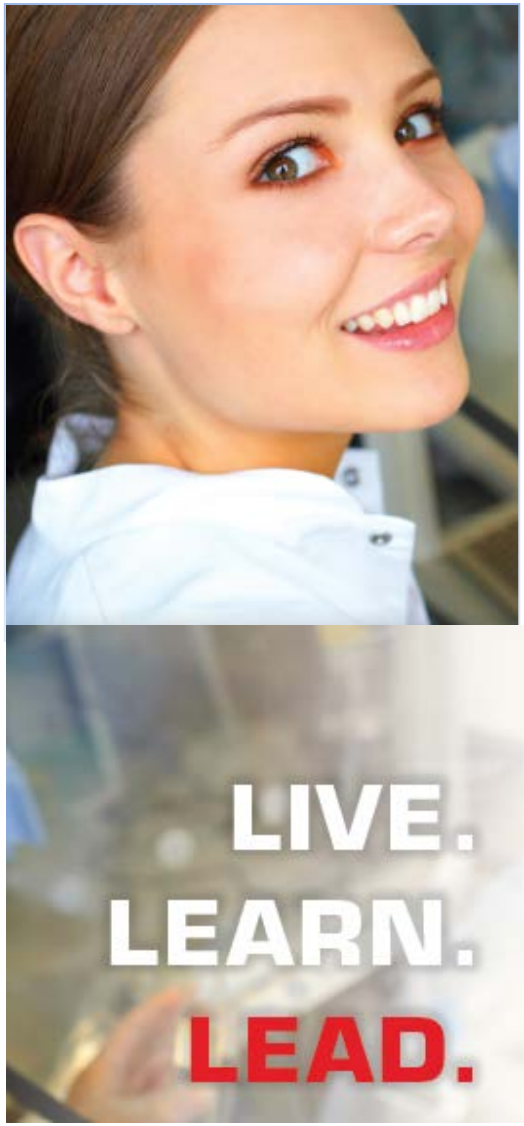
Knowledge and Skills Required

Candidates should have basic knowledge of operating systems, hardware knowledge to manage hardware resources for isolation and experience with C and scripting languages (ex. Perl, Python, Shell) to understand Linux kernel.

Related Papers

“An Essential Relationship between Real-time and Resource Partitioning”
ELC Europe 2013, Oct. 2013.

Semiconductor and Storage Topics



Anisotropic catalytic etching of semiconductor materials

Explanation
Anisotropic etching of semiconductor materials is necessary for manufacturing various devices such as power devices, MEMS devices, and 3D integrated packages. Generally, anisotropic etching of semiconductors is achieved through RIE (Reactive Ion Etching), but the costs of the RIE process and equipment are high. Recently, a catalytic wet etching technique called MacEtch (Metal-Assisted Chemical Etching) was developed*. In MacEtch, a noble metal catalyst layer is deposited on the semiconductor material, which is then put into an etching solution consisting of an oxidant and a hydrogen fluoride solution. The noble metal produces holes and the holes oxidize the semiconductor; the oxidized semiconductor is then etched by the hydrogen fluoride solution. These reactions occur only at the interface between the metal and the semiconductor. As a result, the metal layer descends as the underlying semiconductor is eroded. But the detailed mechanism of MacEtch is still an unsolved problem. The aims of this programme are to analyse the mechanism for MacEtch and explore the possibility of MacEtch for various materials.
**Applied Physics Letters* 77, 2572 (2000)

Toshiba is the world's leading supplier of various semiconductor devices, such as memories, ICs, sensors, and diodes. Once the MacEtch technique is established, the technique could promptly be applied to the manufacturing process of Toshiba's product lines.

Knowledge and Skills Required
Candidates should possess expertise in electrochemistry and catalytic science.

Nano-scale organic memories

Explanation
The aim of this programme is to realise novel single-nanometer-scale molecular devices to outstrip conventional non-volatile memories. It will involve designing molecules according to nano-scale electron transport, fabrication of a nano-scale TEG (test element group) and measuring the electric properties to realise a memory function. The development will include molecular orbital calculation, synthesis, theoretical analysis and TEG fabrication by semiconductor process using combinations of top-down lithography and bottom-up self-assembled materials.

Toshiba, the inventor of NAND flash memory and a major player in

semiconductor technology, has been leading miniaturisation for decades. However, the industry is facing the great wall of nano-fabrication and we are breaking new ground in organic electronics. Why not join us and be a pioneer of nano-scale organic memories?

Knowledge and Skills Required
Candidates should be capable of designing nano-materials or nano-devices and are expected to propose novel concepts for nano-devices. Knowledge of material physics, organic synthesis, polymer science, physical chemistry, or electronic physics are required as well as a strong interest in nano-technology. Applications from candidates who understand nano-scale transport and electron-phonon interaction in single molecules are particularly welcome.

Idea scouting for new functional devices utilising current-induced domain wall motion in nano-magnets and related effects

Explanation
Technologies which allow us to manipulate the magnetisation of nano-magnets using electric means have progressed considerably in the last decade. The working principles of devices such as magnetic random access memory and spin-torque oscillator are based on magnetisation-manipulation on nano-magnets realised by spin-polarised current. Recent reports also show findings like current-induced domain wall motion in nano-wires. The aim of this programme is to propose novel functional device(s) utilising domain walls in magnetic nanostructures. It is expected that the results of the project will give us a rich knowledge of how we can use magnetic domain wall manipulation with electric currents to process information in nano-structures. Fellows on this programme will commit to designing devices, experimenting with procedures, device fabrication and characterisation.

Toshiba Corporation is recognised as one of the leading companies in the field of spintronics with significant achievements such as the first commercialisation of the GMR (giant magnetoresistance) head for hard disk drives. This programme offers the opportunity to research alongside experts who have been developing state-of-the-art technology in this field.

Knowledge and Skills Required
Candidates should possess expertise in experimental approaches to spintronics and/or nano-magnetism. Significant experience in nano-fabrication is also highly desirable.

Related Papers
Morise, H. et al. (2014). Current-Induced Domain-Wall Motion in Perpendicularly Magnetized Magnetic Nanowires with Unflatted Surfaces. *APS March meeting*, AB03.00013, March 2014.
Shirotori, S. et al. (2014). All-metallic non-local spin-valves using polycrystalline CoFeMnSi Heusler alloy with large output. *InterMag 2014*, EB-3, May 2014.

Next generation storage system architecture for cloud data centres

Explanation
The aim of this programme is to propose a massively-distributed large-scale storage system architecture and to investigate and solve its implementation issues by building a prototype system based on Toshiba's next-generation SSDs and HDDs. If possible, new optimal storage architectures for specific purposes, such as time-series/graph databases will be proposed and presented through research papers and other methods.

Toshiba is the only company in the world that manufactures both HDDs and SSDs and leads innovation in both fields. We believe that research experience in storage systems in our company will be valuable experience.

Knowledge and Skills Required
Candidates are required to have background knowledge of computer architecture, storage systems and network systems and should be able to carry out performance evaluations on systems and networks. Ideally, the candidate should be able to propose/verify a large-scale storage architecture through actual implementation and measurement of real test systems. Experience of implementing/operating large-scale systems would therefore be highly advantageous.

Healthcare Topics

Data analysis technologies for healthcare applications

Explanation
Big data analysis technology is expected to extract important information from various kinds of data. In this programme, this technology will be applied to healthcare applications such as stratified medicine and prevention. Life log data collected by wearable sensors and/or genetic data extracted by gene analysis will be provided for data analysis. The aim of this programme is to propose and demonstrate new algorithms for high-efficiency big data analysis on healthcare domains.

Knowledge and Skills required
Candidates should possess expertise in the following technological domains: Bioinformatics, Statistical analysis, Huge scale data processing, Data-driven knowledge discovery, Artificial intelligence, Machine learning.

Musculoskeletal simulations

Explanation
Improvements in computational science and imaging technology have led to their technological application for musculoskeletal simulations in the medical and healthcare fields. In order to uncover the core causes of orthopedic disease such as arthritic symptoms and to provide approaches to treatment, musculoskeletal modeling and dynamics analysis methods should be developed to simulate the forces and movements of the musculoskeletal system. Toshiba will focus on the innovation of medical and healthcare system technologies based on the musculoskeletal simulations.

Knowledge and Skills Required
Candidates should possess expertise in the theory of dynamics and mechanical analysis, and musculoskeletal modeling.

Related Papers
Shores, J. T. et.al. (2013). Kinematic "4 Dimensional" CT Imaging in the Assessment of Wrist Biomechanics Before and After Surgical Repair. *Eplasty 2013*; 13: e9., PMCID: PMC3589877, Published online Feb 23, 2013.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3589877/

Information and Communication Technology Topics

3D reconstruction for multiple moving objects and non-rigid objects

Explanation
3D reconstruction is expected to use various applications such as 3D object data generation for 3D printing, platting buildings from the real environment, autonomous driving which has to avoid obstacles and human body sensing. In recent years, 3D reconstruction technologies for non-rigid objects with dynamically changing shapes and multiple moving objects have attracted attention. This programme involves researching a novel non-rigid or multiple moving object 3D reconstruction theory and method that can be used under practical conditions.

Toshiba has original image recognition processors for automobile and embedded use. These processors have original image recognition algorithms developed by our researchers as hardware accelerators. The new algorithm developed in this programme could be equipped with our next generation processors.

Knowledge and Skills Required
Candidates should be experts in 3D reconstruction such as geometry and

optimisation with programming skills using C/C++ sufficient for building algorithms and conducting experiments.

Related Papers

Seki, A., Okada, R. (2013). Monocular-camera based obstacle detection with measurement error estimation. *ITS World Congress in Tokyo* (2013).

Machine learning for media data understanding

Explanation

Media data understanding such as image recognition and speech recognition are expected to bring us new values by turning unstructured media data into structured data. Toshiba has various sensing device products and developing technology to analyse media data obtained by such devices is important. Media understanding technology often utilises a data-driven recognition model obtained by machine learning. In recent years, novel machine learning methods including a deep learning have been proposed with great success, but they require a lot of training data and computational resources. This programme will research a novel machine learning theory and method that can be used under practical conditions. The media data that the methods handle are mainly images, but they should also handle other media data including handwriting and speech.

Toshiba has several products using pattern recognition and machine learning, e.g. face recognition systems and supermarket scanners with object recognition. New algorithms developed in this programme could provide a promising approach for our next generation products.

Knowledge and Skills Required

Candidates are required to be experts in pattern recognition and machine learning with C/C++ programming skills sufficient for building algorithms and conducting experiments.

Related Papers

Kozakaya, T., Ito, S., Kubota, S. (2011). Random ensemble metrics for object recognition. *ICCV*.
Ito, S., Kubota, S. (2010). Object Classification Using Heterogeneous Co-occurrence Features. *ECCV* (5).
Shibata, T., Kubota, S., Ito, S. (2010) Large Margin Discriminant Hashing for Fast k-Nearest Neighbor Classification. *ICPR*.
Kozakaya, T., Ito, S., Kubota, S., Yamaguchi, O. (2009). Cat face detection with two heterogeneous features. *ICIP*.

Deep learning approaches to knowledge and language processing

Explanation

Deep learning is capable of learning the knowledge representation that is appropriate for a given task, whereas traditional (shallow) machine learning operates within a human-designed knowledge representation. It has achieved notable results in fields such as computer vision, automatic speech recognition and natural language processing (NLP). In NLP, a multi-tasking architecture based on vector representation of words has been proposed. The aim of this programme is to propose and demonstrate new architectures for knowledge and / or language processing based on deep learning.

As the inventor of the Japanese word processor, Toshiba boasts a long history of NLP research and an active community of researchers. Toshiba will provide not only an ideal research environment for a deep learning researcher, but also a chance to exchange ideas with prominent researchers in related areas such as automatic speech recognition, machine translation, data mining and computer vision.

Knowledge and Skills Required

Candidates should possess expertise in the theory of deep learning, natural language processing and its applications.

Related Papers

Zen, H. et al. (2012). Statistical Parametric Speech Synthesis Based on Speaker and Language Factorization. *IEEE Transactions on Audio, Speech, and Language Processing*, vol. 20, pp. 1713-1724.
Nakata K. et al. (2008). Classification Method Utilizing Reliably Labeled Data. *Proc. of KES2008*, pp.114-122.

Sakurai, S., Orihara, R. (2008). Classification Model Learning for Bulletin Board Site Analysis based on Unbalanced Textual Examples. *Proc. of AINA2008*, pp. 494-501.
Paolucci, M. et al. (2002). Semantic matching of web services capabilities. *Proc. of ISWC2002*, pp.333-347.

Image processing for computational photography

Explanation

High functional photography is expected to be the next trend for digital cameras and smartphones. Combining optical hardware technology and digital signal processing, computational cameras achieve new functions including EDoF (Extended Depth of Focus), refocus, high-dynamic-range, capturing depth of field, object extraction and so on. The aim of this programme is to propose novel computational photography technology which is widely applicable to digital equipment, visual surveillance systems, medical equipment, vehicle cameras or other imaging systems.

Toshiba has been developing image processing technology such as super resolution and noise reduction, which are implemented in TVs, PCs and medical equipment for high quality image display. The Toshiba fellowship is a good opportunity to develop an innovative technology by considering the theoretical and implementation points of view.

Knowledge and Skills Required

Candidates should possess expertise in image sensors, image processing and C/C++ programing skills.

Related Papers

R. Ueno, et al. (2013). Compound-Eye Camera Module as Small as 8.5 8.5 6.0 mm for 26 k-Resolution Depth Map and 2-Mpix 2D Imaging. *IEEE Photonics Journal*, vol.5, no.4, Aug. 2013.
T. Ono, et al. (2012) Super-resolution with depth-adapted gain control for depth-feel enhancement of landscape image. *IEEE Global Conference on Consumer Electronics(GCCE2012)*, pp.563-564, Oct. 2012.
T. Yamamoto, et al. (2012). High-Accuracy Motion Estimation with 4-D Recursive Search Block Matching. *IEEE Global Conference on Consumer Electronics (GCCE2012)*, pp.634-637, Oct. 2012.

Quantum computing devices

Explanation

This research programme is aimed at developing quantum-information-processing devices based on EIT (electromagnetically induced transparency) in solids and our proposed frequency-domain quantum computer with quantum optical methods using highly-frequency-stabilized lasers and optical cavities. We have been improving the frequency stability of light sources, advancing a plan to replace a dye laser system with a diode laser (DL) system, improving samples (monolithic optical cavities made of Pr3+:Y2SiO5 crystals) and investigating the properties of the samples for several years. In recent years, we have also been advancing our experiments of observing and manipulating quantum states of ions in the crystal. We are planning to start quantum-states observation and manipulation experiments with DL.

Our research group was one of the first to discover that superpositions of states of nuclear spins of rare-earth ions in crystals can be manipulated with lights and proposed applications of the crystals to quantum information technologies. At present rare-earth-ion-doped crystals are recognized as promising candidates for solid-state materials of which quantum memories or quantum gates are made and are studied at many universities, institutes, and laboratories around the world. We are performing advanced research on quantum-information-processing application of crystals using our original approach to combine the crystals with optical cavities. Joining this leading-edge Toshiba research will be a useful grounding for future research or development in the quantum-information field.

Knowledge and Skills Required

Candidates should have expertise in optical processes in solids and quantum optics and a good understanding of physics, as well as skills in carrying out

experiments. It is highly desirable that candidates will have experience of high-resolution-spectroscopy experiments with diode lasers and some knowledge of quantum information science.

Related Papers

Ichimura, K. et al. (2013). Observation of a dip in a cavity-mode spectrum due to rare-earth ions in a crystal for a readout of a nuclear-spin qubit. *22nd International Laser Physics Workshop (LPHYS'13).*

Ichimura, K. and Goto, H. (2010). A Quantum Computation with a Solid State EIT Medium. *IV International Conference Frontier of Nonlinear Physics*.

Goto, H. and Ichimura, K. (2007). Observation of coherent population transfer in a four-level tripod system with a rare-earth-metal-ion-doped crystal. *PRA 75*, 033404.

Ichimura, K. (2001). A simple frequency-domain quantum computer with ions in a crystal *coupled to a cavity mode.* Opt. Commun., 196, p119-125.

Ichimura, K. et al. (1998). Evidence for electromagnetically induced transparency in a solid medium. *PRA 58*, p4116-4120.

Other Research Topics

Proposals from applicants for new advanced research topics which are relevant to this year's Toshiba Fellowship Programme research areas are also welcome

Explanation

Toshiba appreciates such proposals and will determine their acceptability based on the current circumstances of Toshiba's R&D activities.

› Visit the Toshiba Fellowship Programme website **www.toshiba.eu/fellowship for more information**