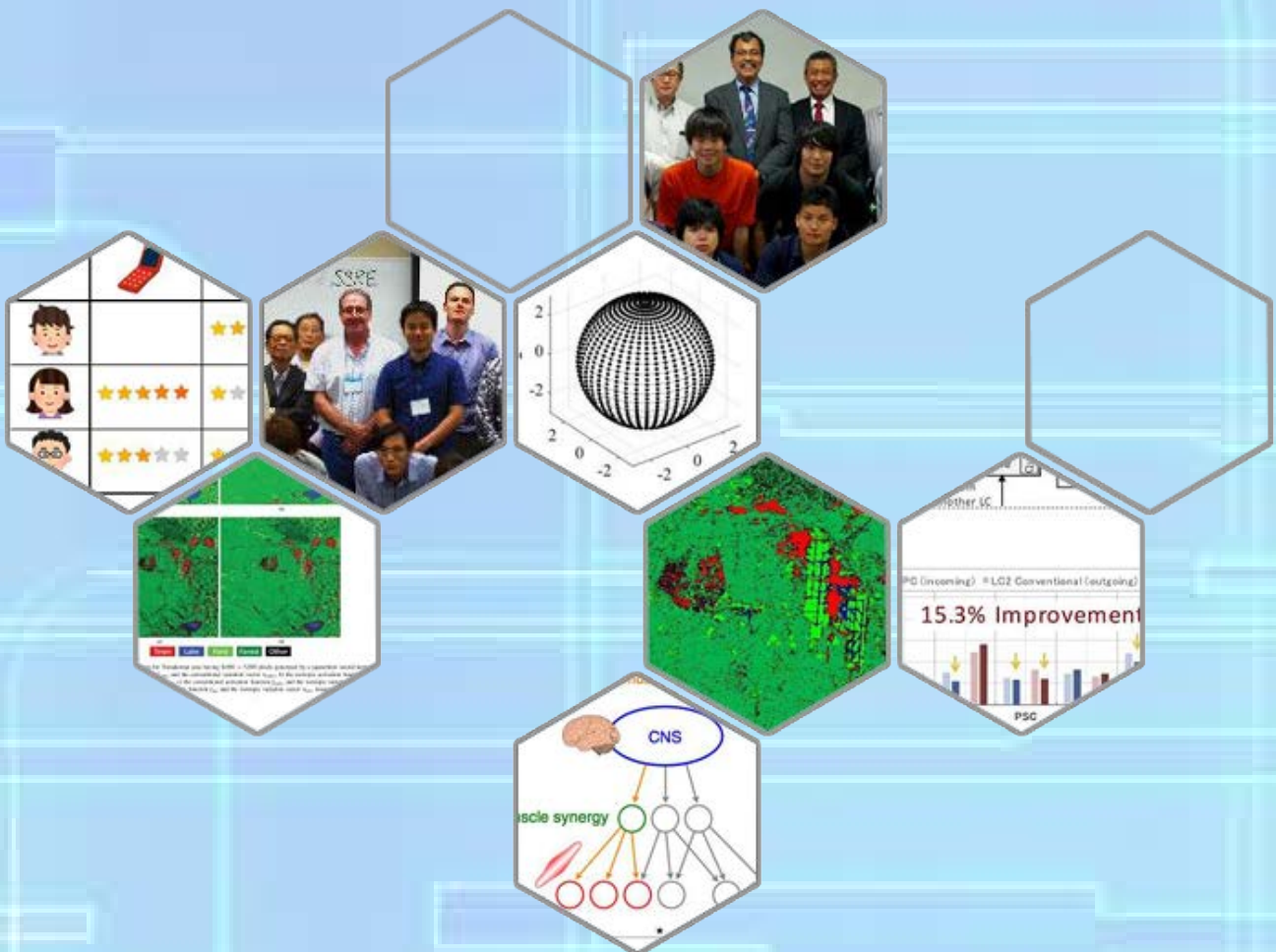


UEC e-Bulletin

Updates on research, innovation, and events at UEC:
Unique and Exciting Campus in Tokyo

Vol.19, September 2018



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- Elucidating mechanisms of voluntary control of human multi-muscle
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Next Generation Router Architecture: Packet Processing Prediction

Recently, dramatic increases in the volume of internet traffic has become a serious problem for routers due to strict demands for high throughput. To make matters worse, it is reported that the total power consumption of network devices is expected to reach several percentage of the total power generated in the world. Hence routers must achieve higher throughput with lower power consumption.

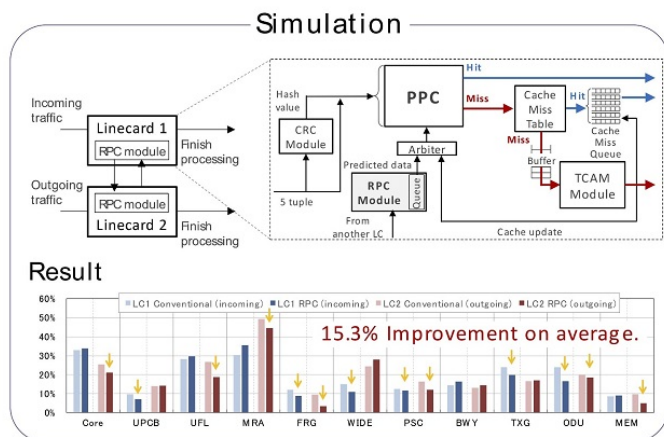
Packet Processing Cache (PPC) is a promising approach to meet these requirements. PPC stores packet processing results into a cache memory, which is a small but high-speed and low-power memory, and reuses the cached results to process the following packets. For PPC, it is important to process as many packets as possible by using the cached results and bypassing conventional packet processing.

Yamaki and colleagues at the University of Electro-Communications, Tokyo, have proposed the novel caching strategy for PPC, called Response Prediction Cache (RPC). RPC predicts the response packets and the processing results based on the request packets and stores them into the cache in advance. By using RPC, routers can process packets before their arrival.

RPC predicts responses based on the request packets and stores them into the cache in advance. By using RPC routers can process packets before their arrival.

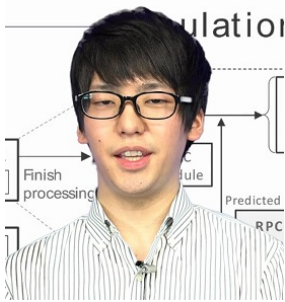
RPC increases the packet processing throughput by 5.02x and reduces the power consumed to process a packet by 75%.

"Packet Processing prediction is a novel approach for routers. If more packets can be processed by this approach, then routers can achieve significantly higher power efficiency," says Yamaki.



Outline of the response prediction and the expected impact.

Reference



- Authors: Hayato Yamaki, Hiroaki Nishi, Shinobu Miwa, and Hiroki Honda.
- Title of original paper: Data Prediction for Response Flows in Packet Processing Cache.
- Journal, volume, pages and year: *Proc. of the 55th Annual Design Automation Conference (DAC'18)*, No. 110, pp. 1-6 (2018).
- Digital Object Identifier (DOI): 10.1145/3195970.3196021
- Affiliations: Department of Computer and Network Engineering. The University of Electro-Communications.
- Yamaki Lab. website: http://www.hpc.is.uec.ac.jp/yamaki_lab/index-jp.html
- Researcher Video Profiles:
<http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2018/hayato-yamaki.html>

Elucidating mechanisms of voluntary control of human multi-muscle

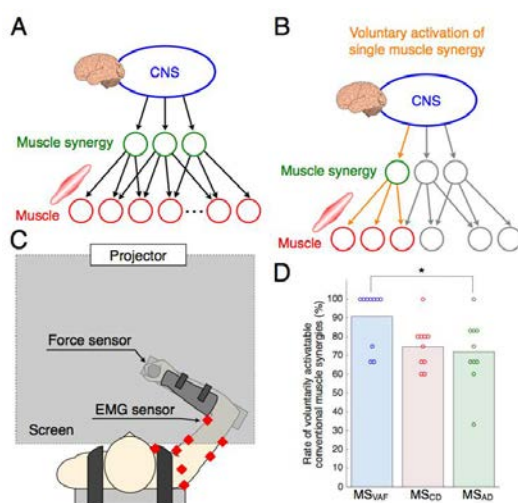
The human body is actuated by many muscles and the central nervous system (CNS) has to control such a redundant system. To simplify the control problem, the CNS controls the muscle synergy that is a functional group of some muscles. The muscle synergy hypothesis has been supported by many studies of electrophysiology and computational neuroscience.

However, the voluntary controllability of muscle synergies is not well understood. The voluntary control of muscle synergy is important both in neuroscience and also for robot control such as man-machine fusion systems. Now, Shunta Togo at the University of Electro-Communications, Tokyo, and Hiroshi Imamizu at the University of Tokyo have empirically tested whether humans can voluntarily activate a single muscle synergy.

The researchers measured muscle activity patterns of 13 muscles related to the isometric hand force production and extracted the muscle synergies. Then, they asked subjects to generate muscle activity patterns parallel to the extracted muscle synergy vector and quantitatively evaluated them.

The results demonstrated that the subjects could voluntarily activate muscle synergies based on the appropriate index. Moreover, some of the more sparse muscle synergies than conventional ones could also be voluntarily activated.

The researchers conclude that humans can voluntarily control muscle synergies. In addition, the results suggest that more sparse control unit can be applied for voluntary multi-muscle control. The voluntary control model of multi-muscle can be applied to control problems in man-machine fusion systems.



Evaluation of voluntary activation of muscle synergies. (A) The concept of muscle synergy hypothesis. (B) Voluntary activation of a single muscle synergy. (C) Apparatus for measurement experiments. (D) Our results show that the muscle synergies based on the appropriate index can be voluntarily activated.

Reference



- Authors: Shunta Togo and Hiroshi Imamizu.
- Title of original paper: Empirical evaluation of voluntarily activatable muscle synergies.
- Journal, volume, pages and year: *Frontiers in Computational Neuroscience* **11**, 82 (2017).
- Digital Object Identifier (DOI): 10.3389/fncom.2017.00082
- Affiliations: Department of Mechanical and Intelligent Systems Engineering, Graduate School of Informatics and Engineering, and Brain Science Inspired Life Support Research Center, The University of Electro-Communications.
- Department website: http://kjk.office.uec.ac.jp/Profiles/72/0007173/prof_e.html
- Researcher Video Profiles:
<http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2018/shunta-togo.html>

Isotropization of Quaternion-Neural-Network-Based PolSAR Adaptive Land Classification in Poincare-Sphere Parameter Space

Quaternion neural networks (QNNs) achieve high accuracy in polarimetric synthetic aperture radar classification by working in Poincare-sphere-parameter space.

However, there are still anisotropic factors that lead to a classification capability degraded from its ideal performance.

Now, Fang Shang at the University of Electro-Communications, Tokyo and colleagues at the University of Tokyo, report an isotropic activation function for the QNN to improve the classification ability.

Fig.1(a) below shows how the conventional activation function maps input 3-D vectors, where vectors with lengths of two are taken as test samples. The input vectors distributed on a sphere are mapped to a cubic space with a side length of two and centered at the origin of the coordinate system. It means that the effect of the mapping process on a vector, i.e. the changes of length and direction, depends on the vector's spatial position. That is, the conventional activation function is anisotropic. Fig. 1(b) shows the situation of the proposed isotropic activation function that compresses the norm of a vector independent of its direction.

Fig.2 shows the results of classification experiments for ALOS-2 PALSAR2 data of Tomakomai area, Japan. The results indicate a great improvement in the classification ability of the isotropic QNN in comparison with the conventional one. The figures of the results were selected as the cover page of the issue of the IEEE journal where these results were published, (Fig.3).

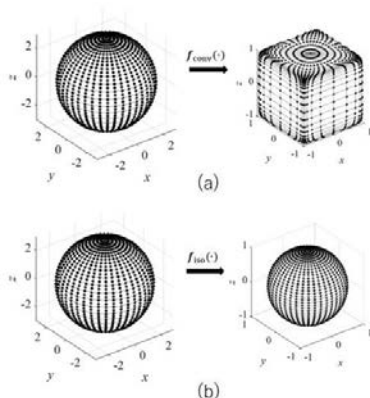


Fig.1

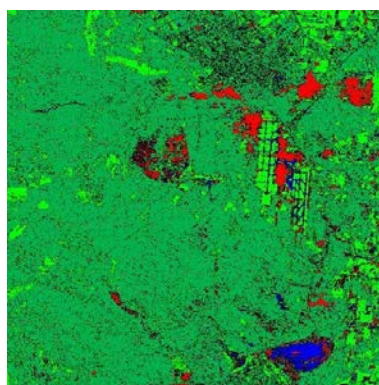


Fig.2

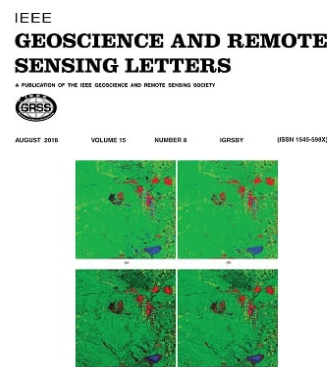


Fig.3



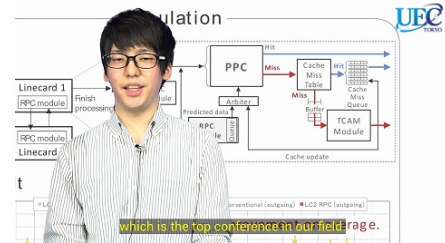
Reference



- Authors: K.Kinugawa, F.Shang, N.Usami, A.Hirose
- Title of original paper: Isotropization of Quaternion-Neural-Network-Based PolSAR Adaptive Land Classification in Poincare-Sphere Parameter Space.
- Journal, volume, pages and year: *IEEE Geoscience and Remote Sensing Letters*, 15(8), 1234-1238, (2018).
- Digital Object Identifier (DOI): 10.3389/fncom.2017.00082
- Affiliations: Department of Computer and Network Engineering, University of Electro-Communications (F. Shang), Department of Electrical Engineering and Information Systems, The University of Tokyo (K. Kinugawa, N. Usami, and A. Hirose).
- Researcher Video Profiles:
<http://www.ru.uec.ac.jp/e-bulletin/researcher-video-profiles/2018/fang-shang.html>

Hayato Yamaki, Assistant Professor, Department of Computer and Network Engineering.

Hayato Yamaki is conducting research on the internet, mainly among routers. Recently, the internet is being used for applications such as IoT, Machine-to-Machine, and cloud services. However, this has led to various problems. For example, the massive increase in the amount of information traffic has led to the problem that enough security functions cannot be secured for communication using devices with low computing power such as IoT.



In response to these problems, Yamaki is developing routers for next-generation networks. that possess intelligent controlling communications functions and the implementation of new packet processing functions.

In conventional routers, communication data "packets" are processed after the arrival of packets. However, in this research, it is possible to proceed with packet processing first by predicting the subsequent packets and their packet processing results and preparing them in advance.

This technology enables five times more throughput with only 15% of the power consumption of conventional systems.

These results were presented at these the Design Automation Conference (DAC), the top conference in this field.

Further information

Hayato Yamaki

Assistant Professor, Department of Computer and Network Engineering, The University of Electro-Communications, Tokyo.

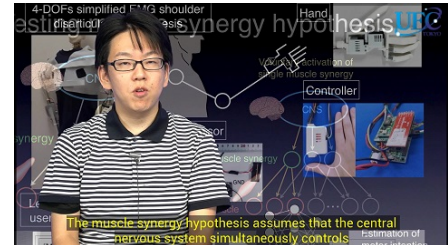
Hayato Yamaki website: http://www.hpc.is.uec.ac.jp/yamaki_lab/index-jp.html

Research Highlight:

<http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2018/next-generation-router-architecture-packet-processing-prediction.html>

Shunta Togo, Assistant Professor, Graduate School of Informatics and Engineering.

The objective of Shunta Togo's research is to elucidate a control mechanism of redundant human body and apply it for robot control. Humans can perform flexible and varied movements by co-ordinated control of their redundant joints and muscles. By elucidating such a dextrous control mechanism, Togo would like to achieve human like control of a robot, especially of the man-machine fusion system, such as a prosthetic hand.



In the field of computational neuroscience, Togo's approach is the control mechanism of human multi-muscle based on the muscle synergy hypothesis. The muscle synergy hypothesis assumes that the central nervous system simultaneously controls some muscles, to simplify the control problem.

Togo experimentally tested the hypothesis that humans can voluntarily control muscle synergies. In the field of robotics, on the other hand, he developed shoulder disarticulation prosthesis, controlled by using muscle activity information. The shoulder disarticulation prosthesis is a robotic arm for people who have lost their arm.

Togo's research group developed a simplified shoulder disarticulation prosthesis with a low degree of freedom and learning function. The robot arm learns the user's muscle activity pattern and applies it to robot control. So, the user can intuitively control the robotic arm without long term training. In evaluation experiments, users could achieve pick and place movements for simple objects.

In future, Togo would like to develop a shoulder disarticulation prosthesis which can achieve more flexible and variety of movements by applying the control strategy of the human body.

Further information

Shunta Togo

Assistant Professor, Graduate School of Informatics and Engineering, The University of Electro-Communications, Tokyo.

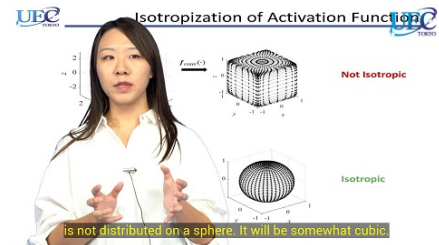
Department website: http://kjk.office.uec.ac.jp/Profiles/72/0007173/prof_e.html

Research Highlight:

<http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2018/elucidating-mechanisms-of-voluntary-control-of-human-multi-muscle.html>

Fang Shang, Assistant Professor, Graduate School of Informatics and Engineering.

Fang Shang is working on the interpretation and applications of data from Synthetic Aperture Radar (SAR). Previously, Shang proposed a method based on stokes vector. One of the topics is how to use stokes vector based parameters for supervised land classification. Usually, quaternion neural networks (QNN) are used. But recently, Shang found that the processing in a QNN is not always isotropic.



That means that if the feature points are distributed on a sphere, the data after processing from a neural network is not distributed on a sphere. It will be somewhat cubic.

So, Shang tried to make the algorithm isotropic. After isotropization, the neural network will have higher performance for land classification. In the future, Shang will continue to improve her method and try to use it for specific applications such as observation of forests and monitoring of glaciers.

Further information

Fang Shang

Assistant Professor, Graduate School of Informatics and Engineering, The University of Electro-Communications, Tokyo.

Department website: http://kjk.office.uec.ac.jp/Profiles/72/0007173/prof_e.html

Research Highlight:

<http://www.ru.uec.ac.jp/e-bulletin/research-highlights/2018/isotropization-of-qnns-based-polsar-adaptive-land-classification-in-poincare-sphere-parameter-space.html>

Data science research on improving service design

Kazushi Okamoto, Assistant Professor, Department of Informatics, Graduate School of Informatics and Engineering, University of Electrocommunications, Tokyo.

Kazushi Okamoto conducts research on data science to improve services by discovering appropriate knowledge from data and applying it. His research is based on statistics, computer science, machine learning, computational intelligence, and knowledge about specific services. Okamoto is particularly interested in fundamental techniques and applications of collection and analysis of behavior logs such as purchase histories and access logs. He targets services that are provided in the real-world and cyberspace.

(1) The real-world case

In general, loan data for libraries is objective data that shows the facts of the usage of books borrowed. However, books, which are only used in the library and are not loaned, cannot be recorded and librarians do not have in depth knowledge about the usage of such books.

Kazushi Okamoto at UEC, Tokyo and colleagues at Chiba University and the National Museum of Japanese History, performed in-library book usage surveys using radio-frequency identification systems installed in bookshelves for two years [1].

They have analyzed the observed data in terms of the number of pickups and times books were used.

The analytical results suggest: (i) their frequency of pickups was three times greater than the loan of books; (ii) the peak usage time was two to four minutes; (iii) the peak pickup frequency and the peak usage time were different, and book usage styles differed depending on the season; (iv) most of the books were pickup only a few times.

It would be difficult to obtain these results from the loan statistics only, and research like this study is a new attempt to ascertain the facts about the usage of books.

(2) Cyberspace case

Kazushi Okamoto is studying collaborative filtering techniques that recommend related users or items with a user-item matrix (Figure 1). The user-item matrix consists of ratings by each user to each item, and the collaborative filtering techniques model the recommendation by word of mouth. Many e-commerce sites and on-line services implement collaborative filtering functions such as "people who bought the item, but also bought this item", but most of the mechanisms are a black box and it is difficult to know why these items are recommended.

Okamoto wants to develop a collaborative filtering method with an explanation function.

He is developing a model-based collaborative method using linear-multiple regression that constructs a recommendation model with training examples and calculates candidates using the model. The method suggests to users and system operators what users or items affect to the recommendation according to users' or items' weights within the model.

Currently, Okamoto is evaluating the recommendation accuracy, and in the future, he will develop a weights presentation method to users and verify its effectiveness.



Predict whether this person is interested in the laptop

Figure1 User-Item Matrix and Prediction of Unobserved Ratings

Reference

[1] Kazushi Okamoto, Rie Marumo, Haruka Sano: In-Library Book Usage Survey by using Radio-Frequency Identification System Installed Bookshelves, *Journal of Japan Society of Information and Knowledge*, 27(3), 227-244, 2017. (in Japanese)



Associate Professor: Kazushi Okamoto (Dr. Eng. from Tokyo Institute of Technology 2011/03)

Current research areas: Data Science, Web Informatics, Service Informatics, Computational Intelligence

Current research subjects: Recommender Systems, Analysis of Behavior Logs

Personal website: <http://www.ds.lab.uec.ac.jp>

The 50th Anniversary International Symposium for Space Science and Radio Engineering (SSRE) held at UEC, Tokyo

The 50th Anniversary International Symposium for Space Science and Radio Engineering (SSRE) (Electromagnetic Environment Measurements and their application) was held on 25-26 June 2018 at the University of Electro-Communications (UEC), Tokyo.

The symposium is held annually at UEC, Tokyo as a platform to present new research findings in space and radio engineering. The meeting this year was held as the 50th anniversary international symposium focusing on electromagnetic environment measurements and their applications. The symposium included invited speakers from overseas including the UK, France, USA, India, Finland, and Taiwan.

The topics of the talks on the science and engineering of electromagnetic wave measurements included space plasma physics (ionosphere, magnetosphere, and aurora), atmospheric electricity (thunderstorm and lightning, and weather), seismo-electromagnetics, electromagnetic compatibility, synthetic aperture radar, and astronomy.

The symposium was opened with a welcome address from Takashi Fukuda, President of the University of Electro-Communications, Tokyo, and the scheduled included 27 oral talks and a conference dinner on the first day. Approximately 100 participants took part in the symposium.



Group photograph of some the participants at the 50th Anniversary International Symposium for SSRE.

Researchers from Sebelas Maret University give lectures on thermo-fluid engineering at UEC, Tokyo.

The lectures on thermo-fluid engineering from Sebelas Maret University (UNS), Indonesia, were given on 29 June 2018 and hosted by Okawa and Enoki Laboratory in UEC.

This lecture series is held irregularly at UEC to improve and expand research and engineering activities of researchers working in this field.

After a welcome address by Kazushi Nakano, Member of the Board of Directors, UEC, Tokyo, the following two speakers from UNS gave their lectures to an audience of more than 50 participants that included graduate students. For further research cooperation, UNS and UEC concluded a joint research agreement.

1. Budi Kristiawan (Professor, Faculty of Engineering, UNS)

"Our Sustainable Thermofluids: A one Step for Numerical Solution using Meshless Method"

His talk focused on meshless methods including radial basis function and the meshless local Petrov-Galerkin method.

2. Agung Tri Wijayanta (Lecturer, Faculty of Engineering, UNS)

"Great Potency of Nanofluids for Thermal Performance to Reduce Environmental Impact"

He presented his recent research activities in thermal performance on heat transfer characterization of nanofluids based on metal oxides.



Group Photo of the Meeting

The University of Electro-Communications (UEC) in Tokyo

is a small, luminous university at the forefront of pure and applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Communications, which was established in 1918 by the Wireless Association to train so-called wireless engineers in maritime communications in response to the Titanic disaster in 1912. In 1949, the UEC was established as a national university by the Japanese Ministry of Education, and moved in 1957 from Meguro to its current Chofu campus Tokyo.

With approximately 4,000 students and 350 faculty, UEC is regarded as a small university, but with particular expertise in wireless communications, laser science, robotics, informatics, and material science, to name just a few areas of research.

The UEC was selected for the Ministry of Education, Culture, Sports, Science and Technology (MEXT) Program for Promoting the Enhancement of Research Universities as a result of its strengths in three main areas: optics and photonics research, where we are number one for the number of joint publications with foreign researchers; wireless communications, which reflects our roots; and materials-based research, particularly on fuel cells.

International Public Relations

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