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## UEC e-Bulletin Updates on research, innovation, and events at UEC: Unique and Exciting Campus in Tokyo

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# Vol.9, March 2016



### **Research Highlights**

- Graph-based data mining reveals patterns in learning space use
- Task allocation: Computing the logistics of snow-plowing
- Metal mesh filters: Calculating pressure drop
- Environmentally friendly refrigerant measures up

#### **Topics**

■ 2015 Tenure Track Research Reports Meeting

#### Preface to volumes 8 and 9 of the UEC e-Bulletin

Volumes 8 and 9 of the UEC e-Bulletin are special issues dedicated to highlighting the excellence in research of young members of faculty on the UEC Tenure Track Program.

Specifically, in 2007 UEC was selected by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) for its 'Initiative for the Promotion of Young Scientists' Independent Research' under MEXT's 'Special Coordination Funds for Promoting Science and Technology'.

Following the success of the MEXT program, UEC introduced its own'Program to Disseminate Tenure Tracking System' throughout the university for hiring all members of faculty as assistant professors. To-date, UEC has employed more than 40 tenure track assistant professors for many hundreds of applicants in this program.

These two issues of UEC e-Bulletin showcase the unique, challenging, and international research being undertaken by sixteen highly talented tenure track assistant professors at UEC, Tokyo.

#### Graph-based data mining reveals patterns in learning space use

Collaborative learning spaces where users can study and work together require constant review so that the available facilities can be optimised. Present approaches use interviews with users but Kazushi Okamoto at the University of Electro-Communications (the affiliation when this paper published was Chiba University), Hitoshi Asanuma, and Kazuhiko Kawamoto at Chiba University propose a mathematical approach to gather usage information into graphs that can be readily mined to identify usage patterns. They suggest the approach will be useful for planning interviews and providing evidence to support the responses of interviewees.

The space studied provides movable desks, chairs, and whiteboards, but for ease the researchers defined only users and moveable desks in the learning space as nodes, where the desks acted as reference nodes. They defined edges between the nodes where the edge length was determined by the distance between the nodes in real space. They could then identify groupings defined by nodes and edges from 324 photos taken in the Chiba University library hourly over the course of two weeks.

The groupings identified were described as subgraphs within graphs that depict usage throughout the space. Using histograms the researchers could identify the most common groupings or subgraphs, and more extensive searches of all the data to identify rare groupings. In addition, a mathematical tool for cluster analysis - "k means ++"- to log the common groupings for different times of the day and week allowed them to see what patterns emerge from the data, such as the common groupings during busy as opposed to quiet periods in the library.

The researchers conclude that their test of the approach against data for the Chiba University Library "validated that the proposal can provide useful data for interview planning and evidences for interview results."

#### Reference

Kazushi Okamoto<sup>1</sup>, Hitoshi Asanuma<sup>2</sup>, and Kazuhiko Kawamoto<sup>3</sup> A graph based data mining method for collaborative learning space in learning commons, *World Automation Congress* (2014) doi:10.1109/WAC.2014.6935976.

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Top: Detected rare subgraph (number in circle: number of users within a usage pattern). Bottom an example picture, including a spatial layout between two usage patterns corresponding to the subgraph.



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Current research subjects: Soft computing based data science

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#### Task allocation: Computing the logistics of snow-plowing

In winter, snowfall can rapidly disrupt daily life and impact on Japan's economy. Snowplowing is a considerable annual expense, and methods for co-ordinating plowing activity are needed to ensure an efficient, cost-effective service. Clever computer models are needed to manage such complex activities, which involve many agents and interactions.

Now, Satoshi Takahashi at the University of Electro-Communications, and Tokuro Matsuo at the Advanced Institute for Industrial Technology in Tokyo have devised a computational method that combines task allocation and scheduling of individual snow-plows to maximize efficiency<sup>1</sup>.

The researchers aimed to identify the best routes for multiple snow-plows to take without replicating route paths, meaning their computer model had to allocate and schedule tasks simultaneously. They considered various routes in the city of Yonezawa as a series of graphical plots; this gave each snow-plow 'agent' a set of potential arcs, or routes, to follow.

Takahashi and Matsuo then devised an algorithm for task allocation, followed by an agent simulation to determine the best-fit arcs for each plow at any given time. Their method calculates directed paths that minimize inefficient movement for each snow-plow, with the option of setting a maximum time limit for a task. Throughout the process, the progress of other snowploughs is monitored so that individual routes can be changed instantaneously.

The researchers found that a higher number of snow-plows does not equal faster, more efficient clearance. There are an optimum number of operating snow-plows needed depending on each snowfall scenario. The model could help direct the country's snow-plow network in future.

#### Reference

Takahashi, S. & Matsuo, T. An agent-based heuristics for large synchronized task allocation. *International Engineering Express* 1 (1) (2015)



Directed graph model of traffic lanes.

Researchers in Tokyo have developed a computational method for directing and allocating tasks to snow-plows so that they clear transport networks in the most efficient and cost-effective way possible.



Assistant Professor: TAKAHASHI Satoshi (Ph.D in Engineering from University of Tsukuba 2013/03)

**Current research areas:** Theory of informatics, Mathematical informatics, Social systems engineering and Safety system, Computational science.

**Current research subjects:** Making Auction Systems for Market design Auction Theory, Combinatorial Optimization, Mechanism Design.

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#### Metal mesh filters: Calculating pressure drop

Metal woven meshes are used extensively as filters in multiple industrial settings, including the petrochemical and pharmaceutical industries. The meshes are carefully designed to allow only particles of a certain size to pass through apertures between the warp and weft. Two types of mesh - the plain Dutch weave and twilled Dutch weave - are particularly desirable because they have high mechanical strength, tiny apertures, and high pressure / heat resistance. However, because of the complexity of the flow paths that fluids take through these meshes, overall flow pressure drops as fluid is filtered.

Predicting this pressure drop is important for industry, because of the need to estimate operating power, output and filter lifespans. Now, Yohei Inoue at the University of Electro-Communications, Tokyo, Japan, together with scientists across Japan, have used computational fluid dynamics to model how liquids pass through plain Dutch weave and twilled Dutch weave meshes1. Their insights allowed them to derive an equation to predict pressure drop across the mesh structures.

The team first developed a computational model of the two mesh structures in three dimensions, together with accurate representation of the resulting aperture sizes in each mesh type. They were then able to clarify the flow patterns through the meshes on a microscopic scale, and visualize patterns of resulting drag forces which influence flow pressure. The model and subsequent numerical simulations allowed Inoue and his team to derive their pressure drop equations.

The researchers hope their equations will enable the design of a sophisticated Dutch weave filtration process in future.

#### Reference

 Yoshida, Y., Inoue, Y., Shimosaka, A., Shirawaka, Y., & Hidaka, J. Effect of aperture structure of Dutch weave mesh on flow resistivity. *Journal of Chemical Engineering of Japan* 48 (9) 730-741 (2015) doi: 10.1252/jcej.14we168

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# (a) Plain Dutch weave mesh



# (b) Twilled Dutch weave mesh

Research at the University of Electro-Communications in Tokyo has led to the derivation of equations to predict flow pressure drops across metal woven mesh filtration systems. These insights may enable the development of more sophisticated filtration processes in future.



Assistant Professor: Inoue Yohei (Ph.D. in Engineering from Osaka University 2007/03)

Current research areas: Fluid engineering

**Current research subjects:** The fluid-structure interaction (FSI) problems, especially in the case of turbulent flow

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#### Environmentally friendly refrigerant measures up

The fluid flow and heat transfer characteristics of refrigerants in narrow tubes is important for designing heat exchangers for air-conditioning systems. While standard refrigerants have been well investigated, environmental concerns have prompted the development of refrigerants with lower global warming potential, and the properties of these alternatives have been less well studied so far. A collaboration of researchers in Japan has now reported on the refrigerant R32, which has a low global warming potential.

A previous report had suggested a much better heat transfer coefficient for R32 compared to another refrigerant that had higher global warming potential, that is, R410A. A number of parameters can affect heat transfer coefficients, including the tube diameter, heat flux and vapour quality - the mass fraction in a saturated mixture that is vapour. These affect the type of heat transfer, which include flow boiling, liquid film evaporation, nucleate boiling and forced convection.

The work was the collaboration of Yudai Matuse at the Hitachi Zosen Corporation, Koji Enoki at the University of Electro-Communications (the affiliation when this paper published was Tokyo University of Agriculture and Technology), Hideo Mori and Yoshinori Yamamoto at Kyushi University, and Keishi Kariya at Saga University. They monitored heat transfer, pressure drop and the phase flow pattern of R32 in a copper tube with an inside diameter of 1.0 mm. They compared the results with another refrigerant R410A, which had been extensively reported on previously.

The researchers concluded, "The liquid film evaporation heat transfer was predominant at low quality or low mass flux in a low heat flux condition." The measured heat transfer data also raised questions with respect to predictions from other studies.

#### Reference

Yudai Matsuse<sup>1</sup>, Koji Enoki<sup>2</sup>, Hideo Mori<sup>3</sup>, Keishi Kariya<sup>4</sup> & Yoshinori Hamamoto<sup>3</sup> Boiling Heat Transfer and Pressure Drop of a Refrigerant R32 Flowing in a Small Horizontal Tube, *Heat Transfer Engineering*, (2016) doi: 10.1080/01457632.2015.1067057.

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Test section. P is pressure gauge, T is Thermocouples set point,  $\Delta P$  is differential pressure gauge.



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Current research subjects: Phase-change heat transfer
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### 2015 Tenure Track Research Reports Meeting

Faculty members of the University of Electro-Communications, Tokyo (UEC, Tokyo) Tenure Track Program presented their latest research findings at the "2015 Tenure Track Research Reports Meeting", held between 16:00 and 18:00 on 22<sup>nd</sup> March 2016.

This year, five tenure track assistant professors described their latest results and future plans on: context-aware wireless networks; research on the Earth's upper atmosphere using optical and radio remote sensing; multimodal categorization robots for forming concepts and acquisition of words; state space model for Kernel based smoothing; and network architectures for ubiquitous networks.





UEC, Tokyo President Takashi Fukuda opens the meeting with words of encouragement for the speakers.

The talks were each followed by wide ranging questions and comments from the audience.

Chaired by Masahisa Yanagisawa, Department of Communication Engineering and Informatics and Maomi Ueno, Department of Social Intelligence and Informatics, the meeting was opened by UEC Tokyo President Takashi Fukuda who emphasized the importance of the tenure track program for nurturing young faculty members who will lead and determine the direction of future research at the university.

Highlights of talks given by the five members of the UEC Tokyo tenure track program at this meeting.

### Suhua Tang, Department of Communication Engineering and Informatics Context-aware wireless networks

Smartphones and other such mobile devices are ubiquitous, offering a myriad of applications. For example, an appropriate 'app' enables users to determine their location on the Earth and navigate further afield. Here, Suhua Tang is exploiting the GPS function of mobile devices to reduce pedestrian-vehicle traffic accidents by transmitting the location of pedestrians to vehicles in real-time. Specific aims of this research include precise pedestrian positioning, transmission control based on the precise circumstances or 'context' of pedestrians, and

reducing power consumption of mobile devices by the 'wake up' control. This is the basis for the so-called 'context aware' wireless network technology.

#### Further information

- Suhua Tang, Yi Yu, Roger Zimmermann, and Sadao Obana, Efficient geo-fencing via hybrid hashing: A combination of bucket selection and in-bucket binary search," ACM Transactions on Spatial Algorithms and Systems, vol.1, no.2, (2015) doi: 10.1145/2774219.
- Suhua Tang, Kiyoshi Saito, and Sadao Obana, "Transmission control for reliable pedestrian-to- vehicle communication by using context of pedestrians," in Proc. IEEE ICVES'15, Yokohama, Japan, pp. 41-47. (2015) doi: 10.1109/ICVES.2015.7396891.
- Suhua Tang, Hiroyuki Yomo, and Sadao Obana, "Dynamic threshold selection for frame length-based wake-up control," IEEE Wireless Communications Letters, vol.4, no.6, pp.609-612, (2015) doi: 10.1109/LWC.2015.2475268



Protecting pedestrians from traffic accidents by precise positioning and pedestrian-to-vehicle wireless communications.



Assistant Professor: Suhua Tang (Ph.D. from University of Science and Technology of China)

Current research areas: Wireless network

**Current research subjects:** Inter-vehicle communications, green communications 2013/03) **e-mail:** shtang@uec.ac.jp

#### Takuo Tsuda, Department of Communication Engineering and Informatics Research on the Earth's upper atmosphere using optical and radio remote sensing

Scientists have been fascinated by the composition of the Earth's atmosphere for centuries. For example, in the late 1920s researchers first reported that the glow of light in the Earth's atmosphere contained light from sodium atom. Now, Takuo Tsuda is shooting laser beams into the upper atmosphere and analyzing the resulting scattered light back on earth to study the sodium layer and other layers of the outer atmosphere for future space utility and for insights into climate change. The research is carried by remote sensing at facilities in northern Europe, Japan's Showa Station in Antarctica.

Further information

- T. T. Tsuda, S. Nozawa, T. D. Kawahara, T. Kawabata, N. Saito, S. Wada, Y. Ogawa, S. Oyama, C. M. Hall, M. Tsutsumi, M. K. Ejiri, S. Suzuki, T. Takahashi, and T. Nakamura, "Decrease in sodium density observed during auroral particle precipitation over Troms, Norway," Geophys. Res. Lett., 40, 4486-4490, (2013) doi: 10.1002/grl.50897.
- T. T. Tsuda, X. Chu, T. Nakamura, M. K. Ejiri, T. D. Kawahara, A. S. Yukimatu, and K. Hosokawa, "A thermospheric Na layer event observed up to 140 km over Syowa Station (69.0°S,39.6°E) in Antarctica," Geophys. Res. Lett., 42, 3647-3653, (2015) doi: 10.1002/2015GL064101.
- T. T. Tsuda, S. Nozawa, T. D. Kawahara, T.Kawabata, N. Saito, S. Wada, C. M. Hall, M. Tsutsumi, Y. Ogawa, S. Oyama, T. Takahashi, M. K. Ejiri, T. Nishiyama, T. Nakamura, and A. Brekke, "A sporadic sodium layer event detected with five-directional lidar and simultaneous wind, electron density, and electric field observation at Troms, Norway," Geophys. Res. Lett., 42, 9190-9196, (2015) doi: 10.1002/2015GL066411.

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Frequency-tunable resonance scattering lidar

Overview of the frequency-tunable resonance fluorescence scattering LIDAR (LIght Detection And Ranging).



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### Tomoaki Nakamura, Department of Mechanical Engineering and Intelligent Systems Multimodal categorization robots for forming concepts and acquisition of words

Human cognitive functions rely heavily on categorising things and are able recognize them by a minimum of flexible and predictive cognitive processing, without having to refer to a whole lifetime of experiences. It is possible to form such categories by classifying perceptive information. Here, Tomoaki Nakamura is studying the meaning of words by considering a category as a concept and connecting it with words. One of the applications of this study is to develop intelligent robots that can associate experiences with concepts and words, with the ultimate goal being to clarify the "human language acquisition process."

Further information

- Tomoaki Nakamura, Takaya Araki, Takayuki Nagai and Naoto Iwahashi, "Grounding of Word Meanings in LDA-Based Multimodal Concepts," Advanced Robotics, Vol.25, pp. 2189-2206, (Apr.2012) doi: 10.1163/016918611X595035.
- Tomoaki Nakamura, Takayuki Nagai, Kotaro Funakoshi, Shogo Nagasaka, Tadahiro Taniguchi, Naoto Iwahashi, "Mutual Learning of an Object Concept and Language Model Based on MLDA and NPYLM," IROS2014, pp.600-607, (Sep. 2014).
- 3. Tomoaki Nakamura, Yoshiki Ando, Takayuki Nagai, Masahide Kaneko, "Concept Formation by Robots Using an Infinite Mixture of Models," IROS2015, pp.4593-4599, (Sep. 2015) doi: 10.1109/IROS.2015.7354031.
- Tatsuya Aoki, Takayuki Nagai, Joe Nishihara, Tomoaki Nakamura, and Muhammad Attamimi, "Multimodal Learning of Object Concepts and Word Meanings by Robots," NIPS 2015 Workshop: Multimodal Machine Learning, (Dec. 2015).



Results of learning process for categorising concepts of items and words.

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Assistant Professor: Tomoaki Nakamura (Ph.D. from the University of Electro-Communications 2011/09) Current research areas: Intelligent robotics

Current research subjects: Language acquisition and understanding by robots

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### Yu Nishiyama, Department of Social Intelligence and Informatics State space model for Kernel Bayes smoothing

Mathematicians employ Kernel methods in machine learning to give "computers the ability to learn without being explicitly programmed," (Arthur Samuel, 1959). Furthermore, state-space models are used to analyse time-series data generated in scientific research. Here, Yu Nishiyama is developing a new smoothing algorithm of state space model based on Kernel Bayesian inference. This research is expected to enable the development of mathematics models for predicting outcomes of research data in science and engineering.

Further information

- Y. Nishiyama, A. H. Afsharinejad, S. Naruse, B. Boots, L. Song, "The Nonparametric Kernel Bayes' Smoother," AISTATS2016.
- K. Natori, M. Uto, Y. Nishiyama, S. Kawano and M. Ueno, "Bayes factor-based learning Bayesian networks," AMBN2015.
- Y. Nishiyama, A. H. Afsharinejad, S. Naruse, B. Boots, L. Song, "Nonparametric Smoothing on State Space Models with Kernel Mean Embeddings," STM2015 & CSM2015.



Application to the inertia and position data of the slot car.



Assistant Professor: Yu Nishiyama (Ph.D. from Tokyo Institute of Technology 2009/09) Current research areas: machine learning, artificial intelligence, data science, mathematical engineering

Current research subjects: kernel methods, Bayesian inference, state space models

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#### Ryo Yamamoto, Department of Information Network Systems Network architectures for ubiquitous networks

Advances in information-communications technology enables users to connect not only computers and smartphones but other "things" to the internet such as televisions, gas and electricity meters. This new and rapidly expanding field of the "internet of things" (IoT) is a rapidly emerging field of research. Here, Ryo Yamamoto is devising innovative networking architecture for ubiquitous networks to supersede and overcome the shortcomings of conventional TCP/IP protocols. Issues to resolve with TCP/IP networks include the fact that an IP address is allocated to each individual device terminal, with associated routing, which is difficult to monitor and manage in ubiquitous networks.

#### Further information

- T. Yamazaki, R. Yamamoto, T. Miyoshi, and Y. Tanaka, "Autonomous retransmission terminal selection with neighbour terminals for ad hoc networks," IEICE Tran. (B), vol.J98-B, no.6, pp.484-496, (June 2015) doi: 10.1109/APNOMS.2014.6996593.
- 2. S.D. San, R. Yamamoto, and Y. Tanaka, "DTN reliability enhancement with end-to-end retransmission in the presence of a complete route," ITC-CSCC 2015, (June 2015).
- 3. T. Yamazaki, R. Yamamoto, T. Miyoshi, T. Asaka, and Y. Tanaka, "Load reduction method based on hop count and neighbour relation in opportunistic routing," IEICE General Conf., pp.S-6-S-7, March 2016.
- 4. T. Sakaguchi, T. Yamazaki, R. Yamamoto, and Y. Tanaka, "Block-based transmission with adaptice reliability control for ad hoc networks," IEICE General Conf., p.111, (March 2016).



Conceptual layer architecture by Ryo Yamamoto for ubiquitous networks.



Assistant Professor: Ryo Yamamoto (Ph.D. from Waseda University 2013/7)

Current research areas: Wireless communication, Network protocols, network architecture

**Current research subjects:** Routing protocol for wireless multi-hop network (MANET, VANET, WSN, DTN), TCP for wireless communication, CCN architecture for wireless multi-hop network.

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### The University of Electro-Communications (UEC) in Tokyo

is a small, luminous university at the forefront of applied sciences, engineering, and technology research. Its roots go back to the Technical Institute for Wireless Commutations, 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.

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