Ministry of Science and ICT

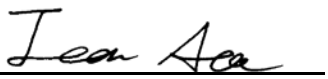
IITP Institute of Information & Communications Technology Planning & Evaluation

APPLICATION FORM
(JOINT RESEARCH)
HIGH POTENTIAL INDIVIDUALS GLOBAL TRAINING PROGRAM)

AGREEMENT

As stated above, I submit this application form to IITP that conducts “High Potential Individuals Global Training Program” supported by Ministry of Science, ICT in South Korea. IITP may disclose the information below to the public for the purpose of providing information and matching a research partnership between your institute and a Korean university.

* IITP : Institute for Information & communications Technology Planning & Evaluation

Printed Name of Chief of Research	Soo Jeon	Date(mm-dd-yyyy)	01-31-2020
Signature of Chief of Research			

☞ ***(Note)*** *This application is to identify the willingness to participate in this research and to find a research partnership for research institutes in Korea. Therefore, in its sole discretion, it is acceptable to contain only minimal information. (max. 3 pages)*

1. Research Title	Cross-Modal Deep Learning for Complex Robotic Tasks						
2. Research Area	**A.I.**	**Big Data**	**Cloud Computing**	**Block Chain**	**AR/ VR**	**ICT/SW Convergence**	**Other ICT /SW**
	X					**X**	
3. Chief of research	Title	Associate Professor		Contact	E-mail : soojeon@uwaterloo.ca		
	Name	Soo Jeon			Tel : +1-519-888-4567 x48898		
4. Affiliation	Name	University of Waterloo		Classification	(X) University ( ) Research Institute ( ) Industry ( ) ETC.		
5. Capacity for students (5 or less)	2		**Support for students** ***(all necessary)***		(X) Visa support (X) Research Mentoring (X) Research Space (X) Accessibility to Research equipment		
6. Research Objective	The overarching goal of this project is to develop new machine learning techniques that can process cross-modal sensory inputs and to apply them to realizing intelligent and cognitive behaviors with robots. The project is intended to form a new international collaboration with Korean researchers who are interested in the application of AI to advanced robotics. The PI from University of Waterloo (Prof. Soo Jeon) is a core member of the Waterloo AI						

	Institute[1] (one of four major AI institutes in Canada) as well as the Waterloo Robohub[2] (the cutting-edge research facility for advanced robotics). In particular, the PI holds expertise in sensory data processing and sensor fusion for industrial automation and robotic applications. Continuing from his current research projects on AI and robotics, the proposed research will tackle one of the hottest topics in AI these days; the cross-modal deep learning. Due to its resemblance to human perception, the cross-modal (or multi-modal) machine learning and deep learning are expected to play a crucial role in synthesizing human-like sensorimotor learning for robots. Tentative research themes to be pursued through this project include: T1) Development of a fundamental framework for training and learning cross-modal sensory data at the low level (i.e. prior to unimodal feature learning) T2) Investigation on new deep learning strategies for audio-visual integration T3) Investigation on new deep learning strategies for visuo-tactile integration T4) Implementation of cross-modal deep learning to real-world robotic tasks
7. Research Summary	The visual sense is indispensable for humans to accomplish complex tasks. For this reason, vision has been a main sensing modality for robots and physical systems that are built to perform real-world tasks at or close to the human level, e.g., self-driving cars, dexterous manipulation with robot arm and hands, etc. On the other hand, we have ample evidence that the aptitude and sophistication of human sensorimotor control often rely heavily on the cognition originating from multiple sources of sensing modalities. Examples include audio-visual perception or visuo-tactile stimulation. While the recent advances in deep learning and AI contributed greatly to realizing machine intelligence for unimodal sensory data, in particular, for vision or audio signals, there is a relatively less understanding in how the deep learning should work for the compound sensory data associated with multiple modalities of senses. This research aims to The first stage of this project will investigate fundamental issues arising from cross-modal deep learning (T1). For example, cross-modal learning at the signal level requires fusing sensory data with varying dimensionality (e.g. visual image provides the stream of 2D image while the audio (or tactile) signal is essentially 1D time series data). Another potential issue is the temporal difference between different modalities of sensory data. As an example, the information contents of visual data are often distributed over the perception duration while the tactile data are often localized in contact period. We plan to develop a unified framework to handle these fundamental issues for cross-modal sensory inputs. In this project, we plan to focus on two specific cross-modal tasks; audio-visual (T2) and visuo-tactile (T3). Due to great commonality between these two cross-modal tasks, we expect the learning techniques developed for one can easily be transferred to the other without much modification. With the visual data as the central modality, the audio and the tactile will be treated as complementary modalities to enhance the cognitive performance of perceptive learning. While we focus on the algorithmic aspects of the cross-modal integration, we will also be working to associate these two tasks with practical applications to physical machines and robots such as the classification with audio-visual integration, and the dexterous grasping with visuo-tactile integration.

[1] https://uwaterloo.ca/artificial-intelligence-institute/

[2] https://uwaterloo.ca/robohub/

The final stage of this project (T4) will involve our effort to implement the cross-modal deep leaning techniques developed by T1 through T3, and to apply them to robotic systems that are available from the PI's laboratory. The PI's research group is in possession of the state-of-the-art robotic systems (Fig. 1) as well as the unique infrastructure called Robohub (Fig. 2) to conduct the proposed research.

Currently, 8 research members (2 PDF's, 2 PhD's and 3 MASc's) are collaborating on diverse research topics on machine learning and AI. With the recent launch of Waterloo AI Institute, the PI's group has an access to diverse expertise on AI across disciplines such as software engineering, computer science and applied mathematics. Furthermore, University of Waterloo has recently become the center of AI research in Canada by becoming the leading institution for the major research investment by Canadian government called the SCALE AI ($230M funding to support the supply chain and logistics excellence consortium led by the SCALE AI supercluster). The PI believes that University of Waterloo and the PI's research group can provide a unique academic environment for Korean students to foster core talents in AI and robotics.

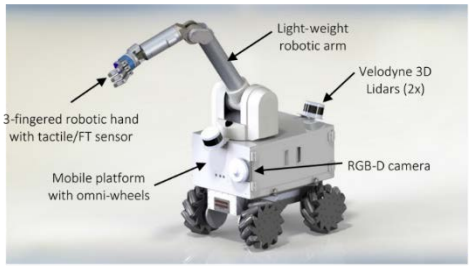


Fig. 1 Sensory-rich robotic testbed

Fig. 2 Robohub facility

8. Need for funding from Korean government

The funding to be provided by Korean government will mainly be used to partially support a postdoctoral student (Dr. Shiyi Yang) and a PhD student (Jeong-Woo Han) both of whom are currently working on the relevant topics in the PI lab, and also to support the participating research personnel for their travels (for conferences as well as for research collaboration with the Korean partner). Under the guidance of the PI, Dr. Yang and Mr. Han will play a major role in training the high potential individual from Korea with the cutting-edge deep learning, AI and robotic perception as well as reinforcement learning through seminars, research discussions, and individual meetings. Other direct cost of research will include additional costs such as the use fee for AI workstations in University of Waterloo, acquisition of some sensors (force feedback tactile sensing units), small electronic parts, etc.

9. Request for Korean Universities

- A total of two students is proposed for this collaboration for the duration of 1 year. PhD's are preferred but MASc's with strong background in deep learning, reinforcement learning and/or robotics are suitable too. Each student is expected to stay in University of Waterloo as a visiting student for six months.
- There will be a close interaction with research personnel in the PI's group, so good communication skills and team-oriented personality are desired.
- The students from Korea are expected to have a strong background in fundamental subjects including data science, dynamical systems, statistical signal processing and mathematical optimization. Some practical knowledge in programming for AI, ROS (Robot Operating System) and robotic sensors (lidar, vision, etc.) will be a plus.