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	Young L. Kim	Date (mm-dd-yyyy)	02-13-2020
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	Hybridization of deep learning and statistical learning for 1D biomedical and mechanical signals						
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 : youngkim@purdue.edu		
	Name	Young L. Kim			Tel : +1-765-496-2445		
4. Affiliation	Name	Purdue University		Classification	(X) University ( ) Research Institute ( ) Industry ( ) ETC.		
5. Capacity for students (5 or less)	3 PhD students and Postdoctoral Fellows		**Support for students** ***(all necessary)***		(X) Visa support (X) Research Mentoring (X) Research Space (X) Accessibility to Research equipment		

6. Research Objective	**The main objective of this collaborative research between USA and South Korea is to develop novel artificial neural network frameworks by integrating deep learning and statistical learning approaches for 1D biomedical and mechanical signals.** Conventional deep learning has been centered in using deep 2D Convolutional Neural Networks (CNNs) for a variety of application of medical imaging and computer vision. 2D CCNs can incorporate multiple hidden layers and numerous parameters to learn complex patterns for various engineering applications, in particular 2D signals (image and video data). On the other hand, we have a handful of deep learning tools for 1D signals in particular when training datasets are sparse and specific to particular applications. Many applications heavily rely on 1D signals, for example, biomedical signals (e.g. ECG), spectroscopy, structural health monitoring, and machine part monitoring. Although 1D CNNs have recently been proposed and have demonstrated the state-of-the-art performance levels, there are significantly limited neural network frames available to analyzing and predicting 1D signals. **As far as 1D signals concerned, biomedical engineering and mechanical engineering share a strong need for advanced and hybridized neural network frameworks.**
7. Research Summary	**We will hybridize deep learning and statistical learning specially designed for analyzing and predicting 1D signals.** Deep learning and statistical learning have complementary strengths to be hybridized, although statistical learning and machine learning are different. Both learning approaches play a key role in inference and prediction. Inference from a mathematical model built from a dataset allows us to gain an understanding and to test a hypothesis. Prediction forecasts new outcomes and identifies an optimal decision. Statistical learning allows us to customize a model for statistical inference. On the other hand, machine learning is centered in prediction and classification. Some key differences between statistical learning and machine learning can be recapitalized as follows: Statistical learning is centered in inference and machine learning is more related to optimization and classification. Statistical learning heavily relies on some assumptions and properties of distributions. In contrast, machine learning typically requires minimal assumptions because it treats its algorithm as a black box and because data are not collected in a carefully controlled manner. We will focus on combining partial least squares regression or compressive sensing with 1D CNNs, multilayer Perceptrons, and Operational Neural Networks (ONNs) for 1D biomedical or mechanical signals. Specifically, partial least squares regression incorporates variations of both predictor and outcome variables simultaneously, enhancing the prediction performance, while it is based on the extraction of principal components. Partial least squares regression transforms high-dimensional measured variables onto a reduced space of latent variables in a similar manner of principal component analyses. It is highly beneficial to examine the significance of individual measured variables by eliminating insignificant ones. Over the past ten years, compressive sensing has shown a new way for computational spectroscopy and imaging, but its implementation has been limited merely in sampling and signal processing. In particular, it is highly useful to solve an ill-posed problem as an inverse mapping from a subsampled space to a dense space. Mathematically, this underdetermined problem can be described by L1-minimization. Specifically, when significant information is contained in a few elements (sparsity), L1-minimization has shown reliable and enhanced performance. When sparsity or compressibility exist in signals, L1-minimization is a powerful alternative to find a minimum l1-norm solution. In this case, the majority of unnecessary components (weights) is forced to be zeros, yielding only few non-zero components and avoiding overfitting.

8. Need for funding from Korean government	**As this fundamental collaborative research requires in a unique combination of biomedical and mechanical 1D signals, it is challenging to secure research funding from typical US federal funding mechanisms.** The research is focused on developing fundamental deep learning tools that can be applied to a variety of 1D signals. In other words, this proposed research is centered on the inception of the impactful and transformative neural network frameworks, rather than focused on specific engineering hypotheses or objectives. In this respect, this funding would be ideal for this proposed research, as compared to traditional grant mechanisms in the US. This seed funding to support this initiative will enable us (the US and South Korea) to have more competitive proposal applications with specific applications.
9. Request for Korean Universities	An ideal partner will be a laboratory in Mechanical Engineering, focusing on signal processing and deep learning characterizations of monitoring of structural damage, nondestructive evaluations, or similar applications, because most of such signals are 1D. In addition, an interest and desire to explore biomedical applications would be a plus. We will share key examples and datasets for developing hybridized deep learning frameworks that can be applied to biomedical applications and mechanical applications as a win–win strategy where all institutions in the US and South Korea will mutually benefit. Regarding student exchange, the selection of students studying abroad should be conducted after mutual consultation and we will cooperate as much as possible to prepare for VISA.