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	Duckbong Kim	Date(mm-dd-yyyy)	01-24-2020
Signature of Chief of Research	Duckbong Kim		

☞ ***(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	Development of a neural network-based process planning framework of hybrid manufacturing (additive/subtractive) process						
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	Assistant Professor	Contact	E-mail : dkim@tntech.edu			
	Name	Duckbong Kim		Tel : +1-931-372-3327			
4. Affiliation	Name	Tennessee Technological University	Classification	(X) University ( ) Research Institute ( ) Industry ( ) ETC.			
5. Capacity for students (5 or less)	3	**Support for students *(all necessary)***	(X) Visa support (X) Research Mentoring (X) Research Space (X) Accessibility to Research equipment				
6. Research Objective	The research goal is to develop a process planning framework of hybrid manufacturing (i.e., additive/subtractive) process based on big data-driven machine learning models.						

7. Research Summary	Metal 3D printing and data science (e.g., machine learning) are considered by many to be the next "disruptive technology" in terms of their potential for changing the manufacturing landscape through their technical advancements and capabilities. Current AM systems and processes are growing more complicated through the inclusion of smart sensors and networks. However, many current Metal 3D printing processes use manufacturers' experience to determine the process parameters, called "hand-tuned." It is difficult to control the structure, quality, and performance by the "hand-tuned" approach since the relationships among process, structure, property, and performance are not characterized. Consequently, it is difficult for a decision-maker to develop informed strategies involved in managing the metal 3D printing systems and processes and aligning with this current, major manufacturing trend. Decision makers in the AM industry need innovative methodologies and techniques to assist in decision-making, adapt to new situations, and predict and correct fabrication problems in dynamic manufacturing environments, especially for the hybrid manufacturing (additive/subtractive) process. In particular, the decision-support techniques have several critical hurdles: (1) their high uncertainty and complexity; (2) their inability to deal with multiple, conflicting objectives; and (3) the dynamicity of the evolving manufacturing systems. These are related to multi-criteria decision making problems. However, most AM manufacturers still make their decisions based on their experiences and intuitions since they have neither the capabilities nor resources to manage those conflicting and complicated problems. In this context, machine learning and data analytics (DA) technology will be investigated as one of the possible innovative solutions to fill these industrial needs. Predictive models and decision methodology based on the machine learning, have been recognized as key enablers that can improve AM practices. In particular, these techniques can potentially address tasks and problems for satisfying different manufacturing requirements and constraints by characterizing the relationships and developing a decision-support framework. Due to the main advantages, this WAAM process can be well-fitted to fabricate the medium- and large-sized structures with the high buy-to-fly ratio. However, this process has several critical bottlenecks for the widely adoption in industry. One of the main hindrances is the poor surface quality of the wire + arc additively-manufactured (WAAMed) structure, compared to those from PBS and PFS. The surface quality can be evaluated in terms of surface waviness (SW), which can be defined as the average maximum peak-to-valley distances after a machining process. This poor surface quality deteriorates the mechanical and chemical properties, since it expedites stress concentration and negatively contributes on corrosion rate and corrosive wear. So far, to control the surface quality, many studies are based on trial-and-error or design of experiment methods. However, these approaches provide neither the fundamental understanding of SW formation mechanism nor its control scheme with respect to the different material/manufacturing conditions. In this project, the overarching research goal is to gain the fundamental knowledge about the surface waviness formation mechanism and its machining process in thin-/inclined walls and multi-bead/multi-layer (MBML) structures and investigate the design rule for the control scheme. An integrated experimental-characterization and theoretical-modeling method will be used to develop a machine learning-based model for process planning of hybrid manufacturing process. The steps are as follows: (1) investigate the weld pool features for affecting the surface roughness of AM part's thin-/inclined walls and MBML structures, (2) elucidate the SW formation mechanisms, (3) verify and validate the mechanisms including the defect formation mechanisms using the computational fluid dynamics (CFD), and (4) train process, ADW features, defects, and SW/ETW to create the knowledge for the fine-tuning.

8. Need for funding from Korean government	Through the mutual exchange of research between Tennessee Technology University (TTU) and Korean university, the main objective of this program is to provide Korean university researchers (i.e., graduate students) with research opportunities, allowing insight into the practical applications of their education and research and bridging the gap among government, academia, and industry to aid in the development of a diverse, globally competitive science, technology, engineering, and math (STEM) workforce. The research focus will be on big data-driven machine learning techniques focusing on technology-intensive manufacturing (e.g., smart manufacturing, additive manufacturing, and data analytics). In addition, this program will lead activities that contribute to professional growth and development in STEM areas. Ultimately, the proposed program is expected to contribute to future innovation in data science and advanced manufacturing, such as smart manufacturing, and provide the foundation for increasing industrial competitiveness and its economic success. The PI has multidisciplinary research experience in advanced design and manufacturing, including metal AM, smart manufacturing, digital thread for AM, data analytics for AM, and development and calibration of high dynamics range imaging (HDRI)- and bidirectional reflectance distribution function (BRDF)-based machine vision systems. Before joining Tennessee Technological University (TTU), the PI was involved in four projects at National Institute of Standards and Technology (NIST) from Oct. 2011 to Jul. 2016: (1) Testbed Development for Sustainable Manufacturing, (2) Sustainable Modeling and Optimization, (3) Systems Integration for Additive Manufacturing, and (4) Modeling Methodology for Smart Manufacturing. Based on the PI's extensive educational and research experience in advanced manufacturing as well as data science, his goal is to develop a new initiative for workforce development, focusing on technology-intensive manufacturing processes by benchmarking the NIST smart manufacturing and AM programs. This will familiarize the Korean students with the emerging technology-intensive manufacturing and data science disciplines and help prepare a future workforce equipped with new skills and knowledge. The philosophy and methods employed will significantly promote self-thinking and team-working abilities and encourage the students to pursue careers in artificial intelligence-based on big data as well as the advanced manufacturing process (e.g., metal AM).
9. Request for Korean Universities	I will cooperate with Korean universities as much as possible to prepare for the J-1 visa and accommodate the exchanging research students in my laboratory for the successful completion of this research. For this big data management and machine learning implementation, the research team will utilize the TTU high performance computing (HPC) hardware and software (see Facilities, Equipment, and Other Resources). The hardware consists of 40 CPU compute nodes, each with 28 CPU cores (Intel Xeon E5-2680v4, 2.4 GHz) and 4 GPU compute nodes, each with 28 CPU cores (Intel Xeon E5-2680v4, 2.4 GHz). A machine learning framework, such as TensorFlow with Keras, will be utilized.