Ministry of Science and ICT

IITP Institute of Information & Communications Technology Planning & Evaluation

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

| AGREEMENT |
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| 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.<br><br>* IITP : Institute for Information & communications Technology Planning & Evaluation<br><br>Printed Name of Chief of Research: Sunghan Kim    Date(mm-dd-yyyy): 02-03-2020<br><br>Signature of Chief of Research: Sunghan Kim<br><br>☞ ***(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)* |

<table>
<tr><td>1. Research Title</td><td colspan="7">Development of Convolutional Neural Network Artificial Intelligence Platform to Detect Cognitive Deficits due to Aging and Early Dementia</td></tr>
<tr><td rowspan="2">2. Research Area</td><td>A.I.</td><td>Big Data</td><td>Cloud Computing</td><td>Block Chain</td><td>AR/ VR</td><td>ICT/SW Convergence</td><td>Other ICT /SW</td></tr>
<tr><td>X</td><td>X</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">3. Chief of research</td><td>Title</td><td colspan="2">Associate Professor</td><td rowspan="2">Contact</td><td colspan="3">E-mail : kims@ecu.edu</td></tr>
<tr><td>Name</td><td colspan="2">Sunghan Kim</td><td colspan="3">Tel : +1-252-737-1750</td></tr>
<tr><td>4. Affiliation</td><td>Name</td><td colspan="2">East Carolina University</td><td>Classification</td><td colspan="3">(X) University ( ) Research Institute<br>( ) Industry ( ) ETC.</td></tr>
<tr><td>5. Capacity for students (5 or less)</td><td colspan="2">Up to 3</td><td colspan="2">Support for students (all necessary)</td><td colspan="3">( X ) Visa support<br>( X ) Research Mentoring<br>( X ) Research Space<br>( X ) Accessibility to Research equipment</td></tr>
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| **6. Research Objective** | Mild cognitive impairment (MCI) is subtle yet measurable memory deficits that occur in the early stages of Alzheimer's disease and related dementia (ADRD). MCI patients' annual conversion rate to ADRD can be as high as 40% much higher than 3% in the normal aging population. Due to the progressive and irreversible nature of ADRD the best strategy to combat it is early diagnosis and timely intervention. However, the current diagnosis of MCI is multifaceted and time-consuming since there is no single test to confirm a diagnosis of the disease due to the non-specific nature of its prodromal symptoms. Our goal is to develop a non-invasive, easy-to-use and cost-effective screening and diagnostic system for MCI utilizing multimodal biomarkers of memory loss and cognitive deficits due to MCI and ADRD. In order to reach this goal, we propose a research study that investigates the effect of MCI on face recognition abilities through electroencephalography (EEG) and saccadic eye movement (SEM) monitoring. Our work is innovative in exploring multimodal non-invasive signals to identify novel biomarkers of neurodegenerative changes by utilizing advanced data-mining and machine-learning methods.<br>We plan to accomplish three specific aims in the proposed study as below:<br>The specific aim 1 (SA1) is to extract potential electrophysiological and behavioral biomarkers from event-related potentials and saccadic eye movement signals that are recorded from geriatric subjects with MCI and age-matched controls who are to perform familiar versus unfamiliar face recognition tasks in an oddball paradigm.<br>The specific aim 2 (SA2) is to extract potential electrophysiological and behavioral biomarkers from event-related potentials and saccadic eye movement signals that are recorded from geriatric subjects with MCI and age-matched controls who are to perform upright versus inverted face recognition tasks in an oddball paradigm.<br>The specific aim 3 (SA3) is to design a machine-learning platform capable of differentiating MCI patients from healthy controls based on the electrophysiological and behavioral biomarkers defined in SA1 and SA2 and evaluate its performance via leave-one-out cross-validations. |
| **7. Research Summary** | Subjects will be recruited through an outpatient neurology office at ECU. During the initial interview information about the proposed study will be provided for those who meet our inclusion/exclusion criteria such as age, visual acuity, history of seizure and schizophrenia. After completing the informed consent process, a study participant will be seated in a comfortable chair which is set 5-feet in front of a 40-inch widescreen visual display for picture presentations. The display will be placed in the middle of their visual field, and its height matched to the eye of the seated subject. First, they will be asked to fixate on each of three dots appearing on the display for a few seconds for the calibration of a SEM tracker installed at the bottom of the visual display. Then, they will be fitted with a 32-channel dry-electrode cap to record neural activity using Guger Technology's high-performance amplification and data acquisition system. Data acquisition will be performed at a sampling rate of 512 Hz. The quality of the acquired digital EEG signals will be checked manually by an experienced experimenter, and if the signal appears to be free of noise contamination, the subject will be ready to complete the two study sessions as described follows. For both study sessions, 120 high-resolution images from four different categories (former presidents, unfamiliar males, unfamiliar females, non-facial objects), will be displayed one at a time in a random order to avoid ordering effects using BCI2000 software while EEG and SEM signals are simultaneously recorded. Each image will be displayed at the center of the screen for 0.5-s with the inter-stimulus interval between the images of 1.5-s. The distance between the screen and the subject will be 5-feet and the size of the images will be adjusted to ensure 2.6° of visual angle. One image sequence, which consists of 24 unique images (4 former presidents, 8 unfamiliar males, 8 unfamiliar females, 4 non-facial objects such as a watch face), will be repeated five times to make up 120 (24×5) images. Therefore, each study session will last approximately 4 minutes. For the first study session which is to test the episodic memory, the subject will be shown the face of one of the 8 unfamiliar males and told his name, e.g., Sam. As the images are sequentially displayed on the screen, the subject will be asked to respond to the target face, i.e., Sam's, by tapping his index finger while responding to all the other images by tapping his middle finger. For the second study session which is to test semantic memory, the subject will be asked to respond to the faces of the four former presidents such as George Washington or Thomas Jefferson |

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| | by tapping his index finger while responding to all the other images (i.e., the unfamiliar faces and non-facial objects) by tapping his middle finger.<br>We will first evaluate the event related potential (ERP) and event related de-/synchronization (ERD/S). The ERP is a predictable waveform that follows the onset of a stimulus, making it a powerful correlate of localized neural activations. Similarly, changes in EEG signal strength in a particular frequency bandwidth (ERD/S) reflects regional brain activation in the time-frequency domain. We will focus on the alpha (8~12 Hz), beta (13~30 Hz) and theta (4~8 Hz) frequency bands. All of these measures will represent an index of regional neural activations, thus allowing us to evaluate the neural aspects of cognitive performance within specific brain areas. Characteristics of the waveforms (e.g., P300 amplitude and latency, and ERD/S at the same time points) will be derived for each study participant and averaged across epochs for each condition and used as biomarkers.<br>Source analysis within consecutive 250 ms time bins following trial onset using standardized low-resolution brain electromagnetic tomography (sLORETA) to define neuroanatomical generator specific for each condition. Clusters of activation will be restricted to have greater than 5 voxels (k > 5). In addition to sLORETA, we will also employ more advanced beamformer source localization routines. The linearly constrained minimum variance (LCMV) beamformer will be applied to the time-voltage data for source localization, and time-frequency data in the above mentioned target bandwidths will be localized with the dynamic imaging of coherent sources (DICS) beamformer. Both estimates will employ the SPM8 cortical mesh consisting of 20,484 vertices representing the cortex.<br>We will also evaluate functional and effective connectivity (FEC) as potential biomarkers. FEC models interactions among neuronal populations with the overall goal of estimating task-related coupling among brain areas, and provides information related to mutual information processing between distinct brain regions. To model FEC for the specific conditions, imaginary coherence and the phase slope index will be calculated to evaluate whole-brain connectivity at the sensor and source levels (e.g., from sources derived through the LCMV and DICS beamformers). These measures will represent an index of interregional neural activations and will serve as additional biomarkers of MCI. |
| **8. Need for funding from Korean government** | The recruited students need to be fully funded to stay in the states including housing, health insurance, salaries/allowance and travel expenses. The PI is requesting one and half months of summer salary and the funding agency will need to negotiate with ECU Research, Engagement Development and Engagement Office for facilities and administrative costs (F&A). A set of wireless dry-electrode brainwave recording device (<$30k) needs to be purchased although the PI has two wired sets in his lab. |
| **9. Request for Korean Universities** | The PI prefers to recruit graduate students who are proficient in Matlab and interested in neuroscience in general and/or electrophysiology more specifically. They should be able to work efficiently as part of a large team or independent researchers. They should be able to communicate with others in English although it is unnecessary for them to be fluent in English. |