

2021 Catalyst Awardees

Sponsor: Academia Sinica

A multidomain biometric sensing platform that detects asymptomatic prodromal phase of Parkinson's disease

Principal Investigator	Chin-Hsien Lin
PI Primary Affiliation	National Taiwan University Hospital
Co-Investigator(s)	Li-Chen Fu; Jyh-Shing Roger Jang

PROJECT DESCRIPTION

Parkinson's disease (PD) is one of the most common neurodegenerative disorders with an estimated number will be nearly 9 million in the year 2030. The symptoms of PD include resting tremor, bradykinesia, rigidity and gait postural instability. There is currently no cure for PD patients. Given the likely entry of mechanism-targeted therapies into early human clinical trials, early detection of PD, especially in the asymptomatic early stage of the disease is crucial.

There are several clues of biometric soft signs that can be detected before the occurrence of the classical motor symptoms of PD, including decreased facial expression, linguistic changes, and changes of gait patterns. Although there are several apps that have been developed in the smartphone or smartwatch, these apps mainly focus on detection of the arm swing movement pattern while wearing the smartwatch or carrying the smartphone. This single-domain modality may not be PD-specific as patients with stroke or arthritis may manifest with decreased arm swinging. An integrated platform with multidomain biometric features with automatic analysis are more sensitive than single modality feature to precisely and accurately detect the prodromal phase of PD. Hence, in this study, we aim to establish a deep learning-based multidomain biometric sensing platform that the combine the biometric physical features, including speech, facial expression, gait and associated movements to detects asymptomatic prodromal phase of susceptible PD patients.

Our results will facilitate future large population screening of PD for early preclinical diagnosis and proper treatment, decreasing medical burden in an aging society.

Connected speech analysis in elderly population

Principal Investigator	Yi-Chien Liu
PI Primary Affiliation	Department of Neurology, Cardinal Tien Hospital
Co-Investigator(s)	Chia-Ying Lee; Chih-Ting Chang; Chia-Ju Chou

PROJECT DESCRIPTION

One of the most effective strategy in preventing pathological aging is very early diagnosis. In this project, we are more interested in differences related to "speech production". Speech samples of both "pathological aging" and "normal aging" are going to be collected regularly. Linguistic markers including lexical richness, semantic units, syntactic complexity and repetitiveness will be assessed.

Improving elderly masticatory function and nutrition by chewing gum, image recognition, and personal health informatics

Principal Investigator	Ta-Chien Chan
PI Primary Affiliation	Academia Sinica
Co-Investigator(s)	Ping-Chen Chung; Chung-Liang Lai

PROJECT DESCRIPTION

Oral health care is an important part of total patient care. Image recognition of gum mixing while patients chew bicolor gum establishes a novel method to test chewing efficiency, and integrates personal health information to set up a portable risk prediction platform. This easy method of measuring biting efficiency provides an alert to the risk of periodontal disease and tooth loss, especially for the elderly, and provides people with a way to prevent the risk factors for tooth loss, in turn avoiding sequential negative outcomes such as malnutrition and the need for nutrition supplements or parenteral nutrition dependency, decline in cognitive function, disability, and increased risk of cancer or death. Our hypothesis is that chewing efficiency can influence the nutrition and cognition of the elderly. To set up the prediction model of elderly nutrition and early dementia, we will collect various sources of data including masticatory function, periodontal, nutrition and cognition status. This easy-to-use approach can become a standard screening approach if a high-accuracy predictive model is established and chewing efficiency, nutrition and cognition ability can be improved through the tool's suggestions and active care intervention by the medical team. The success of this project can not only enhance oral health among the elderly but also reduce the disease burden and improve quality of life. The promotion of this project is easy to implement worldwide, with low cost.

Noninvasive magnetic damping method to image the electrical conductivity of the internal organs

Principal Investigator	Tzu-Chieh Chou
PI Primary Affiliation	Individual collaborating with National Taiwan University
Co-Investigator(s)	Kevin Tze-Hsiang

PROJECT DESCRIPTION

The project aims to augment ultrasound scanners with a new imaging method to differentiate biological tissues based on their electromagnetic properties. For example, the augmented scanner can generate a heat map of electrical conductivity inside the abdominal cavity where hepatic tumors are highlighted and overlapped on top of conventional B-mode ultrasound images. The "combo" imaging technique brings new opportunities to diagnose liver cancer in elderly patients and is expected to improve the current 5-year relative survival rate of 34% for localized tumors according to a previous study.

The proposed imaging method simply requires an ultrasound transducer, an external coil, and a circuit board for direct image reconstruction. The simple construction of the system allows it to be integrated into commercial ultrasound scanners, similar to the Doppler ultrasonography used in imaging the blood flow inside the cardiovascular system. Therefore, it has advantages including low construction cost, high portability, and real-time image display.

The first proof of concept will be demonstrated through benchtop experiments on organ phantoms consisting of normal and disease states with corresponding changes in electrical conductivity. For example, a liver tumor phantom has a conductivity value higher than a healthy liver and is comparable to hepatic tumor biopsy samples. The next step will be collaborating with doctors for animal model experiments and human trials.

Novel top-to-toe screening system for early detecting sarcopenia

Principal Investigator	Jin-Chern Chiou
PI Primary Affiliation	Department of Electrical and Computer Engineering, College of Electrical and Computer Engineering, National Yang Ming Chiao Tung University
Co-Investigator(s)	Liang-Kung Chen, Tzai-Wen Chiu

PROJECT DESCRIPTION

Sarcopenia has identified as a skeletal muscle disease in the international classification diseases (ICD-10). But its etiology and underlying mechanisms and effective treatment remain unavailable. The Dual-Energy X-Ray Absorptiometry (DXA), currently used for diagnosis, can't apply for daily basis chronic monitoring. Furthermore, it can't assess the neural and muscular functions as well as the behaviors simultaneously. Therefore, a new integrated measuring system combined with the automatic intelligent-based analysis to assess the sarcopenia-related changes in neuromuscular functions and behaviors are obligatory. In this proposal, we are going to develop a novel top-to-toe system (TtT system) that is capable of determining the longitudinal causal links between sarcopenia and the age-related neuromuscular changes by establishing the active marker for early detecting of sarcopenia. The TtT system consists of three important modules: high-density insole-based balance sensing, EMG and EEG module, for assessing the static and dynamic changes of balance, muscle kinetic activities and cortical activities. With the proposed system, the protocol of clinical trial for various human movements and excises will be designed in order to acquire effective biomarkers from sarcopenic and non-sarcopenic subjects. Upon the clinical data is obtained, an AI deep learning-based analysis will be performed and determined the causal links between sarcopenia and the age-related neuromuscular changes, which can help the elderly community to early detect this age-related disease, bringing benefits to the aging society.

Oral Precision Medicine - Rapid and painless treatment of periodontal disease using a bacteriophage spray

Principal Investigator	Ping-Ching Wu
PI Primary Affiliation	Department of Biomedical Engineering, National Cheng Kung University
Co-Investigator(s)	Chun-Chan Ting; Cheng-Hung Luo; Pei-Yu Tu

PROJECT DESCRIPTION

In 2019, WHO has classified periodontal disease as a global chronic disease, and the increasing risk by oral pathogens strongly impacts aging health issue. This project plans to establish a non-invasive, precise, painless and non-antibiotic formulation for periodontal disease treatments. Using the bacteriophages, the formulated oral spray can precisely kill specific periodontal pathogens without damaging normal tissues. Bacteriophages are viruses that infect bacteria, replicating and multiplying using host resources. For specific infections, bacteriophages have attracted interests and been developed as therapeutic agents. Our team has been working on the diagnosis and treatment of periodontal pathogens for many years and is composed of biomedical engineer, immunological and clinical dentistry experts. We will establish a phage bio-bank and apply the phage spray in clinical treatment to improve the periodontal-aging disease under a non-invasive and non-adverse process. We believe we can make this research project a success in the shortest possible time.

Population-wide preventative treatment of aging-associated cognitive impairment via adjustment of movie and TV shows frame and refresh rates

Principal Investigator	Ted Weita Lai
PI Primary Affiliation	China Medical University
Co-Investigator(s)	Hilary Chen; Ya Lan Yang; Meng-Chih Wu; Eric Yuhsiang Wang

PROJECT DESCRIPTION

Chronic repeated visualization of a LED light that flickers at a frequency of ~40Hz (known as GENUS: gamma entrainment using sensory stimulus) is recently found to reduce beta-amyloid plaques, improves cognitive function, and offers neuroprotection in mouse models of neurodegeneration. In comparison to the 40Hz required for GENUS, most movie films are filmed at 24 frames per second (FPS) and many TV shows are filmed at 30 FPS; also, TV sets in most households has a refresh rate of 60Hz to 120Hz, and modern TVs tends to aim for 120Hz or higher. Therefore, the typical frame rates and display refresh rates used today are not optimized to provide the 40Hz GENUS-like visual stimulation, and watching a TV/movie likely provide little benefit to preventing cognitive impairment. Since a large majority of general population tend to watch a lot of TV shows (or YouTube videos), we hypothesized that a GENUS-optimized TV output, with movies or TV shows filmed at 40 FPS and/or displayed with a 40Hz refresh rate, can provide population-wide preventative care against cognitive impairment for people of all ages. If we are able to provide evidence that watching TV at GENUS frame rate (40 FPS) and/or GENUS refresh rate (40 Hz) can provide the same therapeutic benefit as watching LED light flickering at 40Hz (which is essentially what GENUS is), the whole filming industry (and YouTube videos) may adapt to provide GENUS therapy for everyone watching TV. This could result in global population-wide decline in aging-associated cognitive impairment.