R&D Theme

Constructing a Human Emotional State Space by AIoT

Progress until FY2022

1. Outline of the project

In this project, we aim to develop AIoT (AI×IoT) technology that enables the objective estimation of emotional states in daily life on a cloud platform using multidimensional psycho-physiological data (e.g., voice data, physical activity, heart rate, respiratory rate, and recording situations) measured by IoT devices. The project is divided into the following three research topics:

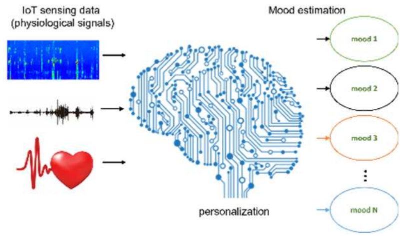
1. Development of human emotion estimation technology with clinical validity using multidimensional psycho-physiological data
   Summary: we develop technology with clinical validity that enables the objective estimation of various emotional states on a cloud platform. This is achieved by utilizing multidimensional psycho-physiological data (e.g., voice data, physical activity, heart rate, respiratory rate) measured by IoT devices in daily life.

2. Assessment of psycho-physiological data in patients
   Summary: we collect psycho-physiological data from patients with mental disorders to construct a human emotional state space with clinical validity.

3. Development of a translational IoT cloud system
   Summary: we develop a cloud-based IoT system capable of acquiring continuous and real-time psycho-physiological data from both humans and animals (mice and rats) in real-world settings on a large scale.

2. Outcome so far

To develop human emotion estimation technology, we first conducted data cleansing on our existing database. Utilizing this refined database, we constructed machine learning models capable of estimating self-annotated emotion scores recorded in daily life.



For emotion state estimation based on spontaneous physical activity data, we developed a multi-task learning model that simultaneously estimates four emotional states (depressive mood, anxiety, positive mood, and negative mood) from local statistics of the physical activity data (>300 individuals with approximately 7,000 recordings). Our model archived an average absolute error of 0.2 (around 20% error of normalized scores) in the performance of estimating emotion scores. Additionally, we confirmed that an optimization approach of specific layers of the constructed network for each individual using transfer learning significantly improved the estimation accuracy.

For the emotion estimation based on speech data, we also developed a multi-task learning model to simultaneously estimate the nine emotions assessed by the Depression and Anxiety Mood Scale questionnaire (DAMS). This includes the following 9 emotions; vigorous, gloomy, concerned, happy, unpleasant, anxious, cheerful, depressed, and worried. The model utilized high-dimensional features extracted from 10 seconds speech data (approximately 20,000 recordings) as input signals. By incorporating personalization layers into the network structure, we achieved successful estimation of the nine emotions, with an average coincident correlation coefficient of 0.55 and a maximum of 0.61.

Our results are comparable to the highest accuracy achieved by models built on data acquired in environments where various factors are well-controlled (e.g., laboratory settings). This highlights the significance of our findings, as we were able to achieve the comparable level of accuracy using data from everyday life.

Regarding the assessment of psycho-physiological data in patients, we designed a research plan and submitted an application form to the ethics committee.

For the development of a translational IoT could system, we developed firmware for acceleration and photoplethysmography data processing on the ring-type wearable device. Additionally, we started integrating the ring-type device with the existing our IoT cloud system (both API and modem-type gateway integration). Furthermore, we conducted experiments to validate the feasibility of adapting the ring-type device for use with mice. Based on the results of these experiments, we designed a prototype tailored for animal use.

3. Future plans

- We plan to improve human emotion estimation by constructing multi-modal learning models that leverage various physiological signals, as well as enhancing feature extraction methods.
- We will gather clinical data and utilize them to develop emotion estimation models with clinical validity.
- We will continue to develop and improve the integration of the ring-type device with our existing IoT cloud system.
- We will proceed with the development a device designed for animal use and conduct its validation studies.

(NAKAMURA Toru: Kobe University
YAMAMOTO Yoshiharu: The University of Tokyo)

R&D Theme

Constructing a Universal Emotional State Space

Progress until FY2022

1. Outline of the project

This project aims to construct a `universal' emotional state space that transcends animal species. To achieve this, we measure a variety of psycho-physiological data from both wild-type mice and mice of disease models (mice with autism model exhibiting increased anxiety and fear-related behavior or mice with susceptibility or resilience to depression) under various conditions, including application of stimuli (Social Defeat Stress : SDS) or drug administrations that induce emotional responses. By combining the psycho-physiological data obtained from both mice and humans, we aim to construct a universal emotional state that possesses biological validity. This project is comprised of the following two research topics.

1. Development of universal emotional state estimation technology
   Summary: by combining IoT measurement data obtained from both mice and humans, we develop a universal emotional state space that transcends animal species and possesses biological validity.
2. Assessment of physiological data and emotional states in animals
   Summary: to construct the universal emotional state space, it is essential to obtain psycho-physiological data from animals. Therefore, we will measure a variety of physiological signals from both wild-type mice and mice of disease models (mice with autism model exhibiting increased anxiety and fear-related behavior or mice with susceptibility or resilience to depression) under various conditions, including application of stimuli (Social Defeat Stress : SDS) or drug administrations that induce emotional responses.

2. Outcome so far

To construct a universal emotional state space that transcends animal species, we investigated the application of transfer learning techniques to develop emotion estimation models for mice based on models originally developed for humans. Additionally, we examined how data from animals with specific conditions can be incorporated into the construction of emotion estimation models for humans.

Regarding the measurement of physiological signals in mice, we conducted the following tasks: 1) establishment of an experimental system dedicated to the measurement of physiological data in mice, 2) setup of an experimental environment for developing depressive mice models using social defeat stress (SDS), and 3) verification tests on a ring-type device aimed at measuring physiological data in mice.

In task 1), we evaluated the specifications of new measurement system capable of collecting physiological data, such as electrocardiogram, body temperature, blood pressure, and acceleration, in mice.

In setting up the experimental environment [task 2)], we allocated adequate space to conduct experiments such as the selection of highly aggressive ICR mice and the co-housing of ICR mice with stressed B6 mice. Given the need for space to conduct experiments involving the induction of social stress or post-stress social behavior tests, we made provisions for securing the necessary experimental space and installing the required equipment. Moreover, considering the need to use a large number of mice for social defeat stress experiments in this project, we also prepared separators to cohabitate ICR and B6 mice.

In task 3), we evaluated the feasibility of using a ring-type wearable device designed for humans to measure multiple physiological data in anesthetized mice. Based on the experimental results, we evaluated the optimal attachment sites on the mouse's body, as well as the appropriate size and shape of the device for mice.

3. Future plans

- We will validate the applicability of the emotion estimation model developed for humans to mice.
- We will attempt to construct a new emotion estimation model by utilizing data from both mice and humans.
- We will collect physiological data from mice, including those with SDS-induced stress.

(NAKAMURA Toru: Osaka University
YAMAMOTO Yoshiharu: The University of Tokyo
TAKUMI Toru: Kobe University)