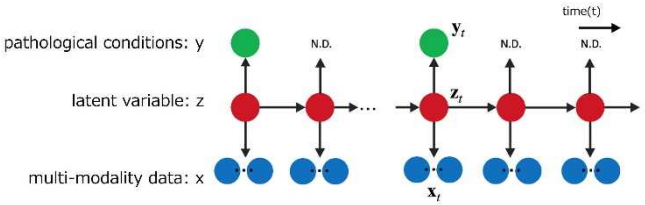
R&D item

5. Elucidation of Inter-Organ Networks in Dementias by AI and Mathematical Research

Progress until FY2023

1. Outline of the project

Our aim is to understand inter-organ networks by constructing data-driven mathematical models in animal models combined with human data. AI and machine learning techniques will be exploited to use the limited data we have collected from living organisms effectively by removing noise from the data and filling in missing values. Also, We will develop machine learning algorithms that can integrate mathematical models with human data, which enable estimation of the condition of each organ and identification of the early stages of dementia using non-invasive and cost-effective measurements in the preclinical 'ME-BYO' conditions.



$$z_{k,t+1}=F(z_{k,t})+\eta_{k,t} \quad x_{n,t}=Uz_{k,t}+u+\varepsilon_{n,t} \quad y_{k,t}=Vz_{k,t}+v+\xi_{k,t}$$

U, V: weight matrix
u, v: bias
ε_n, ξ_k, η_k: noise

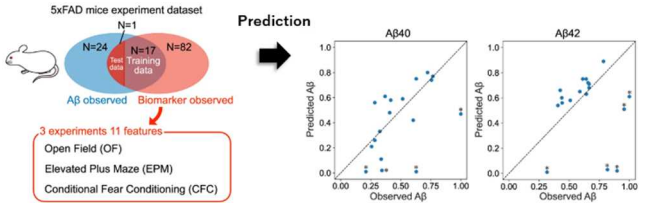
2. Achievement in 2023

Development of a Machine Learning Model to contribute to the Discovery of Early Indicators of Alzheimer's Disease

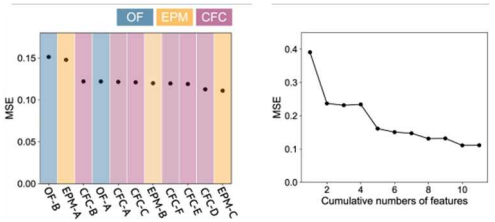
Alzheimer's disease (AD) is a disorder characterized by the progressive neuronal degeneration of the brain. Predominantly seen in the elderly, it is marked by memory decline and cognitive impairment. While the exact cause remains unclear, it is known that in the brains of Alzheimer's patients, the accumulation of a protein called amyloid-beta (Aβ) precedes neuronal degeneration. Current methods to assess the accumulation of Aβ in the brain are costly and invasive. Therefore, a simple and non-invasive biomarker that can predict the amount of Aβ accumulation, measurable from blood, urine, imaging, or other sources, would be highly useful for the early prediction of AD onset.

Typically, when using machine learning to predict Aβ accumulation from biomarkers, paired data (where both the biomarker and Aβ accumulation are observed in the same sample) is required. However, obtaining such paired data is costly and labor-intensive, which has been a barrier in biomarker discovery. In this context, a research group led by Honda Naoki and Yuichiro Yada at Hiroshima University developed a machine learning model that enables the quantitative prediction of Aβ accumulation even with limited paired data. This technological advancement is expected to facilitate the development of novel AD biomarkers based on the predictability of Aβ accumulation.

These research findings were published in the international academic journal npj Systems Biology and Applications" on November 23, 2023.



Using publicly available data where both behavioral characteristics and Aβ levels were measured, we demonstrated that the amount of Aβ in the brain can be estimated from three non-invasive behavioral analysis results.



It was suggested that it is important to use the results of multiple behavioral analyses, not just one, to predict the amount of Aβ.

3. Future plans

We will construct data-driven mathematical models for multimodal data obtained from animal models and preclinical human 'ME-BYO' cohorts to elucidate the transformation of the inter-organ network. We will also apply this to the achievement of prediction and prevention methods for dementia based on brain-organ interactions.