Wikno, 16th–20th September 2025

PREDICTION OF ALZHEIMER'S DISEASE USING NEURAL CDE AND OPTIMAL CONTROL TOOLS

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ABSTRACT

Alzheimer's disease (AD) is one of the reason of causing dementia. Dementia is mostly an aging disease and touches large group of older part each community. It could cause serious damage to memory. AD is pervaded by localized brain atrophies. It deteriorates the key biological functions of neurons, such as communication, metabolism, repair, remodelling, and regeneration. The typical symptoms of the disease are accumulation of amyloid-β ($A\beta$) plaques composed of $A\beta$ peptides, and neu-rofibrillary tangles (NFT) composed of hyperphosphorylated tau proteins. PET scans of the brain of people with AD show accumulation of $A\beta$ and NFT. Some of the scans prove high $A\beta$ and low tau, while others show low $A\beta$ and high tau. This gave rise to two different hypotheses. Based on PET scan patterns of high $A\beta$ and low tau, the amyloid hypothesis states that $A\beta$ aggregation triggers a chain of events that ultimately results in AD pathology, while based on patterns of low $A\beta$ and high tau, the tau hypothesis postulates that tau tangle pathology precedes the $A\beta$ plaques formation and that tau phosphorylation and aggregation are the main cause of AD. There exist several mathematical model that can produce patterns of $A\beta$ and τ as seen in PET scans of AD patients. We consider a certain simplified version of the known models, with parameter estimates based on, and validated by, clinical data for $A\beta$, tau proteins, microglia and neurons following [1]. We use this mathematical model described by five partial differential equations to derive a kind of Neural CDE (neural controller differential equation). It will serve as fundament to derive a new methodology (machine learning) to predict appearance of AD for patience with PET scan at the begging stage of observed dementia. Trying to predict next step in time series (in our case observed dementia) is still a challenging problem. Different type of machine learning methodologies are proposed. We suggest a novel approach to processing data, which have description by mathematical model. It is a kind of neural-controlled differential equation to evaluate time series. We develop a different learning methodology supported by optimal control tools to formulate a kind of verification theorem to predict the next step in the time series.

REFERENCES

[1] Chaeyoung Lee and Avner Friedman: *Generating PET scan patterns in Alzheimer's by a mathematical model*, PLoS ONE **19** (2024), 1–22.