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List of RGJ advisors 2023/2024

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Keywords: Dementia; Data Classification; Deep Learning; Optimization Algorithm; Screening

Summary of research:

Nowadays, the world has developed in science, technology, and medicine by combining and integrating various sciences. Using Big Data for medical innovation is important and depends on developing knowledge and methods combining technologies fundamental to developing new innovations for practical use. Screening for early detection and diagnosis brings it into the treatment process quickly, reducing the severity of the symptoms that will occur. And it is beneficial for medical treatment and physiotherapy for patients who are at risk for that disease. Our research aims to construct software for screening any disease using machine learning methods with datasets from hospital. We focus on extreme learning machine (ELM) which is a type of machine learning that is based on the concept of single-hidden layer feedforward networks (SLFNs). This ELM method, we can improve algorithms by optimization theory. The following researches are our results which were published from using ELM with new optimization algorithms:

1. Breast cancer screening
   - Peeyada, P., Dutta, H., Shiangjen, K., & Cholamjiak, W. (2023). A modified forward-backward splitting methods for the sum of two monotone operators with applications to breast cancer prediction. *Mathematical Methods in the Applied Sciences*, *46*(1), 1251-1265.
   - Peeyada, P., Suparatulatorn, R., & Cholamjiak, W. (2022). An inertial Mann forward-backward splitting algorithm of variational inclusion problems and its applications. *Chaos, Solitons & Fractals*, *158*, 112048.
2. Diabetes mellitus
   - Suantai, S., Yajai, W., Peeyada, P., Cholamjiak, W., & Chachvarat, P. (2023). A modified inertial viscosity extragradient type method for equilibrium problems application to classification of diabetes mellitus: Machine learning methods. *AIMS Mathematics*, *8*(1), 1102-1126.
3. Heart disease detection
   - Suantai, S., Peeyada, P., Fulga, A., & Cholamjiak, W. (2023). Heart disease detection using inertial Mann relaxed CQ algorithms for split feasibility problems. *AIMS Mathematics*, *8*(8), 18898-18918.

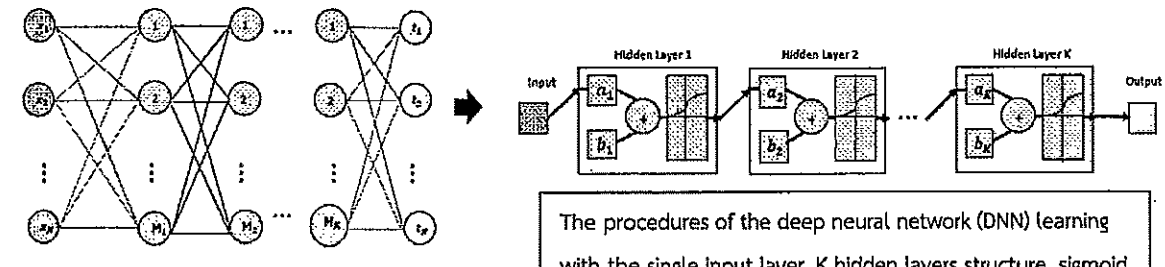
The comparison in above publications shows higher accuracy results than the previous method, but there is no trial to screen for dementia. However, the ELM method is a simple machine learning method because it consists of a single hidden layer. Thus, developing ELM by adding a multi-hidden layer to achieve new ways to get more efficient and accurate than the current method still is very interesting. The main goal of this research project is to develop software to screen dementia among the elderly using deep learning optimization with big data analysis.

Dementia in the elderly is a major public health problem worldwide. Care for the elderly and people with dementia is an important part of the general welfare system in Nordic countries, particularly in Sweden. Health and social care for the elderly are important parts of Swedish welfare policy. Of Sweden's 10 million inhabitants, 20 percent have passed the standard retirement age 65. This number is projected to rise to 23 per cent by 2040, partly because of the large number of

Swedes born in the 1940s [1]. The same is the situation of the elderly with dementia in Thailand. According to the incidence prevalence survey in 2005, it was found that the number of elderly people with dementia was as high as 229,100, and scholars estimate that Thailand will have at least 450,200 elderly people with dementia in the country. In 2020 and will increase to 3 times in 2050 [2]. The minimum budget is used to care for the elderly with dementia throughout Thailand, with a budget of over 1,810 million dollars a year [3]. In the future, Thailand will have more and more patients in this group. Economic problems, the public health system, and social problems arising from people and money used to care for older adults with dementia will increase accordingly [4]. Therefore, screening to detect and diagnose dementia early to quickly bring them into the treatment process is an appropriate approach. And it is beneficial for medical treatment and physical therapy rehabilitation for the elderly who are at risk of dementia to have a good quality of life able to help themselves. There are examples of research using machine learning to help screen for dementia [5,6,7,8,9].

Extreme learning machine (ELM) is a type of machine learning that is based on the concept of single-hidden layer feedforward networks (SLFNs) introduced by Huang et al. [10] And has been used to study and solve problems in various research projects such as research by Sun et al. [11], Wang et al. [12], Malathi et al. [13], and Minhas et al. [14] In 2006 Huang et al. [10] have proven that ELM is more effective than manual learning Gradient-based methods such as backpropagation. However, the original mathematical model was still used in determining the weight (weight) for predicting data by ELM, and the error was high. They were causing further development to solve such problems. For example, in 2011, Martínez-Martínez et al. [15] introduced a new ELM using the regularization method to determine ELM weights. Later, several researchers used ELM in machine learning to screen for dementia and found that the ELM method has a high accuracy which can be studied from the literature [16,17]. Recently, Jasim et al. [18] evaluated the performance of 12 algorithms implemented in ELM. The results indicated that the method was highly accurate but can still be improved to increase accuracy.

Recently, Thai mathematicians [19- 22] have proposed new algorithms based on optimization theory for machine learning using ELM to screen for breast cancer, heart disease, and diabetes. Higher accuracy results than the previous method, but there is no trial to screen for dementia. However, the ELM method is a simple machine learning method because it consists of a single hidden layer. Thus, developing ELM by adding a multi-hidden layer to achieve new ways to get more efficient and accurate than the current method still is very interesting. And can be applied to predict and classify various medical information efficiently and quickly. This will significantly benefit public health agencies, healthcare professionals, and those undergoing further screening for dementia. Multilayer extreme learning machine (ML-ELM) was first presented by Kasun et al. [23]. This machine learning model was inspired by Huang et al. [10], it is getting to be a widely used method in machine learning and deep learning applications. The training dataset is defined by $C := \{(x_n, t_n) : x_n \in \mathbb{R}^q, t_n \in \mathbb{R}^p, n = 1,2,\ldots,N, p, q \in \mathbb{N}\}$ where $\mathbb{N}$ is distinct samples, x_n is an input training data and t_n is a training target. The deep neuron network structure of ML-ELM is shown as follows:



The procedures of the deep neural network (DNN) learning with the single input layer, K hidden layers structure, sigmoid activation function and output layers

For any i^{th} hidden layer of ML-ELM with M_i nodes, the output at the j^{th} hidden node is

$$O_{ln} = \sum_{j=1}^{M_l} \beta_{lj} G(a_{lj} x_n + b_{ij}),$$

where G is an activation function, β_{lj}, a_{ij} and b_{lj} are parameters of the optimal output weight, randomly weight and bias at the j^{th} hidden node and i^{th} hidden layer, respectively. The feed-forward artificial neural network process is presented in K hidden layers structure, mathematically given as:

i) the first hidden layer $\begin{pmatrix} G(a_{11}x_1 + b_{11}) & G(a_{12}x_1 + b_{12}) & \cdots & G(a_{1M_1}x_1 + b_{1M_1}) \\ G(a_{11}x_2 + b_{11}) & G(a_{12}x_2 + b_{12}) & \cdots & G(a_{1M_1}x_2 + b_{1M_1}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{11}x_N + b_{11}) & G(a_{12}x_N + b_{12}) & \cdots & G(a_{1M_1}x_N + b_{1M_1}) \end{pmatrix} \begin{pmatrix} \beta_{11} \\ \beta_{12} \\ \vdots \\ \beta_{1M_1} \end{pmatrix} = \begin{pmatrix} o_{11} \\ o_{12} \\ \vdots \\ o_{1N} \end{pmatrix}$

ii) the second hidden layer $\begin{pmatrix} G(a_{21}O_{11} + b_{21}) & G(a_{22}O_{11} + b_{22}) & \cdots & G(a_{2M_2}O_{11} + b_{2M_2}) \\ G(a_{21}O_{12} + b_{21}) & G(a_{22}O_{12} + b_{22}) & \cdots & G(a_{2M_2}O_{12} + b_{2M_2}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{21}O_{1N} + b_{21}) & G(a_{22}O_{1N} + b_{22}) & \cdots & G(a_{2M_2}O_{1N} + b_{2M_2}) \end{pmatrix} \begin{pmatrix} \beta_{11} \\ \beta_{12} \\ \vdots \\ \beta_{2M_2} \end{pmatrix} = \begin{pmatrix} o_{21} \\ o_{22} \\ \vdots \\ o_{2N} \end{pmatrix}$

iii) the K hidden layer $\begin{pmatrix} G(a_{K1}O_{(k-1)1} + b_{K1}) & G(a_{K2}O_{(k-1)1} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)1} + b_{KM_K}) \\ G(a_{K1}O_{(k-1)2} + b_{K1}) & G(a_{K2}O_{(k-1)2} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)2} + b_{KM_K}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{K1}O_{(k-1)N} + b_{K1}) & G(a_{K2}O_{(k-1)N} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)N} + b_{KM_K}) \end{pmatrix} \begin{pmatrix} \beta_{K1} \\ \beta_{K2} \\ \vdots \\ \beta_{KM_K} \end{pmatrix} = \begin{pmatrix} o_{K1} \\ o_{K2} \\ \vdots \\ o_{KN} \end{pmatrix}$

The goal of ML-ELM is to find the optimal output weight $\beta_K = [\beta_{K1}, \beta_{K2}, \ldots, \beta_{KM_K}]^T$ that making $[O_{K1}, O_{K2}, \ldots, O_{KN}]^T = [t_1, t_2, \ldots, t_N]^T$. Thus, these problems are the linear problems (LB) $H_l\beta_l = T_l$ where $H_l = \begin{pmatrix} G(a_{l1}O_{(l-1)1} + b_{l1}) & G(a_{l2}O_{(l-1)1} + b_{l2}) & \cdots & G(a_{lM_l}O_{(l-1)1} + b_{lM_l}) \\ G(a_{l1}O_{(l-1)2} + b_{l1}) & G(a_{l2}O_{(l-1)2} + b_{l2}) & \cdots & G(a_{lM_2}O_{(l-1)2} + b_{lM_l}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{l1}O_{(l-1)N} + b_{l1}) & G(a_{l2}O_{(l-1)N} + b_{l2}) & \cdots & G(a_{lM_2}O_{(l-1)N} + b_{lM_l}) \end{pmatrix}$, $O_{0n} = x_n, \beta_l = [\beta_{l1}, \beta_{l2}, \ldots, \beta_{lM_l}]^T$ and $T_l = [O_{l1}, O_{l2}, \ldots, O_{lN}]^T$. From the study problem model LB of multilayer ELM, the researcher found that an optimization algorithm can solve LB and its regularization to get an optimal-fitting model for deep learning. The main goal of this research project is to develop software to screen dementia among the elderly using deep learning optimization with big data analysis. Models to predict new data for medical and public health personnel in government agencies resulting in accuracy and speed in receiving the examination. It also reduces government spending on screening and treating patients.

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แบบเสนอโครงการวิจัย (Research Project)

ประกอบการเสนอขอทุนอุดหนุนการวิจัยของสำนักงานการวิจัยแห่งชาติ (วช.)

โครงการปริญญาเอกกาญจนาภิเษก (คปก.) ภายใต้ความร่วมมือไตรภาคีไทย-สวีเดน ประจำปี ๒๕๖๗

1. **Project title:** Efficient Optimization Algorithms for Applying in Dementia Screening Using Deep Learning Technique

   อัลกอริทึมการหาค่าเหมาะที่สุดที่มีประสิทธิภาพสำหรับการคัดกรองโรคสมองเสื่อมโดยใช้เทคนิคการเรียนรู้เชิงลึก

2. **Name of advisor:** Assoc. Prof. Dr. Watcharaporn Cholamjiak

   รศ.ดร. วัชรภรณ์ ช่อลำเจียก

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   Mobile:+66-89-5583-052; Office:+66-546-6666; Fax:+66-546-6664; Email:watcharaporn.ch@up.ac.th

3. **Research area:** Mathematics

4. **Research stakeholders:** University of Phayao hospital

5. **Keyword:** Dementia; Data Classification; Deep Learning; Optimization Algorithm; Screening

6. **Problem statement and significance of research**

According to estimates from the World Health Organization, the number of people living with dementia will double almost every 20 years for the foreseeable future. While in 2010 there were 35.6 million people with dementia worldwide, this number is expected to increase to 65.7 million by 2030 and to 115.4 million by 2050. Dementia is another type of non-communicable disease that is often found in the elderly, which affects older people with impairments in cognitive function in terms of memory and cognition, for example, causing problems in language use, movement involving life skills impairments, and environmental awareness, including issues in planning decisions.

Thailand is among the fastest-aging countries in the world. Of its 67 million population, 12 million Thais are elderly, according to the latest national statistics report. Since 2005, the country has been classified as an 'aged society' as people aged 60 years and above accounted for 10% of the population. It is expected that the country's elderly population will increase to 28% and that Thailand will become a 'super-aged society' by the next decade. With advances in the health care system, the number and proportion of people aged 60 years and older are rising both in Thailand and globally. In 2019, more than one billion of the world's population was above the age of 60. This is expected to increase to 1.4 billion by 2030 and 2.1 billion by 2050. The same as in Sweden, of Sweden's 10 million inhabitants, 20 per cent have passed the standard retirement age of 65. This number is projected to rise to 23 per cent by 2040, partly because of the many Swedes born in the 1940s. In this regard, preparations to support the situation of an aging society are therefore important issues. Because the elderly is a health risk group that affects the healthcare budget. Therefore, promoting the health of the elderly to have desirable health behaviors is an important issue to reduce the economic burden of the country, society, and family. To the increasing trend of the number of the elderly population, the number of people at risk of dementia has also increased. Therefore, screening to detect and diagnose dementia early to quickly bring them into the treatment process is an appropriate approach. And it is beneficial for medical treatment and physical therapy rehabilitation for the elderly who are at risk of dementia to have a good quality of life and be able to help themselves.

The above data shows that the rapid increase in the elderly population requires the government to prepare things such as planning for medical professionals and a large budget. However, the number of doctors specializing in such diseases is limited and needs to be increased to provide patients with services. Therefore, the use of technology-based knowledge related to artificial intelligence or machine learning, including deep learning is the basis for creating tools or innovations that are efficient and accurate in assisting medical personnel in screening and diagnosing diseases are therefore very useful and can be taken immediately.

7. Hypothesis

A new optimization algorithm can use in multilayer extreme learning machine to screen dementia and has more efficiency than the other machine learning methods.

8. Objectives

1. To design new optimizer for multilayer extreme learning machine for screening dementia in the elderly.
2. To publish researches in the international journals indexed in Scopus/WoS Q1-Q2 database.
3. To develop software for screening dementia in the elderly.

9. Literature Review

Dementia in the elderly is a major public health problem worldwide. Care for the elderly and people with dementia is an important part of the general welfare system in Nordic countries, particularly in Sweden. Health and social care for the elderly are important parts of Swedish welfare policy. Of Sweden's 10 million inhabitants, 20 percent have passed the standard retirement age 65. This number is projected to rise to 23 per cent by 2040, partly because of the large number of Swedes born in the 1940s [1]. The same is the situation of the elderly with dementia in Thailand. According to the incidence prevalence survey in 2005, it was found that the number of elderly people with dementia was as high as 229,100, and scholars estimate that Thailand will have at least 450,200 elderly people with dementia in the country. In 2020 and will increase to 3 times in 2050 [2]. The minimum budget is used to care for the elderly with dementia throughout Thailand, with a budget of over 1,810 million dollars a year [3]. In the future, Thailand will have more and more patients in this group. Economic problems, the public health system, and social problems arising from people and money used to care for older adults with dementia will increase accordingly [4]. Therefore, screening to detect and diagnose dementia early to quickly bring them into the treatment process is an appropriate approach. And it is beneficial for medical treatment and physical therapy rehabilitation for the elderly who are at risk of dementia to have a good quality of life able to help themselves. There are examples of research using machine learning to help screen for dementia [5,6,7,8,9].

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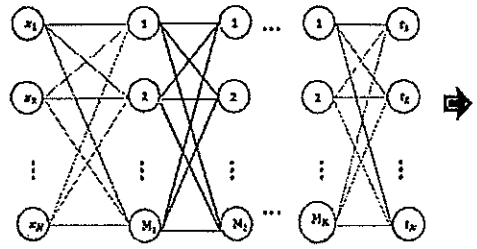

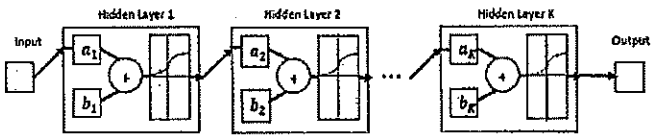

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$$O_{in} = \sum_{j=1}^{M_i} \beta_{ij} G(a_{ij} x_n + b_{ij}),$$

where G is an activation function, β_{ij}, a_{ij} and b_{ij} are parameters of the optimal output weight, randomly weight and bias at the j^{th} hidden node and i^{th} hidden layer, respectively. The feed-forward artificial neural network process is presented in K hidden layers structure, mathematically given as:

i) the first hidden layer $\begin{pmatrix} G(a_{11}x_1 + b_{11}) & G(a_{12}x_1 + b_{12}) & \cdots & G(a_{1M_1}x_1 + b_{1M_1}) \\ G(a_{11}x_2 + b_{11}) & G(a_{12}x_2 + b_{12}) & \cdots & G(a_{1M_1}x_2 + b_{1M_1}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{11}x_N + b_{11}) & G(a_{12}x_N + b_{12}) & \cdots & G(a_{1M_1}x_N + b_{1M_1}) \end{pmatrix} \begin{pmatrix} \beta_{11} \\ \beta_{12} \\ \vdots \\ \beta_{1M_1} \end{pmatrix} = \begin{pmatrix} o_{11} \\ o_{12} \\ \vdots \\ o_{1N} \end{pmatrix}$

ii) the second hidden layer $\begin{pmatrix} G(a_{21}O_{11} + b_{21}) & G(a_{22}O_{11} + b_{22}) & \cdots & G(a_{2M_2}O_{11} + b_{2M_2}) \\ G(a_{21}O_{12} + b_{21}) & G(a_{22}O_{12} + b_{22}) & \cdots & G(a_{2M_2}O_{12} + b_{2M_2}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{21}O_{1N} + b_{21}) & G(a_{22}O_{1N} + b_{22}) & \cdots & G(a_{2M_2}O_{1N} + b_{2M_2}) \end{pmatrix} \begin{pmatrix} \beta_{11} \\ \beta_{12} \\ \vdots \\ \beta_{2M_2} \end{pmatrix} = \begin{pmatrix} o_{21} \\ o_{22} \\ \vdots \\ o_{2N} \end{pmatrix}$

iii) the K hidden layer $\begin{pmatrix} G(a_{K1}O_{(k-1)1} + b_{K1}) & G(a_{K2}O_{(k-1)1} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)1} + b_{KM_K}) \\ G(a_{K1}O_{(k-1)2} + b_{K1}) & G(a_{K2}O_{(k-1)2} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)2} + b_{KM_K}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{K1}O_{(k-1)N} + b_{K1}) & G(a_{K2}O_{(k-1)N} + b_{K2}) & \cdots & G(a_{KM_K}O_{(k-1)N} + b_{KM_K}) \end{pmatrix} \begin{pmatrix} \beta_{K1} \\ \beta_{K2} \\ \vdots \\ \beta_{KM_K} \end{pmatrix} = \begin{pmatrix} o_{K1} \\ o_{K2} \\ \vdots \\ o_{KN} \end{pmatrix}$

The goal of ML-ELM is to find the optimal output weight $\beta_K = [\beta_{K1}, \beta_{K2}, \ldots, \beta_{KM_K}]^T$ that making $[O_{K1}, O_{K2}, \ldots, O_{KN}]^T = [t_1, t_2, \ldots, t_N]^T$. Thus, these problems are the linear problems (LB) $H_i\beta_i = T_i$ where $H_i = \begin{pmatrix} G(a_{i1}O_{(i-1)1} + b_{i1}) & G(a_{i2}O_{(i-1)1} + b_{i2}) & \cdots & G(a_{iM_i}O_{(i-1)1} + b_{iM_i}) \\ G(a_{i1}O_{(i-1)2} + b_{i1}) & G(a_{i2}O_{(i-1)2} + b_{i2}) & \cdots & G(a_{iM_i}O_{(i-1)2} + b_{iM_i}) \\ \vdots & \vdots & \vdots & \vdots \\ G(a_{i1}O_{(i-1)N} + b_{i1}) & G(a_{i2}O_{(i-1)N} + b_{i2}) & \cdots & G(a_{iM_i}O_{(i-1)N} + b_{iM_i}) \end{pmatrix}$, $O_{0n} = x_n, \beta_i = [\beta_{i1}, \beta_{i2}, \ldots, \beta_{iM_i}]^T$ and $T_i = [O_{i1}, O_{i2}, \ldots, O_{iN}]^T$. From the study problem model LB of multilayer ELM, the researcher found that an optimization algorithm can solve LB and its regularization to get an optimal-fitting model

for deep learning. The main goal of this research project is to develop software to screen dementia among the elderly using deep learning optimization with big data analysis. Models to predict new data for medical and public health personnel in government agencies resulting in accuracy and speed in receiving the examination. It also reduces government spending on screening and treating patients.

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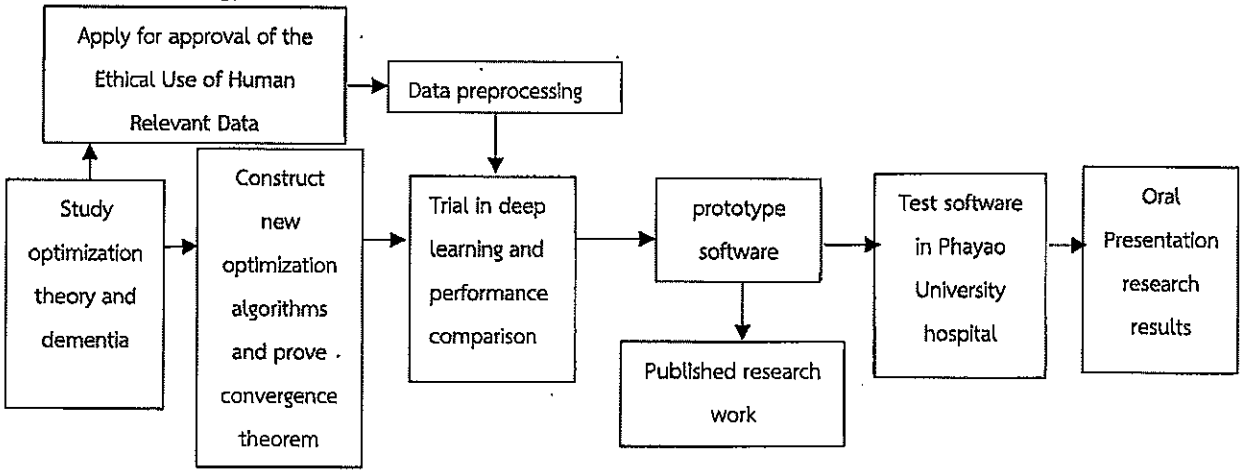
10. Methodology



11. Scope of the study

The scope of research is to investigate new powerful optimization algorithms to determine the optimal weight used in multilayer ELM classifications to screen dementia. The convergence behavior is reported to show the proposed methods' efficiency and implementation. Showing the comparison with other machine learning methods and practical, real-world experiments in dementia screening at Phayao University hospital.

12. Output/ Outcome/ Impact

1. Two papers of publication in Scopus/WoS database with impact factor Q1-Q2.
2. Three times oral presentations of research results in international conferences/seminars.
3. One software of screening dementia.