XVII Simposio CEA de Control Inteligente

27-29 de junio de 2022, León

Machine Learning and Metaheuristic based for Alzheimer's Disease Diagnosis

Akbar, O. A.[a], Lopez-Guede, J. M.[b], Alyaqoobi, H. I.[c], Rahebi, J.[d]

[a] Systems and Automatic Control Department, University of the Basque Country (UPV/EHU), Spain
[b] Systems and Automatic Control Department, University of the Basque Country (UPV/EHU), Spain
[c] Systems and Automatic Control Department, University of the Basque Country (UPV/EHU), Spain
[d] Department of Software engineering, Istanbul Topkapi University, Istanbul, Turkey.

To cite this article: Akbar, O. A., Lopez-Guede, Alyaqoobi, H. I., Rahebi, J. 2022. Machine Learning and Metaheuristic based for Alzheimer's Disease Diagnosis. XVII Simposio CEA de Control Inteligente.

Abstract

Alzheimer's disease was first described in 1907 by Alois Alzheimer. It is a progressive neurological disorder with a gradual onset of dementia. Although Alzheimer's was initially a rare disease, it is now one of the most common diseases in the elderly and is the fourth most common cause of death in this age group in the rankings. In this paper, we present a new methods of group intelligence to improve image threshold in Alzheimer's diagnosis. The challenge of this method is the uncertainty of meta-heuristic methods in solving optimization problems.

Keywords: Alzheimer's Disease Diagnosis, Machine Learning, Feature selection, Fishier Mantis Optimizer (FMO).

1. Introduction

Spontaneous activities of Tosa straw rs-fMRI are measured, summarized by a number of distinct resting-state networks (RSNs) with similar temporal properties (Moussa et al., 2012). SMRI-based images have been used (Howseman & Bowtel, 1999)(Moussa et al., 2012)(Wolz et al., 2011). In sMRI images, structural adaptations refer to physical or synaptic networks that form a bunch of neurons or neural elements together.

Graph theory is a good tool for studying the organization of brain network topology based on rs-fMRI data. In addition to the power of interconnection, the study of the brain network can also determine the directions of interconnection. Graph theory is a method that analyzes the networks in the brain and examines them and has many applications in identifying different diseases (Supekar et al., 2008). Recent studies have shown that the combination of graph theory and machine learning methods based on functional images leads to accurate isolation of Alzheimer's patients (Armstrong et al., 2016).

The use of structural images in the diagnosis of Alzheimer's disease has been the focus of researchers from the past to the present. However, the use of these images has been problematic for researchers due to the limited extraction features and the subsequent accuracy of the prediction. In this article, we try to achieve an acceptable percentage of accuracy by extracting the most and most effective features from these images by using sMRI images.

2. Literature review

In (Wolz et al., 2011), Mr. Cheng et al. Used a combination of sMRI and PET images and experimental samples taken from cerebrospinal fluid to isolate patients who developed Alzheimer's disease and patients who remained mildly disturbed. In this study, an attempt was made to improve the prediction accuracy by combining information containing several diagnostic methods. Separation accuracy was reported at 73% in this paper.

No studies have been performed on the prediction of Alzheimer's disease based on rs-fMRI-based Alzheimer's disease. Rs-fMRI imaging is a powerful tool for mapping and evaluating the function of different brain networks (Van Den Heuvel & Pol, 2010). In recent years, many resistances to the diagnosis of Alzheimer's disease based on this type of imaging have been examined (Khazaee et al., 2016)(Khazaee et al., 2015)(Liu et al., 2012)(Greicius et al., 2003).

In (Khazaee et al., 2016)(Zhang et al., 2012), Mr. Khazaee studied the basics of diagnosing and isolating Alzheimer's patients from normal people and people with mild behavioral disorders. In this study, Mr. Khazaei tried to create an automated method for separating these three groups of samples by using the graph theory method based on functional images.

The most important feature of this paper is to provide an accurate and automated method for predicting Alzheimer's disease based on Garaf's theoretical method and structural statistical estimates of the brain. In addition, in this study, the features that have the highest separation power between groups are found using soft computational algorithms. Another innovation of this study is the use of an rs-fMRI and its combination with sMRI in which it is from two different atoms to define network nodes and structural areas of the brain.

Previous AD or MCI studies have used structural equations, which provide a segmentation based on overlapping structural units. Brain segmentation based on structural features cannot adequately represent the functional network of the brain. This study presents a segmentation based on 111 general functional regions for rs-fMRI data. In the feature selection section, for the first time in the prediction of Alzheimer's disease, the creation of a single and two-objective algorithm for selecting the best features has been used and good results have been obtained.

It is a general term that refers to the reduction of the ability of "dementia" or mental, to the extent that it interferes with daily life (memory loss is a clear symptom of this disease). Alzheimer's is the most common form of dementia Co n Hokke et al., 2012). In general, there are several factors in the incidence of Alzheimer's disease, which are shown in Figure 1:

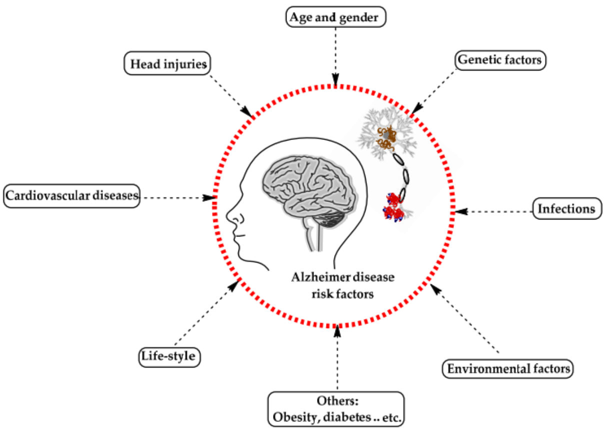

Fig. 1. Different factors in the incidence of Alzheimer's disease (Breijyeh & Karaman, 2020)

According to the above figure, it can be said that there are various factors in the incidence of Alzheimer's disease, including lifestyle, cardiovascular disease, head or brain surgery, age, gender, genetic factors, infection, environmental factors, He mentioned underlying diseases such as diabetes and so on. In Alzheimer's disease, spherical protein structures form outside the neurons in some areas of the brain, as well as filamentous protein structures in the cell body of neurons. The spherical protein structures that result from Alzheimer's disease are called amyloid bodies. In Alzheimer's disease, brain tissue is damaged and parts of nerve neurons become deformed. Figure 1 shows the structure of brain tissue that is asymptomatic of Alzheimer's and it can be seen that the size of the gray area of the brain is normal in a healthy person. For a better comparison in Figure 2, it can be seen that the structures of a person with Alzheimer's disease are damaged, the gray area of the brain is reduced, and areas of plaque appear in nerve neurons:

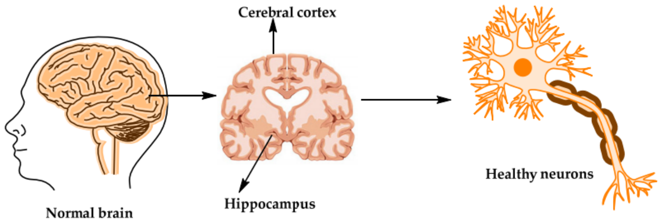

Fig. 2. The structure of a healthy person's brain and nerve cells (Breijyeh & Karaman, 2020)

3. Methodology

Mantis is known as one of the predatory insects .Moths are green, locust-like insects with long legs, large heads, and two pairs of wings (Figure 3, a). Mantis lives in the tropics, and some live in temperate regions. When the mantis stands quietly, he holds his front legs forward like two hands, and in this position, it is like reciting a prayer. After mating, the female moth hunts and feeds on the opposite sex. Some types of mantis can rotate their head at an angle of 180 degrees and use it to scan the environment. Most of these insects live in the foliage of trees and disguise themselves as small branches to deceive their prey. Mantis is arthropod hunters. Most mantis is ambush hunters who feed only on the live prey available to them. They disguise themselves and stay still and wait for the victim to approach. They can chase their victim with slow movements. Sometimes mantis eats smaller ones. They also eat small vertebrates such as lizards, frogs, fish, and birds. A type of mantis is famous for its strange behavior in hunting fish. These fish-eating moths have been hiding in a pond continuously for five days, waiting to catch a fish at the right time. The mantis can hunt two ebony fish every day. They can catch up to nine fish in five days and eat their prey over time. Figure 3, b, shows a fish-eating mantis camouflaging and hunting fish:

a b

Fig. 3. a) mantis and b) fish-eating mantis

The fishier mantis has a set of intelligence hunting behaviors. These insects can consider several situations and move in these situations. The optimal position for the mantis is the location of the prey or fish. The fishier mantis also has homogenous behaviors. The fishier mantis has behaviors in preparation for attacking or giving up hunting in its current state, which is described below.

In the fishier mantis optimizer algorithm, a fishier mantis first considers a number of random situations in the problem space.

Each of these situations is assumed to be a solution, and the fishier mantis tries to put you in a position that is closer to the optimal solution. The initial positions or solutions in Equation (1) are formulated and using the objective function, each of the situations can be evaluated according to Equation (2):

$$Mantis = \begin{bmatrix} X_{11}, X_{12}, X_{13}, \ldots, X_{1d} \\ X_{21}, X_{22}, X_{23}, \ldots, X_{2d} \\ X_{31}, X_{32}, X_{33}, \ldots, X_{3d} \\ \vdots \\ X_{n1}, X_{n2}, X_{n3}, \ldots, X_{nd} \end{bmatrix} \quad (1)$$

In this equation, X_{ij} is the solution of its i-th solution and then its j-th. In the first iteration, a random population is created from solutions such as Equation (2) (Patibandla & Narayana, n.d.):

$$F(Mantis) = \begin{bmatrix} Fittness(X_{11}, X_{12}, X_{13}, \ldots, X_{1d}) \\ Fittness(X_{21}, X_{22}, X_{23}, \ldots, X_{2d}) \\ Fittness(X_{31}, X_{32}, X_{33}, \ldots, X_{3d}) \\ \vdots \\ Fittness(X_{n1}, X_{n2}, X_{n3}, \ldots, X_{nd}) \end{bmatrix} \quad (2)$$

In the equation, $Mantis$ and $F(Mantis)$ are the matrices of solutions or situations and their degree of competence, respectively. In the equation in question, X_i is equal to the last i, and this solution has d dimensions such as $X_{i1}, X_{i2}, X_{i3}, \ldots, X_{id}$. Equation (3) is used to create random solutions:

$$X_i = L + (U - L) \times rand(0,1) \quad (3)$$

In this equation, rand(0,1) is a random vector between zero and one with a uniform distribution. L and U are the lower and upper ranges of the problem space, respectively.

In the proposed method, several innovations for the diagnosis of Alzheimer's disease are presented based on magnetic resonance imaging of the brain. In the proposed method, two layers of classification and zoning are considered for images. In the zoning layer, Atsu multi-level thresholding is used to find damaged areas of brain tissue, and in order to reduce the time of implementation of this algorithm in high-thresholds, new group intelligence methods introduced in 2021 The presented is used as a mantis algorithm.

The reason for using Fishier Mantis Optimizer algorithm is that the algorithm is more accurate in finding optimal solutions due to its strong modeling. Several stages are also used in the classification phase. First, with the improved methods of the middle filter, the noise of the magnetic resonance images of the brain is eliminated and the feature selection phase is performed with the mantis algorithm, and then the images are considered as input of several learning methods. Images can be classified into malignant and benign.

4. Conclusion

In this paper a new method based on group learning that used the Fisher mantis is presented to Alzheimer disease diagnosis. This algorithm used from the inspired nature of the fisher mantis behavior. In this paper, the Alzheimer disease diagnosis presented based on magnetic resonance imaging of the brain. In the proposed method, Otsu multi-level thresholding is used to find damaged areas of brain tissue, and this algorithm is used in order to reduce the time of implementation.

References

Armstrong, C. C., Moody, T. D., Feusner, J. D., McCracken, J. T., Chang, S., Levitt, J. G., Piacentini, J. C., & O'Neill, J. (2016). Graph-theoretical analysis of resting-state fMRI in pediatric obsessive–compulsive disorder. *Journal of Affective Disorders*, *193*, 175–184.

Breijyeh, Z., & Karaman, R. (2020). Comprehensive review on Alzheimer's disease: Causes and treatment. *Molecules*, *25*(24), 5789.

Co n o e .E. Elting . . i nen rg .A. . n S ieten .C. (2012). Genetics of dementia: update and guidelines for the clinician. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *159*(6), 628–643.

Day, B. L., Ocal, D., Peters, A., Bancroft, M. J., Cash, D., Kaski, D., Crutch, S. J., & Yong, K. X. X. (2022). Altered visual and haptic verticality perception in posterior cortical atrophy and Alzheimer's disease. *The Journal of Physiology*, *600*(2), 373–391.

Greicius, M. D., Krasnow, B., Reiss, A. L., & Menon, V. (2003). Functional connectivity in the resting brain: a network analysis of the default mode hypothesis. *Proceedings of the National Academy of Sciences*, *100*(1), 253–258.

Howseman, A. M., & Bowtel, R. W. (1999). Functional magnetic resonance imaging: imaging techniques and contrast mechanisms. *Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences*, *354*(1387), 1179–1194.

Khazaee, A., Ebrahimzadeh, A., & Babajani-Feremi, A. (2015). Identifying patients with Alzheimer's disease using resting-state fMRI and graph theory. *Clinical Neurophysiology*, *126*(11), 2132–2141.

Khazaee, A., Ebrahimzadeh, A., & Babajani-Feremi, A. (2016). Application of advanced machine learning methods on resting-state fMRI network for identification of mild cognitive impairment and Alzheimer's disease. *Brain Imaging and Behavior*, *10*(3), 799–817.

Liu, Z., Zhang, Y., Bai, L., Yan, H., Dai, R., Zhong, C., Wang, H., Wei, W., Xue, T., & Feng, Y. (2012). Investigation of the effective connectivity of resting state networks in Alzheimer's disease: a functional MRI study combining independent components analysis and multivariate Granger causality analysis. *NMR in Biomedicine*, *25*(12), 1311–1320.

Moussa, M. N., Steen, M. R., Laurienti, P. J., & Hayasaka, S. (2012). *Consistency of network modules in resting-state FMRI connectome data*.

Patibandla, R. S. M. L., & Narayana, V. L. (n.d.). Computational Intelligence Approach for Prediction of COVID-19 Using Particle Swarm Optimization. In *Computational Intelligence Methods in COVID-19: Surveillance, Prevention, Prediction and Diagnosis* (pp. 175–189). Springer.

Salehi, A. W., Baglat, P., & Gupta, G. (2020). Alzheimer's disease diagnosis using deep learning techniques. *Int. J. Eng. Adv. Technol*, *9*(3), 874–880.

Supekar, K., Menon, V., Rubin, D., Musen, M., & Greicius, M. D. (2008). Network analysis of intrinsic functional brain connectivity in Alzheimer's disease. *PLoS Computational Biology*, *4*(6), e1000100.

Van Den Heuvel, M. P., & Pol, H. E. H. (2010). Exploring the brain network: a review on resting-state fMRI functional connectivity. *European Neuropsychopharmacology*, *20*(8), 519–534.

Wolz, R., Julkunen, V., Koikkalainen, J., Niskanen, E., Zhang, D. P., Rueckert, D., Soininen, H., Lötjönen, J., & Initiative, A. D. N. (2011). Multi-method analysis of MRI images in early diagnostics of Alzheimer's disease. *PloS One*, *6*(10), e25446.

Zhang, D., Shen, D., & Initiative, A. D. N. (2012). Predicting future clinical changes of MCI patients using longitudinal and multimodal biomarkers. *PloS One*, *7*(3), e33182.