International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor (2018): 7.426

Development of an Algorithm using Machine Learning in Early Diagnosis of Dementia with the help of the Clinical and Multimodality Structural and Functional Volumetric Data

Dr. Prithvijit Chakraborty

Resident, Department of Radiodiagnosis, Medical College & Hospital, Kolkata, India

Abstract: ***Background: Dementia is the most prevalent degenerative disease in elderly whose progression can only be prevented or delayed by early diagnosis. In this study, we proposed a two-layer model algorithm using machine learning techniques. Materials and Methods: Clinical and multimodality structural and functional volumetric data were collected from patients who received dementia screening from May 2016 to May 2017 at our institute and were stored in the programme. Now, from June 2017 to October 2017, imaging data of clinically normal patients having strong risk of dementia were analysed and a predesigned questionnaire was applied on them. They were categorised by the machine as normal or abnormal according to the previously fed data. Random Forest ,Bayes Network, Logistic Regression and F-measure were used for analysis of the algorithm. Now, a year later, from June 2018 to October 2018 those people were again followed up for incidence of Mild Cognitive Impairment (MCI) and Dementia. Results: It was found that using the proposed algorithm the program could diagnose 23.8% preclinical dementia cases , saving a year of lead time. Conclusion: Hence, this programme can save time and economic burden and can take a crucial role in early diagnosis of dementia.***

1. Introduction

Dementia is the most prevalent degenerative disease in elderly whose progression can only be prevented or delayed by early diagnosis. It is defined as multiple cognitive impairments with loss of functional skills related to those cognitive impairments without an altered level of consciousness. Correct diagnosis of dementia requires **historical data, physical exam, cognitive testing, laboratory studies** and **imaging**. Although diagnostic accuracy using clinical criteria for probable dementia is about 88% compared to post-mortem diagnosis, most often there is average delay of **4 years** between symptom onset and earliest physician contact, which usually relates to the patient's social embarrassment about having a memory problem. At this point of the disease, physicians are less able to slow the progression and minimize debilitating behavioural effects of the dementia. Early detection and correct diagnosis can lead to disease-retarding therapies which can slow disease progression and reduce patient and caregiver stress and morbidities. **Machine Learning** methods can simplify the task of early classification of the patient by constructing a set of criteria and can have pivotal role in early diagnosis of dementia[1].

2. Materials and Methods

Approval from institutional ethics committee were obtained.

Inclusion criteria:

1) Clinically normal patients having **high risk of dementia** (e.g Family History of dementia in 1st degree relatives, diabetes, high LDL cholesterol, high homocysteine level, atherosclerosis etc)
2) Patients who gave consent to take part in the study.

Exclusion criteria

1) Patients of delirium.
2) Patients of primary depression.

Clinical and multimodality structural and functional volumetric data were collected from patients who received dementia screening from **May 2016** to **May 2017** at our institute and were stored in the programme. Now, from **June 2017** to **October 2017**, imaging data of clinically normal patients having strong risk of dementia were analysed and a predesigned questionnaire was applied on them.

The **Blessed Orientation-Memory-Concentration (BOMC) test** and **Functional activities questionnaire (FAQ)** were used in this regard. The BOMC consists of six questions and the FAQ consists of ten questions. Together they provide a simple means of assessing cognitive and functional status. The answers to these questions were extracted from the UCI ADRC relational database of over 2,000 variables per subject visit to compute the BOMC and FAQ scores[2]. Each subject was categorized as either unimpaired or cognitively impaired but not meeting criteria for dementia according to the previously fed data. Random Forest ,Bayes Network, Logistic Regression and F-measure were used for analysis of the algorithm. Now, a year later, from June 2018 to October 2018 those people categorised as cognitively impaired but not meeting criteria for dementia were again followed up for incidence of Mild Cognitive Impairment (MCI) and Dementia as per clinical criteria.

3. Results

Between June 2017 to October 2017, 159 patients were screened by the combination of machine learning using multimodality structural and functional volumetric data and BOMS and FAQ data. **75** patients were categorized as cognitively impaired but not meeting criteria for dementia

and 84 patients were categorised as unimpaired. A year later, from June 2018 to October 2018 when those 75 people were assessed again for incidence of dementia using clinical and laboratoey data, it was found that **23.8%** people had developed **either mild cognitive impairment (MCI)** or **dementia**. Among them, majority **(61.1%)** developed mild cognitive impairment whereas 16.7% developed vascular dementia, 11.1% developed Alzheimer's dementia and 5.5% developed frontotemporal lobar degeneration and mixed dementia, each. The sensitivity and specifity of the approach using machine learning and multimodality volumetric data was better than the approach using clinical and laboratory data by 19.3% and 16%, respectively.

4. Discussion

From the above study, it can be inferred that the approach using machine learning and multimodality structural and functional volumetric imaging data has **better sensitivity, specificity, positive predictive value and negative predictive value** than the approach using clinical and laboratory data. In the present study it can diagnose **23.8% cases of subclinical dementia leaving a lead time of one year, which is very significant.** Most of them had developed mild cognitive impairment which is treatable to quite good extent. This means the approach is also significant from the therapeutic point of view. More aspects of this approach should be explored, such as how it performs in general population, **how pattern recognition parameters can be developed** so that incorporation of **artificial intelligence** can be done in large scale **screening** and **detection** of dementia, etc.

5. Conclusion

This analysis demonstrates that the **FAQ** and **BOMC** tests, used in conjunction with **Machine Learning** methods **improve the detection** capacity and lessen the lead time to diagnosis of preclinical dementia over the use of the FAQ and BOMC tests using clinical and laboratory criteria. **Moreover, there is increased accuracy in classifying clinically significant dementia patients due to incorporation of multimodality structural and functional volumetric imaging data.** Also, the **screening time gets reduced to a large extent** due to incorporation of machines compared to human analogues. Since the FAQ and BOMC tests require minimal training to give and perform, they along with multimodality structural and functional volumetric imaging data can be used in variety of health care. Future research will focus on developing **pattern recognition parameters** for artificial intelligence and formation of an accurate guideline **to classify subclinical and clinically significant dementia patients with the help of machine learning and multimodality structural and functional volumetric imaging data**.

6. Conflicts of Interest

There are no conflicts of Interest.

References

[1] R Kohavi, G John, et al. "Mlc++: a machine learning library in c++ in Tools for Artificial Intelligence Conference." IEEE Computer Society Press, 1994.

[2] GG Fillenbaum, A Heyman, WE Wilkinson, and CS Haynes. "Comparison of two screening tests in alzheimer's disease,the correlation and reliability of the mini-mental state examination and the modified blessed test." Archives of Neurology, 44(9):924{7}, Sep 1987.

[3] Ana Luiza, Dallora Shahryar, Eivazza deh ,Emilia Mendes ,Johan Berglund, Peter Anderberg. "Prognosis of Dementia Employing Machine Learning and Microsimulation Techniques: A Systematic Literature Review" Procedia Computer Science, Volume 100, 2016, Pages 480-488.

Figures and Tables

1. (a)

Items	Maximum Error		Score	Weight
1. What year is it now?	1		x4=	
2. What month is it now? Memory phrase (repeat after me):"JohnBrown, 42 Market Street, Chicago"	1		x3=	
3. About what time is it (within 1 hour)?	1		x4=	
4. Count backwards 20 to 1.	2		x2=	
5. Say the months in reverse order (start with December).	2		x2=	
6. Repeat the memory phrase: (1) John (1) Brown (1) 42 (1) Market (1) Chicago	5		x2=	
			TOTAL	

1. (b)

Functional Activities Questionnaire:

Rate the patient's level of performance on each of the following tasks using this scale: 0 a normal; I a has difficulty but does by

self; 2 . requires assistance; 3 - dependent.'

Writing checks, paying bills, and keeping financial records (for example. balancing a checkbook)

Assembling tax records and making out business and insurance papers

Shopping alone for clothes, household necessities, or groceries

Playing a game of skill (for example, bridge or chess) or working on a hobby

Heating water for a cup of coffee or tea and turning off the stove

Preparing a balanced meal

Keeping track of current events

Paying attention to and understanding a television show. book, or magazine

Remembering appointments, family occasions. and medications

Traveling out of the neighborhood (for example. driving or arranging to take buses)

Score:

Scoring: The score is obtained by adding together the points for the 10 items. A total of 30 points is possible.
Score interpretation: The higher the score, the poorer the function (i.e., the greater the impairment). A cutoff point of 9 points.

Figure 1: (a) The Blessed Orientation-Memory-Concentration (BOMC) test and (b) Functional Activities Questionnaire (FAQ)

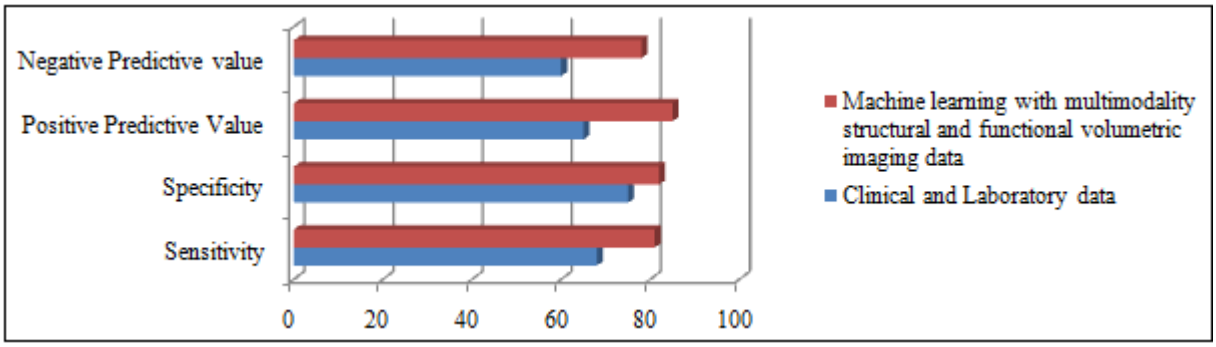

Figure 2: Comparison of performance between machine learning and multimodality structural and functional volumetric imaging data and clinical and laboratoty data.

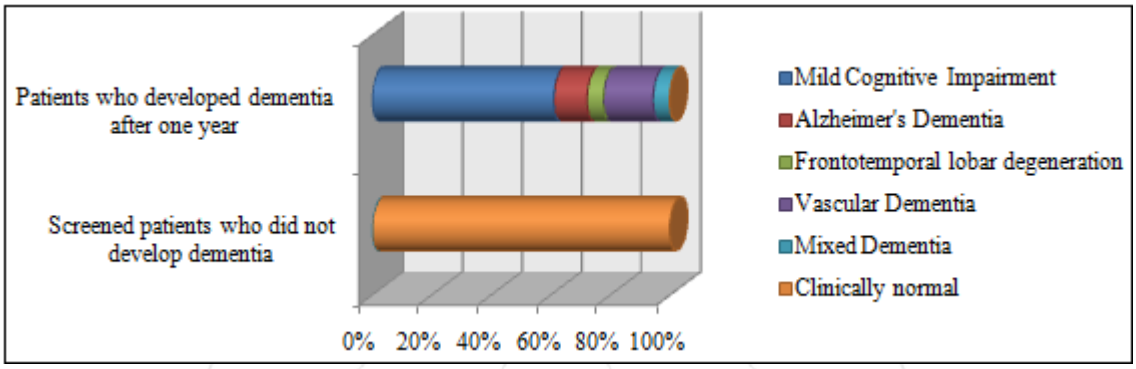

Figure 3 : Distribution of diagnoses of the patients who were again clinically screened after one year