Diagnosis of Alzheimer Diseases in Early Step Using SVM (Support Vector Machine)

Amira Ben Rabeh, Faouzi Benzarti, Hamid Amiri
Université de Tunis El Manar, Ecole Nationale d'Ingénieur de Tunis,
LR-11-ES17 Signal, Images et Technologies de l'Information (LR-SITI-ENIT),
Tunis Le Belvédère, Tunisie
Emails: amira.benrabeh@gmail.com benzartif@yahoo.fr hamidlamiri@yahoo.fr

***Abstract*— Alzheimer is a disease that affects the brain. It causes degeneration of nerve cells (neurons) and in particular cells involved in memory and intellectual functions. Early diagnosis of Alzheimer Diseases (AD) raises ethical questions, since there is, at present, no cure to offer to patients and medicines from therapeutic trials appear to slow the progression of the disease as moderate, accompanying side effects sometimes severe. In this context, analysis of medical images became, for clinical applications, an essential tool because it provides effective assistance both at diagnosis therapeutic follow-up. Computer Assisted Diagnostic systems (CAD) is one of the possible solutions to efficiently manage these images. In our work; we proposed an application to detect Alzheimer's diseases. For detecting the disease in early stage we used the three sections: frontal to extract the Hippocampus (H), Sagittal to analysis the Corpus Callosum (CC) and axial to work with the variation features of the Cortex(C). Our method of classification is based on Support Vector Machine (SVM). The proposed system yields a 90.66% accuracy in the early diagnosis of the AD.**

Keywords—Alzheimer Diseases (AD) ; Computer Assisted Diagnostic(CAD) ; Hippocampus(H) ; Corpus Callosum (CC); Cortex(C) ; Support Vector Machine (SVM).

I. INTRODUCTION

Alzheimer's disease is a degenerative disease that causes progressive cognitive decline and memory. Gradually, destruction of nerve cells occurs in areas of the brain related to memory and language. Over time, the person is more and more difficult to memorize the events, recognize objects and faces, to remember the meaning of words and to exercise its judgment.Generally, symptoms appear after 65 years and the prevalence increases sharply with age. However, contrary to popular belief, Alzheimer's disease is not a normal consequence of aging. Alzheimer's disease is the most common form of dementia among the elderly; it represents about 65% of dementia cases.

Alzheimer's disease affects about 1% of people aged 65 to 69, 20% of those aged 85 to 89 years and 40% of those 90 years to 95 years. In Canada, about 500,000 people have Alzheimer's or a related disease. It is estimated that 1 in 8 men and 1 in 4 women will suffer in their lives. Insofar as women live longer, they are more likely to be reached in one day. Due to the extension of life expectancy, the disease is becoming more common. It is estimated that within 20 years, the number of sufferers will double in Canada [1-5].

The term encompasses dementia, good general, health problems marked by an irreversible decline of mental faculties. Alzheimer's disease is distinguished from other dementias by the fact it develops gradually and mainly affects short-term memory in its infancy. However, the diagnosis is not always easy and it can be difficult for physicians to differentiate Alzheimer's disease dementia "with Lewy bodies," for example. In susceptible individuals, the involution of the brain tissue is most pronounced in the hippocampus and frontal cortex of the anterior. In subjects achieved slightly, involution key in addition the bottom and side portions of the temporal cortex and the posterior part of the limbic convolution. In subjects with moderately, involution extends more widely in the frontal cortex. In all three groups of patients, the left hemisphere is more affected than the right hemisphere [5-7].

The causes of Alzheimer's disease are not known. In the vast majority of cases, the disease appears due to a combination of risk factors. Aging is the main factor. The risk factors of cardiovascular diseases (hypertension, high cholesterol, obesity, diabetes, etc.) also seem to contribute to its development. It is also possible that infection or exposure to toxic products play a role in some cases but no conclusive evidence has been obtained. Genetic factors also play an important role in the onset of the disease. Thus, certain genes can increase the risk of suffering, although they are not directly the cause of the disease. Indeed, the researchers found that about 60% of people with Alzheimer's disease are carriers of the gene apolipoprotein E4, or ApoE4. Another gene, the SORL1, also seems to be often involved. However, many individuals carry these genes and will never have the disease and conversely, some people without these genes may develop the disease. There are also inherited forms of the disease but comprise less than 5% of cases. Only 800 families have been identified worldwide. Children who have a parent with Alzheimer's disease in its inherited form have 1 of 2 risk of having the disease themselves. Symptoms of familial appear early, sometimes before 40 years. However, while several members of the same family are affected by this disease, this does not necessarily mean that it is the hereditary form.[8-12]

Alzheimer disease progresses over several years and its progression varies greatly from one person to another. We now know that the first lesions appear in the brain at least 10 to 15 years before the first symptoms.

They usually appear after the age of 60 years. On average, once the disease occurs, life expectancy is 8 years to 12 years. As the disease occurs at an advanced age, the more it tends to worsen quickly. When it occurs around age 60 or 65 years, life expectancy is about 12 years to 14 years; when it occurs later in life expectancy is no more than 5 years to 8 years. It is not possible to halt the progression of the disease.
Light Stadium. Memory loss occur occasionally. The short-term memory, that is to say the ability to remember recent information (a new phone number, a list of words, etc.), is the most affected. Sufferers attempt to overcome their difficulties through the use of checklists and their families. Mood changes and slight disorientation in space can also be observed. The person has more trouble finding words and follow the thread of a conversation.At this point, it is not certain whether Alzheimer's disease. Over time, symptoms may remain stable or even decrease. The diagnosis is confirmed if memory problems are increasing and whether other cognitive functions deteriorate (language, object recognition, complex movements planning, etc.).moderate Stadium. Memory disorders are amplified. Memories of youth and middle age become less accurate but are better preserved than the immediate memory. It is becoming increasingly difficult for people to make choices; their judgment begins to be altered. For example, they gradually becomes more difficult to manage their money and plan their daily activities. Disorientation in space and time becomes more and more obvious (difficulty remembering the day, birthdays ...). The people have more and more difficulty expressing themselves verbally. Between moderate and advanced stages, unusual behavior problems sometimes arise: for example, aggression, an atypical language, foul or a change of personality traits.Advanced stage (or terminal). At this point, the patient loses its autonomy. Permanent monitoring or accommodation in a nursing home becomes necessary. Psychiatric problems can occur, including hallucinations and delusions paranoid, aggravated by severe memory loss and disorientation. Sleep problems are common. The patients neglect their personal hygiene, become incontinent and struggling to feed themselves. If left unattended, they can wander for hours in vain.[13-17]
The person may die of another disease at any stage of Alzheimer's. However, in its advanced stage of Alzheimer's disease is a fatal disease like cancer. Most deaths are caused by pneumonia caused by difficulty swallowing. Patients may let into their respiratory tract and lungs of saliva or a portion of what they eat or what they drink. This is a direct consequence of the disease progression.

To make the diagnosis, the doctor will use the results of several medical examinations. First, he asks the patient to learn more about the way his memory loss and other difficulties in the daily lives appear. Tests to assess cognitive abilities are carried out, as appropriate: vision tests, writing, memory, problem solving, etc. If memory impairment, even being attentive, patient performance of the test will be abnormal.In some cases, various medical tests may be performed to rule out the possibility that the symptoms are due to another medical condition (a vitamin B12 deficiency, a malfunction of the thyroid gland, stroke, depression, etc.).
If deemed necessary, the doctor may advise the patient to have a brain imaging exam (preferably an MRI, magnetic resonance imaging) to observe the structure and activity of different areas of his brain. The imaging can highlight the volume loss (atrophy) of certain brain areas, typical of neuron degeneration [18]. In this context, we have created a tool to diagnose Alzheimer's disease at an early stage, when memory loss is mild or even before the onset of symptoms. Indeed, the disease moved insidiously well before symptoms of dementia appear. For this reason we chose to analyze both had three brain sections: frontal, sagittal and axial.

II. Materiel

Our approach is applied to reference MRI based OASIS (Open Access Series of Imaging Studies) DATABASE [19-20]. The images are a grayscale and size of 500 * 500 pixels. These images are made by experts.

III. Proposed Application

We propose an application to detection the disease in early stage. Our application contains 2 steps: segmentation used the Region of Intert ROI to extract the three areas: Hippocampus, Corpus Callosum and Cortex. After that, there are step of classification based on SVM (Support Vector Machine). We present the three sections: Frontal, Sagittal and Axial. Also his roles:
- Frontal section (or coronal): This cut is a front view of the brain. It is acquired on the plane perpendicular to the axial and sagittal cuts. For this section, we used the variation descriptors of the hippocampus.
- Axial (or transverse), this cup is a top view of the brain. It corresponds to a plane perpendicular to the static magnetic field. In our work, we are interested in the variation descriptor of cortex.
- Sagittal cup is on a plane parallel to the inter-hemispheric plan. These are side views of the brain. After the step of segmentation we extracted the variation descriptors of Corpus Callosum.
We classified any component by SVM (Support Vector Machine) and for the final decision we used the following decision tree:

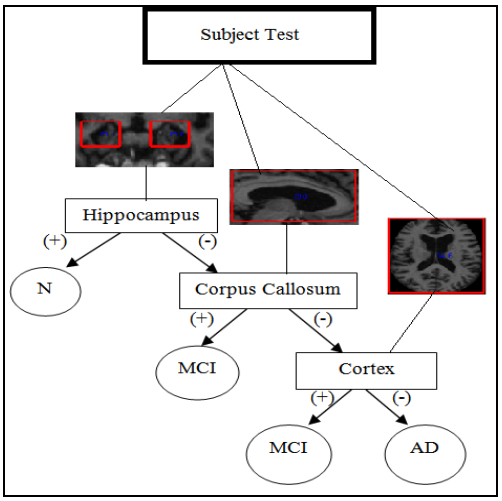

Fig 1. Our Method of Classification

N: normal MCI: Mild cognitive impairment
AD: Alzheimer Disease
(+): Result of SVM is positive (IRM Normal).
(-): Result of SVM is negative (IRM Abnormal).

The decision tree is based on the three results of the classification of the Hippocampus , Corpus Callosum and Cortex using SVM:

- If the hippocampus is classed (+) that the patient is normal.
- If the hippocampus is classed (-) and the Corpus Callosum classed (+) that the patient is MCI (the first step of Alzheimer).
- If the hippocampus is classed (-), the corpus callosum classed (-) and the cortex classed (+) the patient is MCI(the first step of Alzheimer).
- If the hippocampus is classed (-), the corpus callosum classed (-) and the cortex classed (-) that the patient is suffering of Alzheimer.

IV. RESULT

We work with 75 subjects.

- 50 Normal.
- 17 MCI (Mild Cognitive Impairment).
- 8 Suffering from Alzheimer.

We present an example of patient suffering of Alzheimer's diseases:

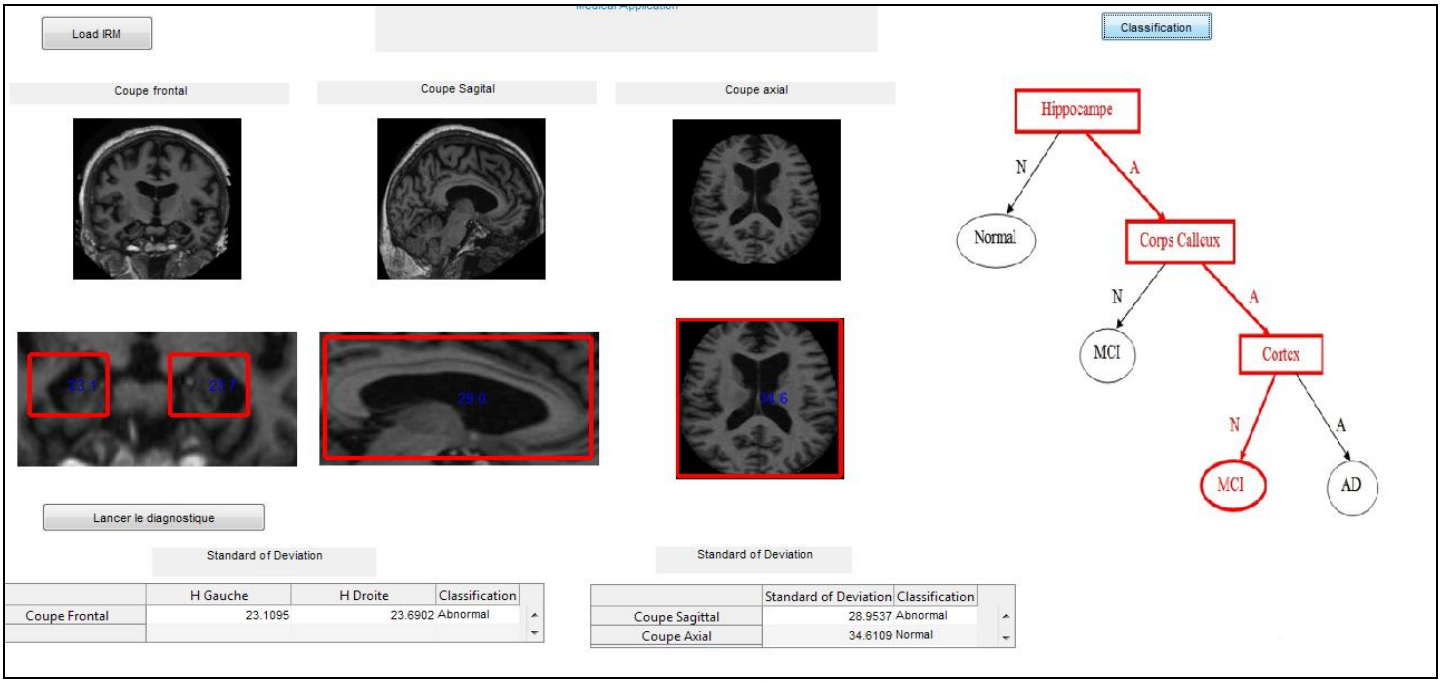

Fig 2. Our Application: Diagnosis of Alzheimer Diseases

The figure 2: present our application: the diagonasis of the Hippocampus, Corpus Callosum and the Cortex. The three tables inside the interface shows the values of variation features of the hippocampus, Corpus Callosum and the Cortex. Also the classification of any component using the SVM Classifier.

The decision tree, for this example. We find that the classification of the Hippocampus is abnormal,

we passe a Corpus Callosum we find that their classification is Abnormal so we passe a Cortex we find that the component is normal. The final decision that the patient is in MCI step.

The following table shows the results of diagnosis for 4 solutions:
M1: Diagnosis using only the Frontal Section (Hippocampus).
M2: Diagonasis using only the Sagittal Section (Analyses the Corpus Callosum).
M3: Diagnosis using only the Axial Section (Analyses the Cortex).
M4: Diagonasis using the three sections (Analyses the three components: Hippocampus, Corpus Callosum and the Cortex).

Table 1: Measurement using 4 methods

	T	TFP	TFN	Accuracy
M1	55	5	15	73.33%
M2	54	2	19	72%
M3	37	8	30	49.33%
M4	68	2	5	90.66%

T: True, TFP: False Positive , TFN: False Negative

The figure present curve of the Accuracy for the four methods.

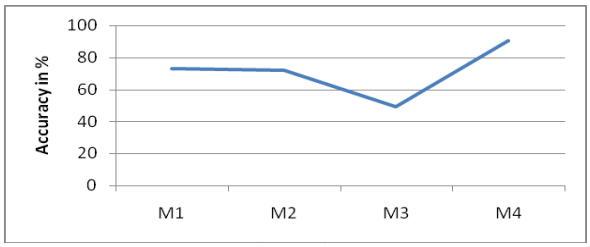

Fig 3. Accuracy of Classification using SVM

V. Discussion

The table 1 present the Accuracy of the four solutions. We find 90.66% for M4, against 73.33% for M1, 72% for M2 and 49.33% for M3.
Combining the classification of the three sections, we find the best result. The success of any system of classification is depending of the method of classification. In our work we used the SVM and a decision tree also the variation feature of any component, give us a best result.

VI. Conlusion

Computer Assisted Diagnostic is very important field to detect disease's in early stage. In this paper, we present our realized application to detect Alzheimer's diseases .Analyzing the three sections of the brain: Frontal, Sagittal and Axial.
We propose as future work, to improve our application. We add a longitudinal monitoring application to detect and follow Alzheimer disease.

REFERENCES

[1] Ray S, Britschgi M, et al. Classification and prediction of clinical Alzheimer's diagnosis based on plasma signaling proteins. Nat Med. 2007 Nov;13(11):1359-62. Epub 2007 Oct 14.

[2] Burgener SC, Buettner L, et al. Evidence supporting nutritional interventions for persons in early stage Alzheimer's disease (AD). J Nutr Health Aging. 2008 Jan;12(1):18-21. Review.

[3] Ferreira PC, Piai Kde A, et al. Aluminum as a risk factor for Alzheimer's disease. Rev Lat Am Enfermagem. 2008 Jan-Feb;16(1):151-7. Review.

[4] Neuronutrition and Alzheimer's disease. Ramesh BN, Rao TS, Prakasam A, et al. J Alzheimers Dis. 2010;19(4):1123-39. Review.

[5] Scarmeas N, Stern Y, et al. Mediterranean diet and risk for Alzheimer's disease. Ann Neurol. 2006 Jun;59(6):912-21.

[6] Scarmeas N, Luchsinger JA, et al. Mediterranean diet and Alzheimer disease mortality.Neurology. 2007 Sep 11;69(11):1084-93.

[7] Burgener SC, Buettner L, et al. Evidence supporting nutritional interventions for persons in early stage Alzheimer's disease (AD). J Nutr Health Aging. 2008 Jan;12(1):18-21. Review.

[8] Esposito E, Rotilio D, et al. A review of specific dietary antioxidants and the effects on biochemical mechanisms related to neurodegenerative processes. Neurobiol Aging. 2002 Sep-Oct;23(5):719-35. Review.

[9] Salerno-Kennedy R, Cashman KD. Relationship between dementia and nutrition-related factors and disorders: an overview. Int J Vitam Nutr Res. 2005 Mar;75(2):83-95. Review.

[10] Luchsinger JA, Tang MX, Shea S, Mayeux R. Caloric intake and the risk of Alzheimer disease.Arch Neurol. 2002 Aug;59(8):1258-63.

[11] Mattson MP. Neuroprotective signaling and the aging brain: take away my food and let me run.Brain Res. 2000 Dec 15;886(1-2):47-53. Review.

[12] Unverzagt FW, Kasten L, et al. Effect of memory impairment on training outcomes in ACTIVE. J Int Neuropsychol Soc. 2007 Nov;13(6):953-60.

[13] Lemonick MD, Park A. The Nun Study. How one scientist and 678 sisters are helping unlock the secrets of Alzheimer's. Time2001 May 14;157(19):54-9, 62, 64.

[14] Effect of physical activity on cognitive function in older adults at risk for Alzheimer disease: a randomized trial. Lautenschlager NT, Cox KL, Flicker L, et al. JAMA. 2008 Sep 3;300(9):1027-37. Erratum in: JAMA. 2009 Jan 21;301(3):276.

[15] Panza F, Solfrizzi V, et al. Mediterranean diet and cognitive decline. Public Health Nutr. 2004 Oct;7(7):959-63.

[16] Larrieu S, Letenneur L, et al. Nutritional factors and risk of incident dementia in the PAQUID longitudinal cohort. J NutrHealthAging. 2004;8(3):150-4.

[17] Morris MC, Evans DA, et al. Consumption of fish and n-3 fatty acids and risk of incident Alzheimer disease. Arch Neurol. 2003 Jul;60(7):940-6.

[18] Solfrizzi V, Panza F, Capurso A. The role of diet in cognitive decline. J Neural Transm. 2003 Jan;110(1):95-110. Review.

[19] Ardekani, B. A., K. Figarsky, and J. J. Sidtis, "Sexual dimorphism in the human corpus callosum:An MRI study using the OASIS brain database," Cereb Cortex, Vol. 10, No. 25, 2514-2520, 2012.

[20] Ardekani, B. A., et al.,"Corpus callosum shape changes in early Alzheimer's disease: An MRI study using the OASIS brain database," Brain Struct. Funct., Vol. 219, No. 1, 343-352, 2013.