Detection of Neurodegenerative Disease Using Salient Brain Patterns

Supriya D Pise, Dr. S. R. Ganorkar,

PG student, Department of E & Tc, Sinhgad College of Engineering, Pune, India,

Professor, Department of E & Tc, Sinhgad College of Engineering, Pune, India,

ABSTRACT: The recognizable proof deformities in the MRI cerebrum pictures can spare various lives. A technique to actualize the bit capacity for highlight extraction to distinguish the neurodegenerative Alzheimer ailment in Brain Image is proposed. The information Brain picture has changed over into dark picture and preprocessed and saliency map picture is gotten from the preprocessed Picture. The saliency map acquired gives the power related data from the pictures. In the wake of getting the saliency map picture we need to standardize the saliency delineate applying the portion combination to the standardize picture to remove the component of the picture. The standardization procedure refines the pictures pixels to certain amplify and the definite data speaking to the distinctive divides independently is gotten. The element extraction process decreases the dimensionality of the picture information to make the procedure more advanced and basic. At long last by utilizing the SVM classifier is sustained with elements, for example, force, textural and measurable data, parallel tissue divisions or cortical thickness estimations. General proposed calculation used to diminish the computational time and the nearness of superfluous and uproarious components. The notable locales found with the proposed approach as methodically important for separation of AD patients this outcomes totally reasonable to what has been accounted for by clinical investigations of AD.

KEYWORDS: Alzheimer's disease (AD), automated pattern recognition, magnetic resonance imaging (MRI).SVM classifier.

I. INTRODUCTION

A Neurodegenerative infection is an umbrella term for a scope of conditions which basically influence the neurons in the human cerebrum. Neurons are the building squares of the sensory system. Which incorporates the mind and winding rope? Neurons regularly don't recreate or supplant themselves so when they get to be harmed or bite the dust they can't supplant by the body. Cases of neurodegenerative ailments incorporate Parkinson's, Alzheimer's and Huntington's infection. Neurodegenerative illnesses are incorporated and weakening conditions those outcomes in dynamic degeneration and passing of nerve cells. This causes issues with development (called ataxias) or mental working (called dementias). Dementias are in charge of the best weight of ailment with Alzheimer's speaking to around 60-70% of cases. Restorative imaging is generally perceived to mark the arrangement of methodology that no imperceptible produce pictures of the household part of the body. The unconventional thickness of reverberation is known as the Larmour recurrence and is resolved put on the particular tissue being imaged and the quality of the primary trancelike field. A mechanical cerebrum morphometric thinking that do play out this assessment, commit almost no to the attention to the ailment. In regardless of the significance of these essential wellsprings of therapeutic capacity, Medicinal status are once in a while further handle in certain clinical practice, so the advisor take determination just situated in the natural information. Here they present another completely mechanized model study technique. That uncover separate mind game plan associate to the presence of neurodegenerative disorder mining effective variety and thusly characterize unbiasedly any neurological wreckage. In variety the entrance here in definite can be seen as an addition to the cutting edge investigation of partisan striking appearance much nearer to the clinical examination of a therapeutic finding. As far as the human hunt separate locales found by the forthcoming get to very consolidates to what has been communicated in systematic class of AD. Alzheimer's illness grows contrastingly for each person, there are numerous regular side effects. Early side effects are frequently erroneously thought to be 'age-related' concerns, or signs of anxiety. In the early stages, the most widely recognized side effect is trouble in

recollecting late occasions, known as fleeting memory misfortune. Amid the last phase of AD, the individual is totally needy upon parental figures. Dialect is diminished to straightforward expressions or even single words, in the long run prompting complete loss of discourse. In spite of the loss of verbal dialect capacities, individuals can frequently comprehend and return enthusiastic signs. Alzheimer is the regular type of dementia a general term for memory misfortune and other scholarly capacities neurological turmoil in which the demise of cerebrum cell causes memory misfortune and psychological decay. Neurodegenerative illnesses influence focal sensory system. Neurodegenerative is blend of two words those are Neuro signifies 'nerve cell' and Degeneration signifies 'dynamic misfortunes'. General meaning of Neurodegenerative ailments is dynamic loss of memory that incorporates loss of neurons and demise of neurons assistant that prompts loss of structure of nerve and elements of nerve. An Alzheimer's ailments begin as little or mellow and dynamically it will deteriorate. The manifestation of this malady incorporates loss of intuition abilities, memory and behavioral changes. It begins in late middle age around 45 to 65 age bunches or in seniority and even it can influence any age bunch also. The ailments is portrayed under four phases in view of utilitarian hindrance or contrasts, those are Pre-dementia, direct and progressed. In Pre-dementia, those are more discernible like brief time memory misfortune; in this it demonstrates that to hard to recollect the late happened realities. In early stage the patient confronts challenges with observation and dialect. In moderate stage the execution of most regular exercises of every day living is overlooked and talking troubles additionally happens. In cutting edge or last stage the patient is totally rely on others or guardians and dialect is diminished to phrases or even one single word this leads consistent loss of discourse. Neuroimaging is a profitable mat lab apparatus for determination of this kind of neurodegenerative illness, for example, Alzheimer sicknesses. Neuroimaging incorporates the extraction of anatomical examples of database pictures; the extraction of anatomical examples depends on visual saliency maps. Used to separate between ordinary controls (NC) and Alzheimer`s malady (AD). A way to deal with model gathering contrasts in basic mind MR pictures in view of visual saliency maps. Visual saliency strategy [9] is utilized to produce saliency maps that highlight specific areas, which can be related to infection related examples that permit further subject order, specifically Alzheimer's ailment. Highlight that the development of the saliency maps did exclude any from the earlier data in regards to the pathology. The visual saliency maps are utilized to construct a picture portion (figured with two diverse measures), which is encouraged to a bolster vector machine to convey a satisfactory Differentiation between typical controls (NC) and plausible Alzheimer's malady (AD) subjects. None of the current strategies have tended to the issue of programmed arrangement of MR volumes utilizing visual saliency areas as elements, which end up being anatomically reliable with mind locales known not amongst AD and NC bunches.

II.   RELATED WORK

The Proposed technique assessing both its precision for separating diverse exploratory gatherings and its ability of deciding the important anatomical areas together with their weights. This is proficient utilizing a combination methodology that is GBVS usage which combines base up and beat down data streams. The base up methodology highlights significant locales corresponded with the AD finding. The top-down plan distinguishing designs related to obsessive stages. Keeping in mind the end goal to highlight the nature of the model is given by the quantitative execution measures, as well as by its fitness to consequently identify very discriminative cerebrum locales, steady with those areas that have been portrayed as imperative in the movement of the infection. The most famous method has been proposed by bolster vector machine (SVM), which has been connected to ordering people with a few neurological issue. The SVM classifier is generally sustained with components, for example, force, textural and measurable data, paired tissue divisions or cortical thickness estimations. Correlations between the piece bunch and the standard have demonstrated that the isolation of data into various component scale bits, enhances the order execution in all subject gatherings. In forthcoming framework they utilize the part work for highlight extraction as opposed to existing technique. This in view of a two-stage visual saliency smaller than expected that correspond base up and best down procedure to get unmistakable examination of mind MR pictures as customary controls or plausible AD subjects. Augmentation of the underlying information into these different scale spaces assault to sparsity the crude brains information, advancing the profundity constriction. In they proposed model, the information space is the space of saliency maps, so a bit capacity measures the partiality between saliency maps. Sparsity is determined by the objective of find a lessened arrangement of saliency maps that better abridge optical outlines to separate practical AD cases from ordinary restriction. In the forthcoming access the pre-characterized bits supporter the information picture into

particular element saliency maps, whose voxels relate to measurements of the saliency map space? At last utilizing this Feature Extraction

values order the qualities by utilizing the SVM Classifier. This occasion illuminate that the learning strategy here in utilized can exclusively investigate the structure space and to ideally consolidate or blend every part. Propose a calculation completely programmed division technique taking into account synchronous locale twisting driven by both anatomical and probabilistic priors. Utilizing nearby Anatomical examples anatomical data is inferred that are steady in controls and patients, around points of interest naturally distinguished amid the disfigurement. The enlistment of physically portioned Hc and Am Probabilistic data is gotten from a map book worked for 16 youthful sound subjects. Introduction is span from worldwide data and distortion is compelled by neighborhood anatomical and probabilistic data. The outcomes are contrasted and eight patients with AD. The precision is compass upto 60 to 80 rates. It proposes a strategy that utilizations diverse learning parameters and utilizations "greatest like hood technique to characterize the information pictures". Right determination of AD particularly for its initial stage likewise called as amnestic mellow intellectual weakness (MCI), is critical that some way or another decreases threat stage. It is realized that AD is identified with the basic decay, neurotic amyloid affidavits, and metabolic modifications in the mind and the exactness is range upto 74 rate. Fan proposes a strategy that prompts cross approval of Alzheimer ailments separation through "example arrangement technique" utilizing mci bunch pictures utilizes a discovery of examples of cerebrum ailments. In propose strategy explore the additional benefit of brushing auxiliary MRI and PET pictures of local cerebral blood stream in segregating between MCI and ordinary control. Applying strategies of versatile provincial element extraction, highlight determination and multivariable bolster vector machine characterization. 90 rate of arrangement exactness. In the proposed paper which incorporate the saliency mapping is new idea. saliency map figured by utilizing the GBVS(graph based visual saliency) for the high exactness. Highlights extricated utilizing this saliency map like edge saliency map, introduction saliency map, force saliency map. In the year 2014 work by Andrea Rueda, Fabio A. González, Senior Member,and Eduardo Romero the precision of 97% is accomplished utilizing "Removing Salient Brain Patterns for Imaging-Based Classification of Neurodegenerative Diseases. EXISTING studies propose neuroimaging may turn into a profitable apparatus in the early determination of neurodegenerative sicknesses by removing anatomical examples and uncovering concealed relations from auxiliary Magnetic Resonance (MR) pictures. The benefit of neuroimaging against clinical, neuropsychological and biochemical investigation stays to be shown in vast agent populaces, yet there exists adequate proof in little arrangement of patients with various conditions of neurodegenerative issue. The standard examination work process is performed by master neurologists or radiologists, who can make sense of complex anatomical examples and unobtrusive changes with clinical importance. The procedure that a specialist takes after while looking at a specific case includes two various types of undertakings: those related with picture observation, for example, visual hunt or investigation ways, and others connected with psychological abilities, mostly identified with indicative. A specialist structures a conclusion by utilizing relevant learning and intertwining data from various sources, a procedure that has been as of late under study [1]. At investigating auxiliary mind MR pictures, a primary point is to discover anatomical changes, either neighborhood or worldwide, identified with practical aggravations. Specifically, radiologists analyze pictures by taking a gander at unmistakably locales and look at them via seeking contrasts [1]. In the computational endeavor of imitating the human vision process –a synchronized shared work between the cerebrum and low level visual mechanisms– the idea of visual consideration has presented an era of systems that can change a picture into a chain of command of important areas, known as striking districts. Significant locales in radiological terms might be characterized as those picture territories that are outwardly changed and are involved with a specific level of clinical interpretability. All things considered, most strategies used to think about brains build up nearby as opposed to territorial (remarkable) contrasts. Right now, a morphometric cerebrum examination comprises of an arrangement of systems meant to remove and measure anatomical contrasts between gatherings of subjects. Ordinarily, this investigation involves two principle forms: to begin with, all pictures are twisted or enrolled together to a typical reference casing or format, and second, an evaluation of the assessed neighborhood disfigurement required to enlist is figured, creating particular estimations of premium. Voxel-Based Morphometry (VBM) [2] and Deformation-Based Morphometry (DBM) [3] are at present the most utilized systems to look at populaces. In VBM, nearby contrasts, found in cerebrum tissue divisions, are voxel-byvoxel measurably dissected, while DBM factually thinks about data originating from the disfigurements fields got after enlistment to the layout. With these strategies, coordinated correspondences between subjects are expected and measurements are processed for the same voxel over all subjects. Notwithstanding, conclusions are restricted when the

same structure might be incompletely present, or when a solitary anatomical locale may show different shapes over the populace. Then again, some pathology may influence not just a one of a kind anatomical structure or even adjacent areas, yet limited structures isolated from each other. These sorts of examples are hard to discover and break down with these exemplary morphometric systems. A late proposition, the Feature-Based Morphometry (FBM) [4], adapts to these issues by displaying the picture as a composition of neighborhood scale-invariant elements and by learning, from them, a probabilistic model that reflects bunch related anatomical attributes. Be that as it may, these methodologies dismiss the nearby measurable conditions, and after that inconspicuous changes are not really identified; precisely the inverse methodology utilized by the radiologists, who investigate areas instead of pixels [5].

III. METHODOLOGY

The proposed method contains two sections one is trained section another one is test section. In trained section all the images to be trained first and stored in database as
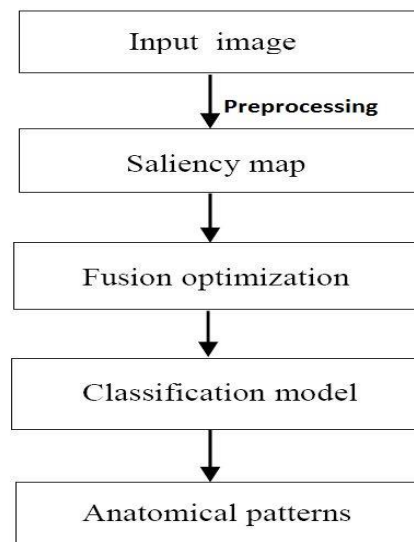

Fig 1 Block diagram of proposed system

After that test one by one image for further classification process of Alzheimer diseases.It shows the proposed system. Brain images from the database are given as input then the given input image is converted into Gray image so that computation in mat lab is reduced. All images should be processed in Gray format. The converted Gray image is passed through saliency method to get saliency map. After getting saliency image the normalization process is carried out so that range of pixel intensity values changes. After saliency calculation the fusion method is carried out to get master saliency of each scaled images. Using kernel K-means clustering method depending on feature values the relevant information is extracted, classified using SVM classifier and anatomical pattern analysis is done. Support vector machines are supervised learning model that associated with learning algorithms that used to analyse the data and identify the patterns which is used for classification process and map the trained data to classify accurately. Red regions are pathology and blue regions are normality for identification of brain diseases. In this way anatomical interpretation is done. Performance analysis is based on accuracy, sensitivity and specificity is done.

A. Saliency map

Automatic estimation of salient object regions across image without any prior assumption or knowledge of the contents of the corresponding scenes. Introduce a regional contrast based salient object extraction algorithm which simultaneously evaluated global contrast different and spatial weighted coherence scores. Proposed algorithm is simple, efficient, and naturally multiscale and produces full resolution high-quality saliency maps. Further used to initialize a

novel iterative version of grab cut for high quality salient object segmentation. We evaluated our algorithm using traditional salient object deletion dataset as well as more challenging internet image dataset. Algorithm consistently outperforms existing salient object detection and segmentation methods. Yielding higher precision and better recall rates. Saliency map has its root in feature integration theory and appears first in the class of algorithmic models above it includes the following elements.

1. An early representation composed of a set of feature maps computed in parallel permitting separate representations of several stimulus characteristics.
2. A topographic saliency map where each location encodes the combination of properties across all feature maps as a conspicuity measure.
3. A selective mapping into a central non-topographic representation through the topographic saliency map of the properties of a single visual location.
4. A winner takes all network implementing the selection process based on one major rule conspicuity of location.
5. Inhibition of this selected location that causes an automatic shift to the next most conspicuous locations. Feature maps code conspicuity with in a particular feature dimension. The saliency map combines information from each of the feature maps into a global measure where points corresponding to onelocation in a feature map project to single units in the saliency map. Saliency at a given location is determined by the degree of difference between that location and its surround. Saliency typically arises from contrasts between items and their neighborhood, such as a red dot surrounded by white dots, a flickering message indicator of an answering machine, or a loud noise in an otherwise quiet environment. Humans and other animals have difficulty paying attention to more than one item simultaneously, so they are faced with the challenge of continuously integrating and prioritizing different bottom-up and top down influences.

B. Normalization
In image processing normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare. Normalization is sometimes called contrast stretching or histogram stretching. In more general fields of data processing such as digital signal processing it is referred to as dynamic range expansion. To changing the Intensity, Coordinates values, etc….In image processing, normalization is a process that changes the range of pixel intensity values. Applications include photographs with poor contrast due to glare. Normalization is sometimes called contrast stretching or histogram stretching. Auto-normalization in image processing software typically normalizes to the full dynamic range of the number system specified in the image file format.

C. Kernel Feature Extraction
Kernel methods have received major attention, particularly due to the increased popularity of the Support Vector Machines. Kernel functions can be used in many applications as they provide a simple bridge from linearity to non-linearity for algorithms which can be expressed in terms of dot products.Each measurement has its own wavelength range of the light spectrum, some of which may be outside the visible spectrum. If the set of possible color values is sufficiently small, each of those colors may be placed on a range by itself; then the histogram is merely the count of pixels that have each possible color. Most often, the space is divided into an appropriate number of ranges, often arranged as a regular grid, each containing many similar color values. The color histogram may also be represented and displayed as a smooth function defined over the color space that approximates the pixel counts. Kernel methods have received major attention, particularly due to the increased popularity of the Support Vector Machines. Kernel functions can be used in many applications as they provide a simple bridge from linearity to non-linearity for algorithms which can be expressed in terms of dot products. Most often, the space is divided into an appropriate number of ranges, often arranged as a regular grid, each containing many similar color values. The color histogram may also be represented and displayed as a smooth function defined over the color space that approximates the pixel counts.

D. SVM Classifier
Support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns newexamples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is arepresentation of the examples as points in space, mapped so that the examples of the separate categories are

divided by a clear gap that is as wide as possible. Support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible.

E. Anatomical Interpretation

Red regions are pathology and blue regions are normality identifying the diseases in brain. 1The discipline of anatomy is divided into macroscopic and microscopic anatomy. Macroscopic anatomy, or gross anatomy, is the examination of an animal's body parts using unaided eyesight. Gross anatomy also includes the branch of superficial anatomy. Microscopic anatomy involves the use of optical instruments in the study of the tissues of various structures, known as histology and also in the study of cells. The history of anatomy is characterized by a progressive understanding of the functions of the organs and structures of the human body. Methods have also improved dramatically, advancing from the examination of animals by dissection of car cases and cadavers (corpses) to 20th century medical imaging techniques including X-ray, ultrasound, and magnetic resonance imaging. Anatomy is the study of the structure of mnimals and their parts, and is also referred to as zootomy to separate it from human anatomy.The discipline of anatomy is divided into macroscopic and microscopic anatomy. Macroscopic anatomy, or gross anatomy, is the examination of an animal's body parts using unaided eyesight.The history of anatomy is characterized by a progressive understanding of the functions of the organs and structures of the human body.Red regions are pathology and blue regions are normality identifying the diseases in brain.

F. Performance Analysis

Result analysis of our process accuracy,sensitivity,specificity. To avoid the possible inflated performance estimation on the unbalanced datasets, the balanced classification accuracy was also computed, a simple arithmetic mean of the sensitivity and specificity. The balanced accuracy (BAC) removes the bias that may arise by imbalanced datasets. In a binary classification problem, if the classifier performs equally well on either class, BAC reduces to the ordinary accuracy. If, however, the classifier has taken advantage of an imbalanced dataset, then the ordinary accuracy will be inflated, whereas the BAC will drop to chance (50%), as desired. The time is set aside during the training phase and then classified using the SVM model trained with the remaining subjects. To avoid the possible inflated performance estimation on the unbalanced datasets. The balanced accuracy (BAC) removes the bias that may arise by imbalanced datasets. The balanced classification accuracy was also computed, a simple arithmetic mean of the sensitivity and specificity. Result analysis of our process accuracy, sensitivity, specificity.

IV. SALIENCY BASED PATTERN EXTRACTION

Require: N structural brain volume (N_{NC} : number of normal subjects,N_{AD} : number of pathological subjects).

Step 1   :   calculation of saliency maps.

Step 2   :   bottom – up saliency fusion.

Step 3   :   top-down learning.

Step 4   :   anatomical interpretation

Calculation of Saliency Maps

The search of particular patterns among the anatomical areas in structural brain MR images can be considered as equivalent to figure out a preferential information flux through a net of nodes belonging to a fully-connected graph, being each node a particular anatomical region and each edge a similarity (or dissimilarity) measure between regions. If

an image is partitioned and its parts are somehow related together as a fully-connected graph, the interaction process between an user and the image can be modeled as a privileged path of that graph. Some approaches have taken into account the possibility of using graphs and induced Markov chains to model saliency and attention fixations in natural images.

Calculation of saliency map is done by using the Graph-based visual saliency method (GBVS).This GBVS method encodes dissimilarity between feature pixels by a closeness

measure in the graph connection i.e., salient pixels are the most dissimilar in a local context, a closer approximation to the visual analysis made by radiologist when studying a medical image.

The edge weight between graph nodes $g_{i,j}^A$ and $g_{p,q}^A$ is calculated as

$$w_A\left(g_{i,j}^A g_{p,q}^A\right) = d\left(g_{i,j}^A g_{p,q}^A\right) \times F(i - p, j - q) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where encodes the dissimilarity $d(g_{i,j}^A g_{p,q}^A)$ (in terms of the respective feature information) and F(i-p, j-q) represents the spatial closeness between nodes.

V.   EXPERIMENTAL RESULTS

GUI creation :
The following fig 2 shows GUI. In that two section are present INPUT and OUTPUT section. Input section is testing section in that get image as a test image from dataset shows AD count and NC count and according to count rate decision taking about AD or NC. In training phase fusion and SVM are present and generated different saliency maps. In testing section window shows AD count and NC count according to this count if AD count is more than NC with decided threshold then it is diseased image or patient is suffering from disease.
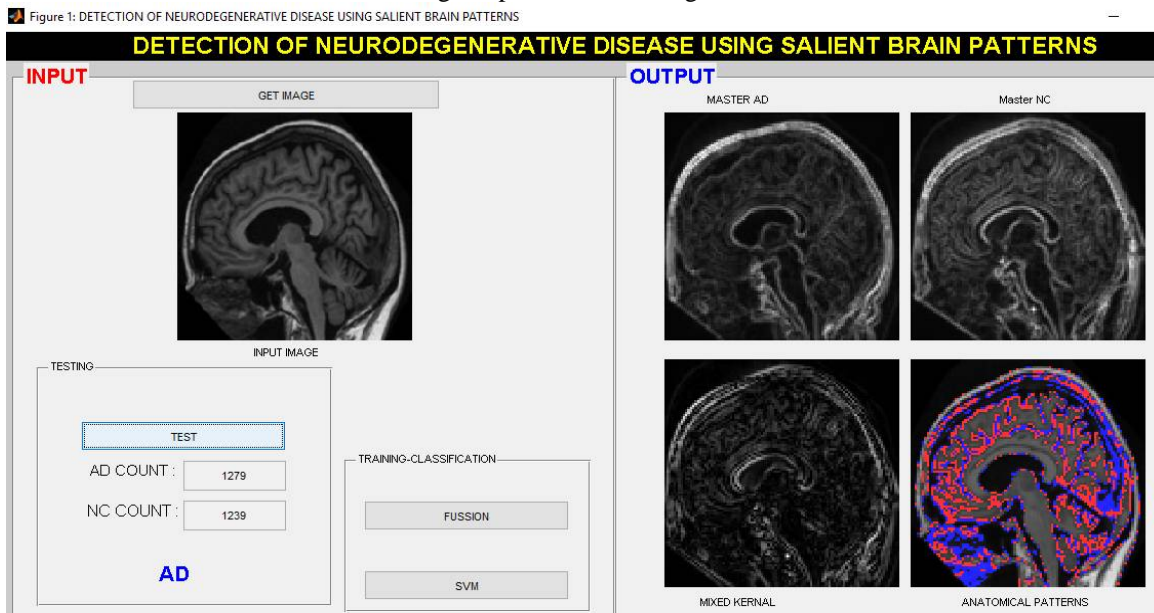

Fig 2 GUI creation

VI.   CONCLUSION

Saliency map calculated by using the GBVS (graph based visual saliency) for the high accuracy. By using the GBVS cannot loss any information. This strategy provides a subject classification into normal control or Alzheimer disease patients, based on support vector machines, which was compared with the diagnosis previously given by expert

radiologists. Saliency maps allow us to identify regions of relative change in intensity, orientation and edges, associated with each class (demented or non-demented), describing basic regional patterns suitable for subject classification. The accuracy of 80 - 90% is achieved using saliency map characterization and kernel k-means method is adapted which is very useful in differentiation of Neurodegeneration diseases with better accuracy (6).

REFERENCES

[1] J. Beutel, H. Kundel, and R. Van Metter, Handbook of Medical Imaging. Vol. 1: Physics and Psychophysics. SPIE Press, 2000.

[2] J. Ashburner and K. Friston, "Voxel-based morphometry: the methods,"Neuroimage, vol. 11, no. 6, pp. 805–821, Jun 2000.

[3] J. Ashburner, C. Hutton, R. Frackowiak, I. Johnsrude, C. Price, K. Friston et al., "Identifying global anatomical differences: Deformation-based morphometry," Hum Brain Mapp, vol. 6, no. 5-6, pp. 348–357, 1998.

[4] M. Toews, W. Wells, D. Collins, and T. Arbel, "Feature-based morphometry: Discovering group-related anatomical patterns," NeuroImage, vol. 49, no. 3, pp. 2318–2327, Feb 2010.

[5] H. Kundel, C. Nodine, D. Thickman, and L. Toto, "Searching for lung nodules a comparison of human performance with random and systematic scanning models," Invest Radiol, vol. 22, no. 5, pp. 417–422, May 1987.

[6] G. Orr`u, W. Pettersson-Yeo, A. Marquand, G. Sartori, and A. Mechelli, "Using support vector machine to identify imaging biomarkers of neurological and psychiatric disease: a critical review," Neurosci Biobehav R, vol. 36, no. 4, pp. 1140–1152, Apr 2012.

[7] P. Padilla, M. L´opez, J. G´orriz, J. Ramirez, D. Salas-Gonzalez, and I. A´lvarez, "Nmf-svm based cad tool applied to functional brain images for the diagnosis of alzheimer's disease," IEEE T Med Imaging, vol. 31, no. 2, pp. 207–216, Feb 2012.

[8] M. Garc´ıa-Sebasti´an, A. Savio, M. Gra˜na, and J. Villan´ua, "On the use of morphometry based features for alzheimer's disease detection on mri,"in Bio-Inspired Systems: Computational and Ambient Intelligence, ser.
Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2009, vol. 5517, pp. 957–964.

[9] N. Doan, B. van Lew, B. Lelieveldt, M. van Buchem, J. Reiber, and J. Milles, "Deformation texture-based features for classification in alzheimer's disease," in SPIE Medical Imaging, 2013.

[10] M. Liu, D. Zhang, P. Yap, and D. Shen, "Hierarchical ensemble of multi-level classifiers for diagnosis of alzheimer's disease," in Machine Learning in Medical Imaging, ser. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2012, vol. 7588, pp. 27–35.

[11] E. Westman, J. Muehlboeck, A. Simmons et al., "Combining mri and csf measures for classification of alzheimer's disease and prediction of mild cognitive impairment conversion," NeuroImage, vol. 62, no. 1, pp. 229–238, Aug 2012.

[12] B. Magnin, L. Mesrob, S. Kinkingn´ehun, M. P´el´egrini-Issac, O. Colliot, M. Sarazin et al., "Support vector machine-based classification of alzheimer's disease from whole-brain anatomical MRI," Neuroradiology, vol. 51, no. 2, pp. 73–83, Feb 2009.

[13] J. Masdeu, J. Zubieta, and J. Arbizu, "Neuroimaging as a marker of the onset and progression of alzheimer's disease," Journal of the Neurological Sciences, vol. 236, no. 1:2, pp. 55–64, 2005.

[14] B. Dubois, H. Feldman, C. Jacova, J. Cummings, S. DeKosky, P. Barberger-Gateau et al., "Revising the definition of alzheimer's disease: a new lexicon," Lancet Neurol, vol. 9, no. 11, pp. 1118–1127,
Nov 2010.

[15] R. Sperling, P. Aisen, L. Beckett, D. Bennett, S. Craft, A. Fagan et al., "Toward defining the preclinical stages of alzheimer's disease: Recommendations from the national institute on aging - alzheimer's association workgroups on diagnostic guidelines for alzheimer's disease,"Alzheimers Dement, vol. 7, no. 3, pp. 280–292, May 2011.

[16] N. Fox and J. Schott, "Imaging cerebral atrophy: normal ageing to alzheimer's disease," Lancet, vol. 363, no. 9406, pp. 392–394, Jan 2004.

[17] B. Ridha, J. Barnes, J. Bartlett, A. Godbolt, T. Pepple, M. Rossor, and N. Fox, "Tracking atrophy progression in familial alzheimer's disease: a serial fMRIg study," Lancet Neurol, vol. 5, no. 10, pp. 828–834, Oct
2006.

[18] C. Davatzikos, Y. Fan, X. Wu, D. Shen, and S. Resnick, "Detection of prodromal alzheimer's disease via pattern classification of magnetic resonance imaging," Neurobiol Aging, vol. 29, no. 4, pp. 514–523, 2008.