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Smart System to Detect Brain Age Using Machine Learning

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Abstract: *Detecting brain ageing is of paramount importance in the medical field due to its significant contribution to the rising number of deaths each year. Brain ageing stands out as a prevalent health concern, characterized by a high mortality rate and widespread occurrence. Extensive research endeavors are underway to address this issue, with Magnetic Resonance Imaging (MRI) emerging as a pivotal tool for identifying and tracking the progression of brain ageing. MRI scans offer detailed insights into the ageing process, facilitating superior outcomes compared to alternative methodologies. In our paper, we propose an innovative approach for detecting brain ageing using MRI scanned images. The methodology encompasses several crucial steps, beginning with image preprocessing, where the application of a median filter enhances image quality. Subsequently, segmentation techniques employing mathematical morphological operations isolate regions indicative of brain ageing. Geometric features such as area, perimeter, and eccentricity are then computed for the identified ageing regions. The culmination of our approach involves the utilization of an Iterative Convolutional Neural Network (CNN) classifier. This classifier distinguishes between ageingous (malignant) and normal (benign) brain regions based on the extracted features. To further enhance the accuracy of our classification, we employ both Artificial Neural Network (ANN) as a baseline method and introduce the Optimistic Convolutional Neural Network (OCNN), a novel algorithm proposed in our research. Through rigorous experimentation and evaluation, we compare the performance of ANN and OCNN, analyzing their respective accuracies. Our findings unequivocally demonstrate that the OCNN outperforms the traditional ANN, offering superior accuracy and efficacy in detecting brain ageing from MRI scans. This underscores the potential of advanced neural network architectures in revolutionizing medical image analysis and diagnosis. In conclusion, paper presents a robust methodology for detecting brain ageing using MRI scanned images, leveraging state-of-the-art image processing techniques and innovative neural network algorithms. By enhancing the accuracy and efficiency of brain ageing detection, our research contributes significantly to the ongoing efforts aimed at mitigating the adverse impacts of this pervasive health issue.*

Keywords: Magnetic Resonance Imaging (MRI), Computed Tomography (CT), Optimistic Convolutional Neural Network (OCNN).

I. INTRODUCTION

Ageing represents a pervasive health challenge, with escalating mortality rates in recent years. Notably, brain ageing emerges as a predominant concern, particularly among males. This condition is characterized by uncontrolled cell proliferation within brain tissues, often exacerbated by factors such as smoking and tobacco consumption. Malignant nodules, indicative of advanced brain ageing, pose significant risks, contributing substantially to global ageing-related fatalities. Despite advancements in detection, diagnosis, and treatment modalities, many individuals succumb to this formidable disease.

Early detection plays a pivotal role in mitigating brain ageing's fatality rates, with delayed diagnosis correlating with increased mortality. Classification of brain ageing is based on cell size, categorized into small and large cell types. Furthermore, staging of brain ageing is contingent upon nodule size and location within the brain.

Computed Tomography (CT) scans offer superior efficacy in detecting and diagnosing brain ageing compared to conventional chest X-rays. By combining multiple X-ray images from various angles, CT scans provide detailed views of internal organs without invasive procedures. Additionally, Magnetic Resonance Imaging (MRI) scans offer enhanced imaging capabilities, particularly in visualizing blood vessels and soft tissue structures. The automated nature of MRI systems minimizes human error, rendering them preferable over alternative modalities due to reduced distortion and increased reliability.

Statistical data underscore the magnitude of the ageing epidemic, with males comprising a significant proportion of cases, particularly attributed to cigarette smoking. In 2005 alone, an estimated 1,372,910 cases of ageing were reported, with projections indicating a staggering 570,280 ageing-related deaths in the United States. Of these fatalities, approximately 29% are attributed to brain ageing, highlighting its substantial contribution to overall mortality rates.

In conclusion, the imperative for early detection and intervention in brain ageing underscores the critical importance of advanced imaging modalities such as CT and MRI scans. By leveraging these technologies, healthcare professionals can enhance diagnostic accuracy,

improve treatment outcomes, and ultimately mitigate the devastating impacts of this pervasive disease.

II. LITERATURE SURVEY

1. Brain ageing detection system using brain CT image processing. Publisher: IEEE 2023 PMoffy Vas; Amita Dessai

Ageing is the root cause for a large number of deaths worldwide, out of which brain ageing is the cause of the highest mortality rates. Computer tomography scan is employed by radiologists to detect ageing in the body and track its growth. Visual interpretation of database can lead to ageing detection at later stages, thus leading to late treatment of ageing which only boosts up the ageing death rates. Therefore, image processing tools can be used for early detection of ageing. In this paper, a brain ageing detection algorithm is proposed using mathematical morphological operations for segmentation of the brain region of interest, from which Haralick features are extracted and used for classification of ageing by artificial neural networks.

2. Sex and Smoking Status Effects on the Early Detection of Early Brain Ageing in High- Risk Smokers Using an Electronic Nose Publisher: IEEE 2023 Annette McWilliams; Parmida Beigi; Akhila Srinidhi; Stephen Lam; Calum E. MacAulay

Objective: Volatile organic compounds (VOCs) in exhaled breath as measured by electronic nose (e-nose) have utility as biomarkers to detect subjects at risk of having brain ageing in a screening setting. We hypothesize that breath analysis using an e-nose chemo-resistive sensor array could be used as a screening tool to discriminate patients diagnosed with brain ageing from high-risk smokers. Methods: Breath samples from 191 subjects-25 brain ageing patients and 166 high-risk smoker control subjects without ageing-were analyzed. For clinical relevancy, subjects in both groups were matched for age, sex, and smoking histories. Classification and regression trees and discriminant functions classifiers were used to recognize VOC patterns in e-nose data. Cross-validated results were used to assess classification accuracy. Repeatability and reproducibility of e-nose data were assessed by measuring subjectexhaled breath in parallel across two e-nose devices. Results : e-Nose measurements could distinguish brain ageing patients from high-risk control subjects, with a better than 80% classification accuracy. Subject sex and smoking status impacted classification as area under the curve results (ex-smoker males 0.846, ex-smoker male 0.816, current smoker male 0.745, and current smoker male 0.725) demonstrated. Two e-nose systems could be calibrated to give equivalent readings across subject-exhaled breath measured in parallel. Conclusions: e-Nose technology may have significant utility as a noninvasive screening tool for detecting individuals at increased risk for brain ageing. Significance:

The results presented further the case that VOC patterns could have real clinical utility to screen for brain ageing in the important growing ex-smoker population.

3. Multi-Stage Brain Ageing Detection and Prediction Using Multi-class SVM Classifier Publisher: IEEE 2023 Janee Alam; Sabrina Alam; Alamgir Hossan

Recognition and prediction of brain ageing in the earliest reference point stage can be very useful to improve the survival rate of patients. But diagnosis of ageing is one the major challenging task for radiologist. For detecting, predicting and diagnosing brain ageing, an intelligent computer-aided diagnosis system can be very much useful for radiologist. This paper proposed an efficient brain ageing detection and prediction algorithm using multi-class SVM (Support Vector Machine) classifier. Multi-stage classification was used for the detection of ageing. This system can also predict the probability of brain ageing. In every stage of classification image enhancement and segmentation have been done separately. Image scaling, color space transformation and contrast enhancement have been used for image enhancement. Threshold and marker-controlled watershed based segmentation has been used for segmentation. For classification purpose, SVM binary classifier was used. Our proposed technique shows higher degree of accuracy in brain ageing detection and prediction.

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In this paper proposes an innovative approach for detecting brain ageing using MRI scanned images. The methodology encompasses several crucial steps, beginning with image preprocessing, where the application of a median filter enhances image quality. Subsequently, segmentation techniques employing mathematical morphological operations isolate regions indicative of brain ageing. Geometric features such as area, perimeter, and eccentricity are then computed for the identified ageing regions.

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In conclusion, our paper presents a robust methodology for detecting brain ageing using MRI scanned images, leveraging state-of-the-art image processing techniques and innovative neural network algorithms. By enhancing the accuracy and efficiency of brain ageing detection, our research contributes significantly to the ongoing efforts aimed at mitigating the adverse impacts of this pervasive health issue.

4. Automatic detection of abnormalities in brain radiographs caused by planocellular brain ageing. Publisher: IEEE 2023 Vesna Zeljkovic; Milena Bojic

We propose in this paper automatic algorithm for early planocellular brain ageing detection in brain X ray images. Considering the fact that brain ageing is one of the most lethal ageings and that it is usually diagnosed too late, the solution is to attempt early diagnosis at general practitioners level, using cheapest diagnostic tools, chest radiography. The proposed algorithm determines and segments the suspected area in brain X ray images. It consists of two steps: comparison between extracted planocellular brain ageing structure and the analyzed brain X ray image by calculating similarity coefficients and finding the maximum similarity coefficient which will indicate the suspected ageing

affected area in the brain image. The obtained results are promising and confirm that the proposed algorithm should serve as the foundation for future research in this area.

5. Texture Analysis Based Feature Extraction and Classification of Brain Ageing Publisher: IEEE 2023 Sanjukta Rani Jena; Thomas George; Narain Ponraj

Brain ageing is most life-threatening disease, treatment of which must be the primary goal throughout scientific research. The early recognition of ageing can be helpful in curing disease entirely. There are numerous techniques found in literature for detection of brain ageing. Several investigators have contributed their facts for ageing prediction. These papers largely pact about prevailing brain ageing detection techniques that are obtainable in the literature. A numeral of methodologies has been originated in ageing detection methodologies to progress the efficiency of their detection. Diverse applications like as support vector machines, neural networks, image processing techniques are extensively used in for ageing detection which is elaborated in this work.

6. Study of malignancy associated changes in sputum images as an indicator of brain ageing. Publisher: IEEE 2023 Remya K Sudheesh; Jeny Rajan; V S Veena; K Sujathan

Brain ageing is one among the major causes of ageing related deaths. Fortunately, an early stage diagnosis can increase the survival rates of the patients. Sputum cytology is one of the easiest and cost-effective method for brain ageing diagnosis. Chances of misdiagnosis and sampling error related to sputum cytology led to the concept of malignancy associated changes. Malignancy associated changes (MAC) are the subtle changes that happens to the normal appearing cells near or distant from the malignant cells. Literature suggests that these changes can be used as an indicator for brain ageing rather than using malignant cells which are very less in number compared to the normal appearing cells in sputum cytology images. The proposed work is intended to detect cells with MAC from sputum smear images. Analysis of nuclei texture features of sputum cell nuclei using Gray Level Co- occurrence Matrix and Gray Level Run Length Matrix from both normal and ageing patients revealed that both type of cells could be differentiated. Among 110 texture features calculated for each nuclei, a set of 35 features which clearly distinguishes normal cells and normal appearing cells were chosen. Support Vector Machine (SVM) classifier is used to classify the cells into two classes i.e cells with MAC and cells without MAC. This study demonstrates that the presence of MAC cells in conventional microscopic sputum cytology images can be identified using image processing techniques and it can have some significance in the early detection of brain ageing.

7. Application of SAW gas chromatography in the early screening of brain ageing Publisher: IEEE 2023 Shi-tang He; Yi-bo Gao; Jian-ying Shao; Yan-yan Lu.

Brain ageing is the leading cause of ageing death in China and the whole world. Early diagnosis is key to reduce the mortality from brain ageing. Exhaled breath analysis can be used in the early screening of brain ageing. Many scientists in the world have carried out the research and nominated dozens of volatile organic compounds as biomarkers for brain ageing. But the results from different researchers were not consistent, because the human body odor is affected by eating habits, environment and numerous other factors, resulting in large variation, and the sample sizes were not large enough (maximum 285). In order to increase the sample size, a rapid analysis method is necessary. SAW gas chromatography can be used to realize the wide spectrum (volatile and semi volatile organic compounds), fast (few minutes) and high sensitivity (ppb~ppt) analysis. Using airbags sampling, direct injection mode, we have gotten several volatile organic compounds reported in the literature by GC/SAW analysis of the exhaled breath samples of 19 brain ageing patients and 19 healthy volunteers.

8. Effects of Erlotinib after Acquired Resistance to Gefitinib in Advanced Non-small-cell Brain Ageing Publisher: IEEE 2023 Jingjing Pan; Meiqi Shi; Jifeng Feng

Patients with advanced or metastatic non-small cell brain ageing (NSCLC) may get benefit from epidermal growth factor receptor-tyrosine kinase inhibitors (EGFR-TKIs) but eventually develop acquired resistance to these. Here, we report a case of advanced NSCLC patient who developed resistance to gefitinib but then got benefit from erlotinib. The patient

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first received palliative chemotherapy, after that commenced gefitinib for maintenance therapy. When developed acquired resistance to gefitinib, two cycles of chemotherapy were provided but failed to control his disease progression. He was rechallenged with another TKI-erlotinib as salvage treatment. So far, the patient still received erlotinib treatment and his disease was stable. Nowadays, TKI resistance is becoming meaningful and attracting more attention. The choices for those with an initial dramatic clinical response to TKI then finally developed acquired resistance are controversial and needed further research.

III. METHODOLOGY

Artificial Neural Networks (ANNs) represent a class of neural networks distinguished by their ability to process sequential data through interconnected nodes, forming a graph structure over time. This temporal aspect enables ANNs to exhibit dynamic behavior, making them particularly suited for tasks such as continuous handwriting recognition or speech analysis, where input sequences vary in length and context.

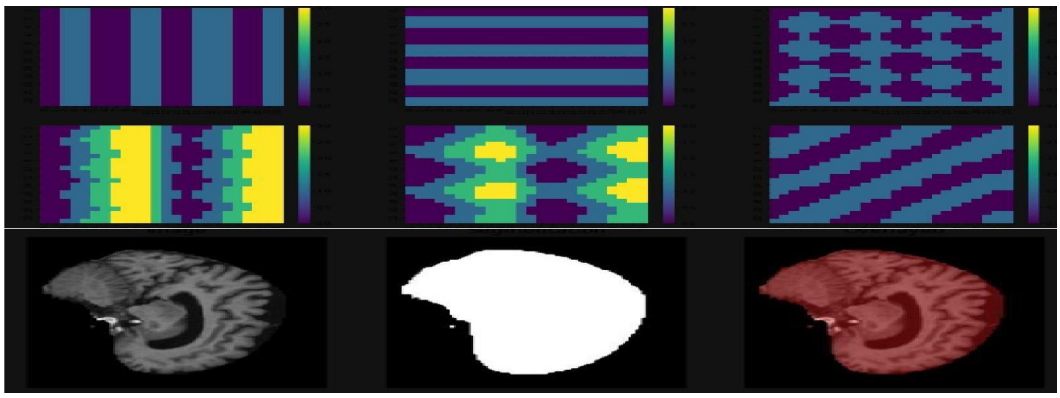
The term "recurrent neural network" (RNN) encompasses two main categories: finite impulse and infinite impulse networks, both characterized by their temporal processing capabilities. Finite impulse RNNs feature a directed acyclic graph structure, allowing them to be unfolded into a strictly feedforward architecture. Conversely, infinite impulse RNNs possess a cyclic graph structure that cannot be unfolded, offering greater flexibility in modeling complex temporal dependencies.

Both types of recurrent networks can maintain internal states, often referred to as memory or gated states, which enable them to retain information over time. These memory states can be controlled directly by the network, facilitating tasks such as sequence prediction or pattern recognition. Additionally, memory networks like Long Short-Term Memory (LSTM) and Gated Recurrent Units (GRUs) leverage gated memory mechanisms to enhance learning and adaptability.

Despite their advantages, existing ANNs suffer from several limitations. Detection of only edges, rather than more complex features, restricts their ability to capture intricate patterns in data. Furthermore, ANNs often entail high computational overhead and complexity, leading to reduced efficiency and increased processing time. Moreover, the presence of noise in input data can degrade the performance of ANNs, necessitating robust noise mitigation techniques for improved accuracy and reliability.

In summary, while ANNs offer powerful tools for processing sequential data and capturing temporal dynamics, addressing their current limitations is crucial for advancing their applicability and effectiveness across various domains.

IV. EXPERIMENTAL RESULTS



V. CONCLUSION

This paper focuses on modeling brain aging as a classification task and outlines the utilization of machine learning (ML) techniques to classify brain aging as either benign or malignant. The study compares the performance of ML algorithms with existing methods by evaluating accuracy metrics. It was noted that the ML- based classification

approach exhibited higher efficiency in brain aging detection compared to traditional algorithms, as evidenced by superior accuracy and precision. The results suggest that ML techniques offer a more effective means of classifying brain aging compared to conventional methods, highlighting their potential for improving diagnostic accuracy and decision-making processes in this domain.

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