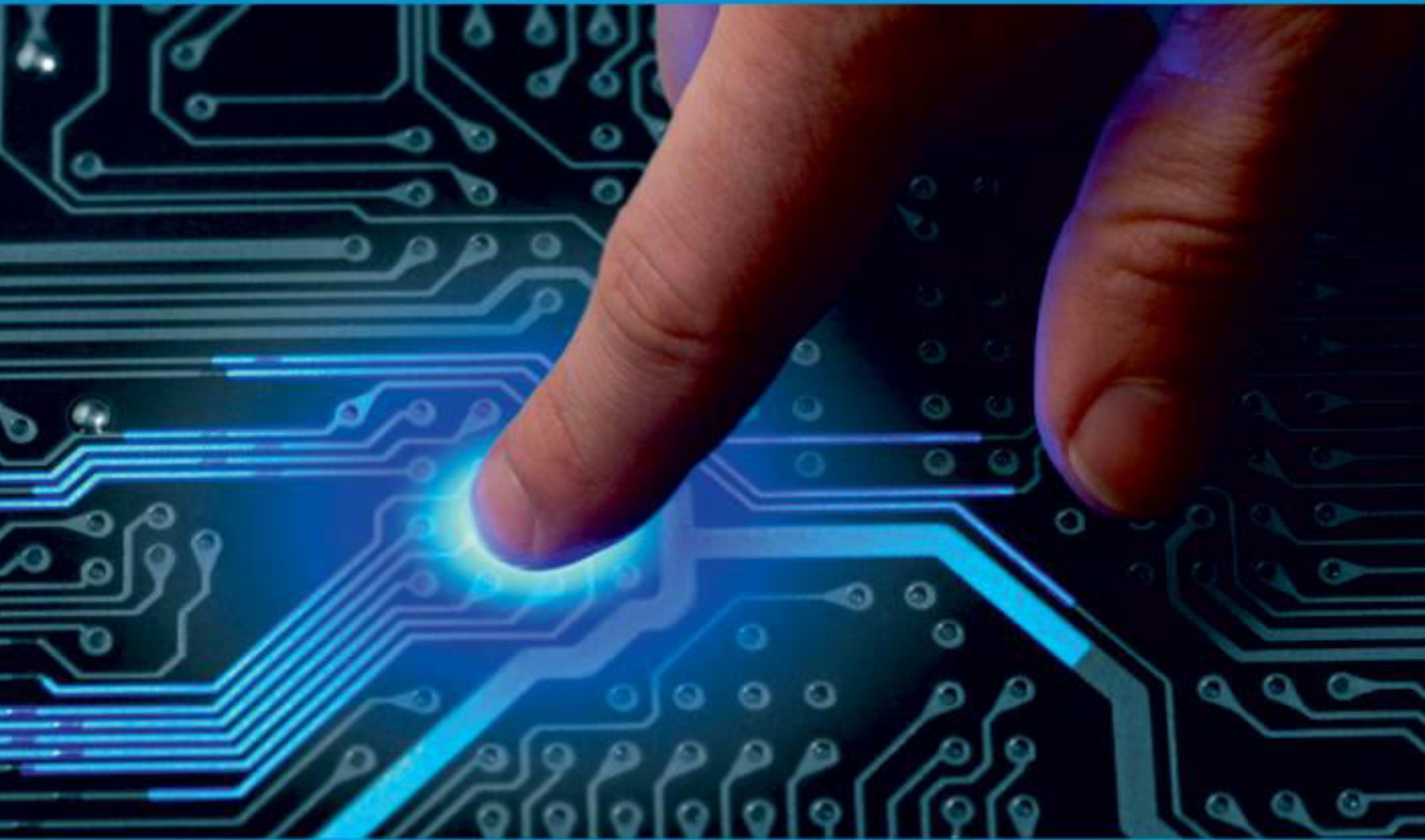
IJIRCCE

e-ISSN: 2320-9801 | p-ISSN: 2320-9798



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

Volume 12, Issue 7, July 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.379

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 7, July 2024 ||

| DOI: 10.15680/IJIRCCE.2024.1207066|

Unveiling Brain Age with Early Alzheimer's and Parkinson's Identification

Gargi G, Sandhya N

PG Student, Dept. of MCA, Visvesvaraya Technological University, The National Institute of Engineering, Mysuru, India

Assistant Professor, Dept. of MCA, Visvesvaraya Technological University, The National Institute of Engineering, Mysuru, India.

ABSTRACT: With a focus on early detection and diagnosis of neurodegenerative conditions like Parkinson's and Alzheimer's diseases, the research "unveiling brain age with early Alzheimer's and Parkinson's identification" offers a thorough framework for brain age estimation and disease classification using machine learning techniques. The technology combines convolutional neural networks for disease classification based on brain imaging data with regression methods for brain age estimation from structural MRI scans; regression models that are trained and assessed include lasso regression, ridge regression, regression random forest regression, linear regression and support vector. Low mean absolute error and high r-squared values show that the ridge and lasso regression models are effective in accurately estimating brain age to evaluate the difference between the chronological age and the anticipated brain age. A comparison study is performed; notable differences between estimated and measured brain ages are markers for possible neurodegenerative diseases. In the event of notable deviations, an extensive dataset of MRI scans with disease labels is used to train the classification model. The efficacy of the CNN model in illness categorization is demonstrated by its high precision, accuracy, f1-scores and recall. The methodology includes MRI data preprocessing feature extraction and model training with cutting edge machine learning methods. The CNN model obtains a 99.39 accuracy rate, its robustness is demonstrated by precision, recall and f1-scores this system possesses the capacity to get better patient outcomes by enabling early detection and diagnosis of neurodegenerative diseases.

KEYWORDS: Brain Age Estimation, Disease Classification, Convolutional Neural Networks, Regression.

I. INTRODUCTION

Neurodegenerative illnesses, such as Parkinson's and Alzheimer's are progressing and have no known cure, they provide serious difficulties to international healthcare systems. Effective treatment and management of these kinds of disorders depend on early detection and precise diagnosis. Recent advances in machine learning and neuroimaging technologies present viable solutions for dealing with these challenges by enabling the development of computational models for brain age estimation and disease classification. This research focuses on leveraging methods for estimating brain age using machine learning and classify neurodegenerative diseases using structural MRI scans. Brain age estimation serves as a valuable biomarker for assessing neurodevelopmental trajectories and detecting abnormalities tied with aging and neurodegenerative conditions. By comparing chronological age with predicted brain age, deviations can indicate potential neurodegenerative pathology. The classification aspect of the project aims to differentiate between normal aging and specific neurodegenerative diseases, namely Parkinson's and Alzheimer's.

Convolutional neural networks (CNNs), well-suited for image analysis tasks, are employed to learn discriminative features from MRI scans and classify them into respective disease categories. The integration of regression-based brain age estimation with CNN-based disease classification forms a comprehensive approach for early detection and diagnosis. The significance of this research lies in its potential to enhance patient outcomes by using early intervention and personalized treatment strategies. By accurately estimating brain age and detecting neurodegenerative diseases at their incipient stages, clinicians can initiate timely interventions to slow disease progression and mitigate cognitive decline. Furthermore, the proposed framework can aid researchers in better understanding the underlying neurobiological mechanisms of these diseases. This introduction sets the stage for the subsequent sections, which will delve into the methodology, results, and discussion of the proposed approach. Through rigorous evaluation and analysis, this research intends to support the growing body of knowledge in computational neuroscience and clinical neuroimaging, ultimately advancing the field of early neurodegenerative disease detection and diagnosis.

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |

|| Volume 12, Issue 7, July 2024 ||

| DOI: 10.15680/IJIRCCE.2024.1207066|

II. EXISTING SYSTEM

Most of the current neurodegenerative disease diagnostic methods rely on clinical evaluations, which can be imprecise and sensitive, especially early in the disease's course. Though accurate analysis and interpretation of neuroimaging techniques—like MRI scans—require sophisticated computing approaches, they offer important insights into the anatomy and function of the brain. Current machine learning-based methods frequently concentrate on estimating brain age or classifying diseases separately, with little regard for integration and thorough evaluation.

III. PROPOSED METHODOLOGY

A. Proposed System:

Utilizing the complimentary advantages of both approaches, the suggested method combines convolutional neural networks (CNNs) for disease classification with regression algorithms for brain age estimation. Potential neurodegenerative disorders can be identified by measuring brain age and examining differences from chronological age. Then, a CNN-based classification algorithm improves diagnostic accuracy and reliability by differentiating between specific neurodegenerative disorders and normal aging. Advantages of the proposed system are:

- Early Detection: By enabling early neurodegenerative disease identification, the proposed system expedites prompt intervention and treatment.
- Comprehensive Analysis: The system offers a comprehensive evaluation of neuroimaging data, improving diagnostic accuracy by fusing brain age estimation with disease classification.
- Personalized Treatment: Early diagnosis accuracy enables customized treatment plans based on the requirements of each patient, which may enhance results and quality of life.
- Research Advancement: By combining machine learning methods with neuroimaging data, researchers are able to better comprehend neurodegenerative disorders and progress computational neuroscience and clinical neuroimaging research.

B. Methodology:

The methodology begins with data collection and preparation by compiling a diverse dataset of pill photos, ensuring a variety of sizes, hues, and textures, and organizing the data into balanced testing, validation, and training sets while maintaining data integrity through accurate tagging. Image pre-processing involved enhancing image quality and applying techniques such as Gaussian blur, histogram equalization, and Canny edge detection, followed by pixel normalization for standardization. For model selection, we evaluated deep learning architectures like CNNs, ResNet, and DenseNet, considering model complexity, computational resources, and performance measures. We trained multiple models, incorporating transfer learning to adapt pre-trained models to pill classification, optimizing hyperparameters, and iteratively adjusting parameters to prevent overfitting or underfitting. Model evaluation was conducted using the validation dataset, assessing metrics such as precision, accuracy, recall, and F1-score to select the best-performing model. We then validated the chosen model's performance with an impartial test dataset to ensure robustness and reliability under various conditions. Finally, we compared and analyzed different models, examining factors influencing performance and extracting insights to guide future iterations and optimizations of the classification system.

The CNN architecture in our project consists of several key components: Convolutional layers, the core of CNNs, utilize learnable filters to extract features like edges, textures, and shapes from input images, with filter size, number, padding, stride, and activation functions (e.g., ReLU) as critical hyperparameters. Pooling layers, placed between convolutional layers, reduce spatial dimensions while retaining essential information through operations like max pooling, controlled by pooling size and stride. Fully connected (dense) layers follow, flattening feature maps into vectors for prediction, with neurons connected to preceding layers and activation functions applied to introduce non-linearity. The final dense layer, often with a single neuron and a ReLU activation function, predicts class probabilities. Techniques like dropout and batch normalization are employed to prevent overfitting and improve generalization by randomly dropping neurons and normalizing activations, respectively. The output layer, designed for binary classification, uses a single neuron with a ReLU activation function to predict the probability of an image belonging to a specific class, with binary cross-entropy loss function used to measure the discrepancy between predicted probabilities and ground truth labels during training.

International Journal of Innovative Research in Computer and Communication Engineering
| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |
|| Volume 12, Issue 7, July 2024 ||
| DOI: 10.15680/IJIRCCE.2024.1207066|

III. SYSTEM ARCHITECTURE

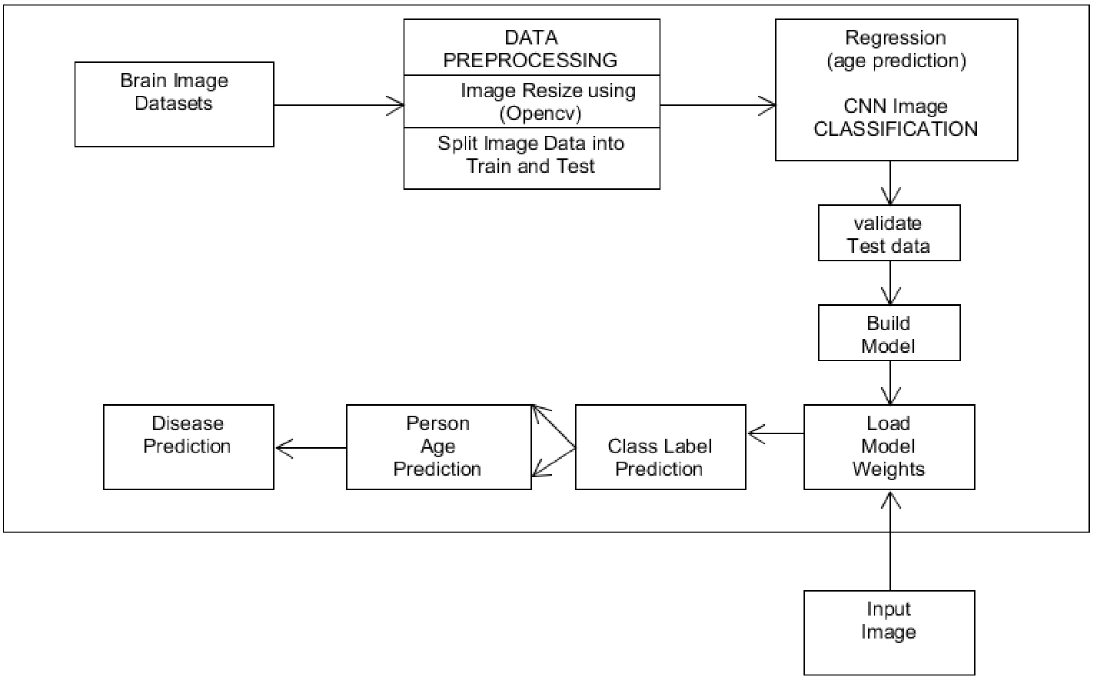


Fig. 1 System Architecture

IV. PSEUDO CODE

Steps involved in CNN algorithm for brain disease classification:
Step 1: Choose a data set
Step 2: Prepare the data set for training
Step 3: Create training data and assign labels
Step 4: Define and train the CNN model
Step 5: Test the model's accuracy

Steps involved in brain age calculation:
Step 1: Choose a dataset
Step 2: Prepare the dataset for training
Step 3: Split the data into training and testing data
Step 4: Train and test accuracy of different models
Step 5: Train and generate the Lasso model file

V. RESULTS

For the Brain Age Estimation, the regression algorithms employed, including, lasso regression, ridge regression, linear regression, random forest regression, and support vector regression, demonstrated varying levels of performance in inferring brain age from structural MRI scans. Ridge and lasso regression emerged as the most effective methods, exhibiting low mean absolute error and high R-squared values, indicative of accurate predictions.The CNN-based disease classification model achieved exceptional precision, accuracy, F1-scores and recall for distinguishing between normal aging, Parkinson's disease, and Alzheimer's disease with an accuracy of 99.39%, illustrated in the fig 2. The model demonstrated robust performance in identifying neurodegenerative conditions based on brain imaging data facilitating early detection and personalized treatment strategies

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |
|| Volume 12, Issue 7, July 2024 ||
| DOI: 10.15680/IJIRCCE.2024.1207066|

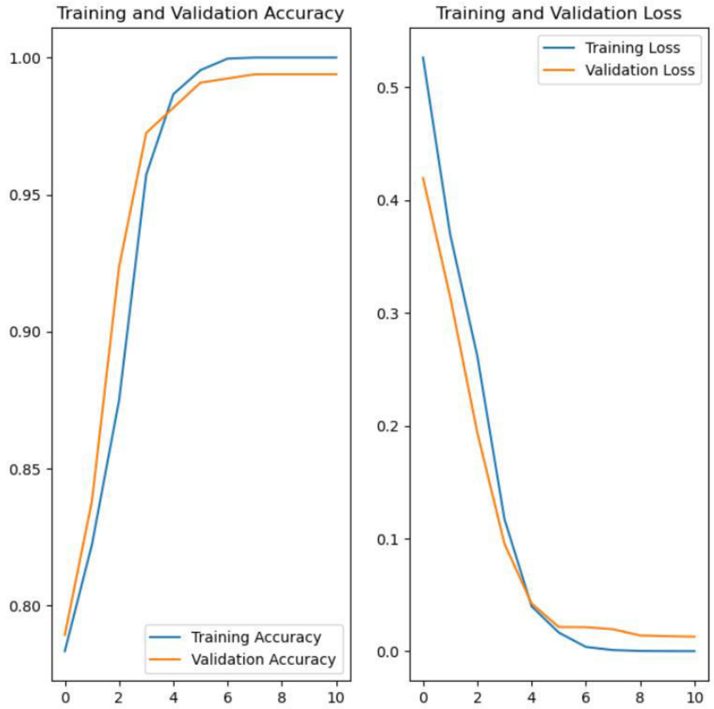


Fig 2 Model Accuracy

VI. CONCLUSION

The comprehensive approach developed in this project for brain age estimation and disease classification using machine learning techniques holds notable promise for early detection and diagnosis of neurodegenerative conditions, such as Parkinson's and Alzheimer's diseases. Through a meticulous methodology encompassing regression algorithms for brain age estimation and convolutional neural networks (CNNs) for disease classification, the project achieved notable results and insights. The results of this project have substantial implications for clinical practice and research in neurodegenerative disease diagnostics and management. Early detection of neurodegenerative conditions enables timely interventions, potentially slowing disease progression and improving patient outcomes. Moreover, the integration of machine learning techniques with neuroimaging data contributes to advancements in computational neuroscience and clinical neuroimaging research, fostering a deeper understanding of neurodegenerative diseases' underlying mechanisms.

REFERENCES

1. Siar, M. and Teshnehlab, M., 2019, October. Age detection from brain MRI images using the deep learning. In 2019 9th International Conference on Computer and Knowledge Engineering (ICCKE) (pp. 369-374). IEEE.
2. Levakov, G., Rosenthal, G., Shelef, I., Raviv, T.R. and Avidan, G., 2020. "From a deep learning model back to the brain—Identifying regional predictors and their relation to aging". Human brain mapping, 41(12), pp.3235-3252.
3. Cheng, J., Liu, Z., Guan, H., Wu, Z., Zhu, H., Jiang, J., Wen, W., Tao, D. and Liu, T., 2021. "Brain age estimation from MRI using cascade networks with ranking loss". IEEE Transactions on Medical Imaging, 40(12), pp.3400-3412.
4. Wang, Q., Hu, K., Wang, M., Zhao, Y., Liu, Y., Fan, L. and Liu, B., 2021. "Predicting brain age during typical and atypical development based on structural and functional neuroimaging. Human Brain Mapping", 42(18), pp.5943-5955.
5. Zhaonian Zhang , Richard Jiang "Robust Brain Age Estimation Based on sMRI via Nonlinear Age-Adaptive Ensemble Learning"
6. S.Suneetha, A.Dileep, T.Srinu, D.Barath, R.Prabhas "Brain disease detection and brain age estimation using CNN"
7. Soman, K., Nelson, C.A., Cerono, G., Goldman, S.M., Baranzini, S.E. and Brown, E.G., 2023. "Early detection of Parkinson's disease through enriching the electronic health record using a biomedical knowledge graph". Frontiers in Medicine, 10, p.1081087.
8. Joo, Y., Namgung, E., Jeong, H. et al. Brain age prediction using combined deep convolutional neural network and

| e-ISSN: 2320-9801, p-ISSN: 2320-9798| www.ijircce.com | |Impact Factor: 8.379 | A Monthly Peer Reviewed & Referred Journal |
|| Volume 12, Issue 7, July 2024 ||
| DOI: 10.15680/IJIRCCE.2024.1207066|
multi-layer perceptron algorithms. Sci Rep 13, 22388 (2023). https://doi.org/10.1038/s41598-023-49514-2
9. Sethuraman, S.K., Malaiyappan, N., Ramalingam, R., Basheer, S., Rashid, M. and Ahmad, N., 2023. “Predicting Alzheimer’s disease using deep neuro-functional networks with resting-state fMRI”. Electronics, 12(4), p.1031.
10. Nguyen, H.D., Clément, M., Mansencal, B. and Coupé, P., 2024. “Brain structure ages—A new biomarker for multi-disease classification”. Human Brain Mapping, 45(1), p.e26558.