Deep Learning Model for Enhance Joint Classification of Parkinson's and Alzheimer's Diseases from Challenging Datasets

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ABSTRACT

Parkinson's and Alzheimer's diseases are life-threating diseases that, annually, cause millions of deaths worldwide. The widely used traditional practice to diagnose these neurological diseases involves manual intervention, a time-consuming and relatively inaccurate approach. In essence, Parkinson's and Alzheimer's diseases are characterized by overlapping features that can hardly be distinguished by doctors. This challenge has invited researchers to devise advanced methods, including those based on artificial intelligence (AI, deep learning), to effectively classify salient features of the diseases. Concerned by the challenge and inspired by the continuing efforts of

researchers, we have developed a deep learning model that generates promising classification results, outperforming the classical work of Alhudhaif et al. (2024) by the following performance values: MRI dataset – (0.72%, accuracy); (1.25%, sensitivity); (0.09%, specificity); (0.95%, precision); and (1.10%, F1-Score); PET dataset – (0.55%, accuracy); (1.25%, sensitivity); (0.37%, specificity); (1.35%, precision); and (1.30%, F1-Score). Qualitative analysis, in addition, suggests an improved performance relative to the existing works. These results advance our current understanding on the application of AI for detection and diagnosis of Parkinson's and Alzheimer's diseases. Our results may be extended to manufacture commercializable products for assisting medical doctors to provide more accurate treatments to patients with such neurological diseases. The future perspective of the study is to patent a medical product with AI capabilities to generate real-time classification results of Parkinson's and Alzheimer's diseases. This product may seamlessly be integrated with MRI and PET machines.

Relevance and Significance of the Project

This project includes multidisciplinary components, including artificial intelligence, data science, computer science/engineering, and medicine. In addition, the product development part involves signal processing and electronics engineering disciplines.

Our study can positively impact the medical field by improving the traditional practice of diagnosing Parkinson's and Alzheimer's diseases. This will maximize the quality of the service in medical industry by improving the patient's satisfaction where it can ultimately increase the financial gain in a business perspective.

Materials and Methods

The following methodologies were followed to generate results:

- ❑ Dataset collection from online credible sources; dataset pre-processing;

  Dataset characteristics:

  - ✓ Dataset format: PNG
  - ✓ Dataset modality: MRI, PET
  - ✓ Dataset source: Kaggle for MRI, ADNI and PPMI for PET

- ✓ Dataset size: 7,367(MRI), 7329(PET)

- ❑ Design and training of a deep learning model without transfer learning from pre-trained models;
- ❑ Simulation of the designed model on the JupyterLab using Python;
- ❑ Evaluation of the model using performance metrics: accuracy, sensitivity, specificity, precision, and F1-score.
- ❑ Testing robustness of the proposed model

  By using different dataset modalities from different dataset sources.

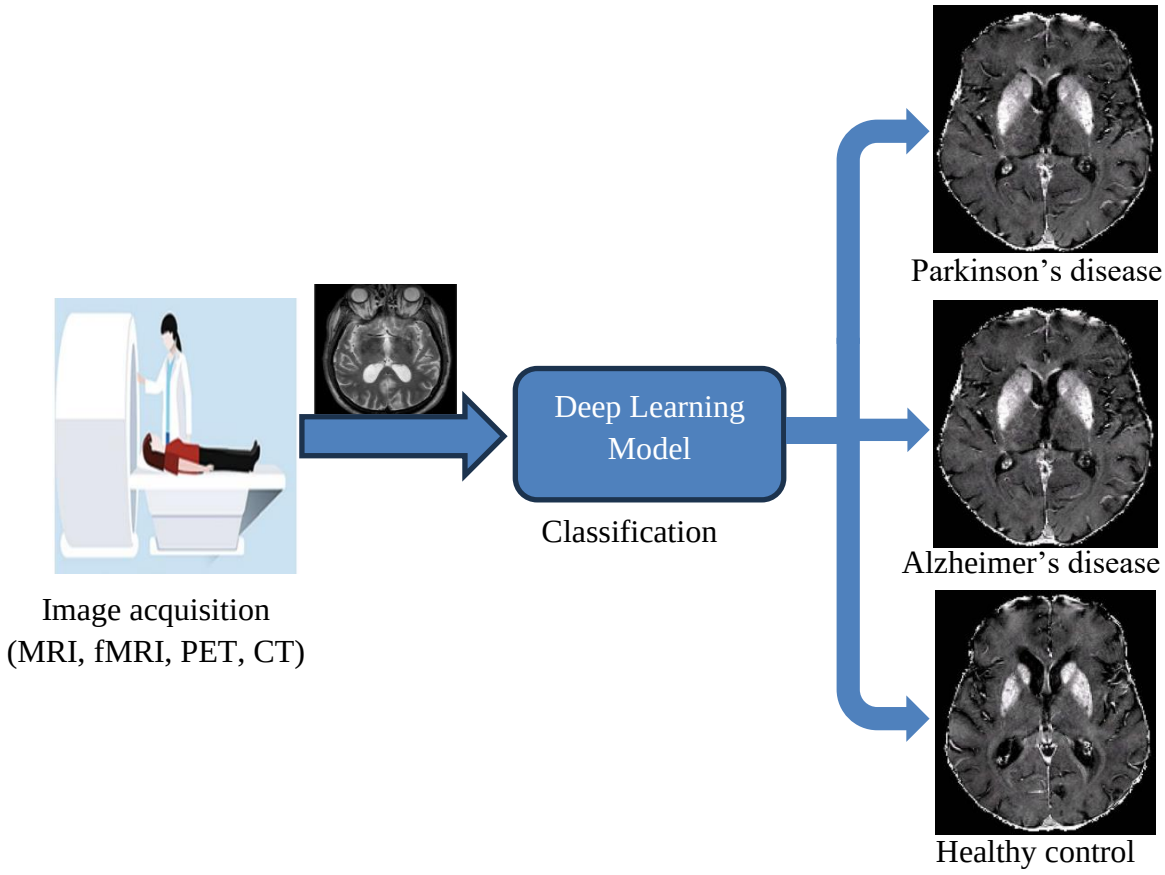


Figure 1. Design architecture and flow of the research problem.

Entrepreneurial imagination and opportunities for the community

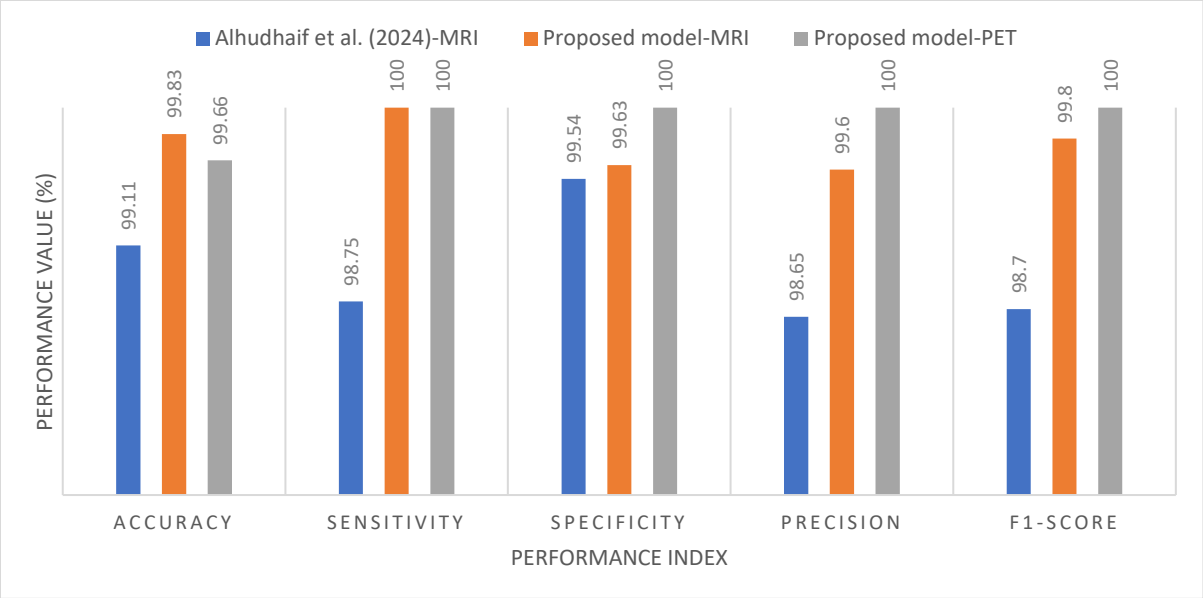
This is applied research that solves the society's healthy problem, despite that the medical product with this proposed model will be of low cost, very accurate and high quality then will help to facilitate medical practices with less diagnosis time and an improved performance but it can be sold as a product to medical institutions such as hospitals and be provided as medical service to a society to which in return is a business opportunity with a financial gain.

Scientific and practical contributions

The proposed research work has contributed to a body of knowledge, the literature review has been done and found that overlapping features between Alzheimer's disease and Parkinson's disease are an important driving reason for a joint classification of Alzheimer's disease and Parkinson's disease. The overlapping features has been visualized and confirmed qualitatively by using PCA (Principal Component Analysis) with a scatter plot. However, the two research outputs are the algorithm and an enhanced classification model without using pre-trained models with an improved performance that outperforms the existing research works with pre-trained models. Furthermore, the proposed model with a simplified design that reduced model complexity and reduced model training time where regularization techniques such as early stopping have been employed. Also, the research study achieved to challenge the robustness of the proposed model using two different dataset modalities where the gap of performance in terms of accuracy is 0.17% which is far better compared to that of 9.3% for existing works done by (Nancy Noella & Priyadarshini, 2023) and (Hatabu et al., 2017). This shows the importance of using different datasets to overcome the overfitting behavior of the model.

Results and Discussion

The simulation results of the proposed model has been analyzed and compared against the outperforming existing work done by (Alhudhaif, 2024). The two dataset modalities used to challenge the robustness of the model.



OUTPUTS

- Deep learning model and algorithm for joint classification of Parkinson's and Alzheimer's diseases;

OUTCOMES

This research project has the following prospective outcomes:

- Improved experience and increased efficiency of doctors in diagnosis of Parkinson's and Alzheimer's diseases;
- Reduced time and improved convenience in generating diagnostic classification results of Parkinson's and Alzheimer's diseases;
- Improved accuracy of classification results;
- Improved quality of delivery of medical services to patients with Parkinson's and Alzheimer's diseases.

Societal impact and commercialization prospects

Most of people in a society are suffering with these neurological diseases and unfortunately, they are not aware of it where the 10.06 million deaths of neurological patients happened in 2019. Medical experts from hospitals finds it difficult during diagnosis of the neurological diseases and

therefore the death rate of these patients may keep increasing substantially. This proposed work might bring a promising positive result in hospitals and Therefore in a society.

On commercialization perspective, this research can be commercialized to a product for a medical industry where by a product will have low TCO (Total Cost of Ownership) as well as low CAPEX and OPEX, more accurate and very robust with less complexity to tradeoff the model computation time. Also, the TTM (Time To Market) is very significant and reasonable due to easiness of implementation.

Originality of innovation product

The proposed model is novel where by it is not using transfer learning from pre-trained models such as VGG19, DenseNet201 and DarkNet53 for a joint classification of Parkinson's and Alzheimer's diseases with overlapping features in a human brain. Therefore, the product with this proposed model will be novel for commercialization.

Publications

- 1 Manuscript under construction, intended to be submitted to *EURASIP Journal on Advanced in Signal Processing*, Elsevier

Conclusion

This research study uncovered the challenge of overlapping features between Parkinson's disease and Alzheimer disease during diagnosis. The proposed deep learning method has shown promising results compared to existing research works in all performance metrics. This outperforming model can be extended to web-based application to solve the real-world problems of neurological diseases in medical domain. The commercialized product will improve the efficiency of medical practicians and there therefore improve the quality-of-service delivery in hospitals, provide timely disease management to patients and hence contribute to reduce the death rate of these patients in a global level. The quantitative simulation results of the proposed model has been analyzed and compared against outperforming existing work done by (Alhudhaif, 2024) where the proposed model with MRI dataset gave an accuracy of 99.83% which improved by 0.72%, Sensitivity (Recall) of 100% which improved by 1.25%, Specificity of 99.63% which improved by 0.09%, Precision of 99.60%

which improved by 0.95% and F1-score of 99.80% which improved by 1.10% against existing works. The proposed model with PET dataset gave an accuracy of 99.66% which improved by 0.55%, Sensitivity (Recall) of 100% which improved by 1.25%, Specificity of 100% which improved by 0.37%, Precision of 100% which improved by 1.35% and F1-score of 100% which improved by 1.30% against existing related works. The quantitative evaluation of the simulation results proved that a proposed model with MRI and PET datasets outperforms the existing related works. However, the performance of the model was evaluated qualitatively by displaying the true label and the predicted label on top of the given image where the results showed better performance with high accuracy. The training time of the existing related work (Suganya A, 2023) dropped from 53.24 minutes to 22.50 minutes for the proposed model with the MRI dataset and to 16.37 minutes with the PET dataset. The gap in performance for a proposed MRI and PET is an accuracy of 0.17% which shows the robustness of the model and is good for overcoming overfitting as per dataset perspective.