Cawangan Melaka

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volume 1

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Progress in Computing and Mathematics Journal
College of Computing, Informatics, and Mathematics
Universiti Teknologi MARA Cawangan Melaka, Kampus Jasin
77300, Merlimau, Melaka Bandaraya Bersejarah

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EDITORS

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PREFACE

Welcome to the inaugural volume of the **Progress in Computing and Mathematics Journal (PCMJ)**, a publication proudly presented by the College of Computing, Informatics, and Mathematics at UiTM Cawangan Melaka.

This journal represents a significant step in our commitment to fostering a vibrant research culture, initially providing a crucial platform for our undergraduate students to showcase their intellectual curiosity, dedication to scholarly pursuit, and potential to contribute to the broader academic discourse in the fields of computing and mathematics. However, we envision PCMJ evolving into a beacon for researchers both nationally and internationally. We aspire to cultivate a space where groundbreaking research and innovative ideas converge, fostering collaboration and intellectual exchange among established scholars and emerging talents alike.

The manuscripts featured in this first volume, predominantly authored by our undergraduate students, are a testament to the hard work and dedication of these budding researchers, as well as the guidance and support provided by their faculty mentors. They cover a diverse range of topics, reflecting the breadth and depth of research interests within our college, and set the stage for the high-quality scholarship we aim to attract in future volumes.

As editors, we are honored to have played a role in bringing this journal to fruition. We extend our sincere gratitude to all the authors, reviewers, and members of the editorial board for their invaluable contributions. We also acknowledge the unwavering support of the college administration in making this initiative possible.

We hope that PCMJ will inspire future generations of students and researchers to embrace research and innovation, to push the boundaries of knowledge, and to make their mark on the world of computing and mathematics.

Editors
Progress in Computing and Mathematics Journal (PCMJ)
College of Computing, Informatics, and Mathematics
UiTM Cawangan Melaka

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AUTOMATED FACIAL PARALYSIS DETECTION USING DEEP LEARNING

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Article Info | Abstract

Facial paralysis, stemming from nerve issues, results in the inability to control facial muscles, leading to asymmetry and weakness. This condition not only affects appearance but also disrupts daily activities. Diagnosis is time-consuming and requires specialised expertise and equipment. To address these challenges, a deep learning-based system is proposed to analyse facial expressions and distinguish between normal and paralyzed states. “Automated Facial Paralysis Detection using Deep Learning” system leveraging the InceptionResNetV2 model, undergoes preprocessing, feature extraction, and feature classification. Facial images are preprocessed with techniques like data augmentation for robustness. Features are extracted to identify relevant characteristics, which are then classified using InceptionResNetV2. Evaluation on a Kaggle dataset, divided into training, validation, and testing sets with a ratio of 5:1:1, shows an impressive accuracy of 92.7% in identifying normal and paralyzed facial expressions. This underscores InceptionResNetV2's unmatched effectiveness in facial paralysis detection, marking significant progress in healthcare diagnostics.

Keywords: Facial paralysis, deep learning, facial paralysis detection, InceptionResNetV2, facial expressions, diagnostic challenges, data augmentation, feature extraction, feature classification, Kaggle dataset, accuracy, healthcare diagnostics.

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INTRODUCTION

Facial paralysis, or peripheral facial nerve paralysis, is a medical condition caused by neurological dysfunction in the facial region, resulting in the inability to control facial muscles responsible for normal facial movements in Figure 1. This causes facial asymmetry and unilateral weakness of the facial muscles, which can significantly affect the patient's daily life, including work and social communication. Early and effective treatment of facial paralysis is necessary to alleviate facial disfigurement, and an accurate diagnosis of facial paralysis is crucial in the treatment process (Liu et al., 2021).

Various conditions such as Bell's palsy, stroke, and brain tumour can cause facial paralysis, resulting in noticeable drooping of the face and difficulties with normal facial expressions, speech, blinking, swallowing saliva, and eating. The human face plays a crucial role in visual communication, conveying important nonverbal messages such as identity, intent, and emotion. Clinicians rely on physical indications of facial paralysis to assess the patient's condition and monitor their progress (Parra-Dominguez et al., 2021).

Facial paralysis affects approximately 25 cases per 100,000 persons annually, and its incidence continues to rise. Due to the prevalence of this condition, the accurate diagnosis and evaluation of facial paralysis are crucial. The current diagnosis and evaluation process still heavily relies on doctors' personal experience and specific rating scales process (Liu et al., 2021).

To address existing challenges, the potential of deep learning algorithms in medical image analysis has been explored for improving the accuracy and efficiency of tasks, including facial paralysis detection. By analysing vast amounts of medical data, deep learning models can automatically learn relevant patterns and features, leading to accurate and reliable predictions with little human intervention. Combining deep learning with image analysis can surpass the limitations of traditional machine learning methods and offer more precise and efficient tools for detecting facial paralysis. By creating a facial paralysis detection system based on deep learning, healthcare providers can enhance the diagnosis and treatment planning of the condition, resulting in better patient outcomes and decreased healthcare costs.

Figure 1: Sample Paralyzed Face

Project Statement

Detecting facial paralysis quickly and accurately is crucial, but current methods are often slow and need specialised skills. To address this challenge, a proposal advocates for the development of a deep learning-based system tailored to rapidly analyse facial expressions and distinguish between normal and paralyzed states (Hossain et al., 2022). By leveraging advanced image processing techniques like convolutional neural networks, this system aims to diagnose facial paralysis swiftly and reliably, thereby significantly enhancing patient outcomes and quality of life.

Additionally, conventional machine learning methods in medical image analysis often rely on manually engineered features with limited ability to accurately detect facial paralysis (Hossain et al., 2022). Despite advancements in stroke detection methods, such as retinal scanning and MRI, these techniques remain inaccessible to the public due to cost and availability constraints, primarily serving medical professionals for diagnostic and treatment purposes. Consequently, there is a pressing need for affordable facial paralysis detection systems utilising advanced deep learning techniques to ensure consistent and accurate diagnoses.

The absence of reliable diagnostic tools poses significant challenges in accurately diagnosing and monitoring facial paralysis, leading to suboptimal treatment outcomes (Barbosa et al., 2019). Subjective evaluation methods, like the House–Brackmann grading system, lack automatic quantitative assessment and can yield inconsistent results among clinicians (Jiang et al., 2020). Objective and quantitative evaluation systems are crucial for ensuring consistent and reliable assessment results, ultimately improving treatment outcomes and patient satisfaction.

Deep learning algorithms exhibit potential in enhancing facial paralysis detection from images by learning complex patterns from extensive datasets (Liu et al., 2021). Therefore, a deep learning-based approach for facial paralysis detection, diagnosis, and treatment planning is proposed, aiming to revolutionise healthcare and address critical challenges in diagnosis and treatment.

Project Aim

The aim of this project is to develop a deep learning-based facial paralysis detection system that can accurately detect facial paralysis from real-time webcam feeds and images with high precision and reliability, improving the accuracy of diagnosis and treatment planning for the condition, and ultimately leading to improved patient outcomes and reduced healthcare costs.

Objective

There are several objectives that this project will be focus on:

1. To design a facial paralysis detection system for detecting between normal and paralysed facial.
2. To develop a deep learning-based facial paralysis detection system using deep learning.
3. To evaluate the functionality and accuracy of the developed system.

Project Scope

The scope of the project includes the development of a deep learning-based facial paralysis detection system using a specific set of normal and paralysed facial images. The aim is to develop a deep learning-based facial paralysis detection system using a specific dataset of normal and paralyzed facial images. It involves collecting 1000 images each of facial paralysis patients caused by stroke and normal faces from Kaggle datasets. By combining the UTK Face Cropped and Facial Droop datasets, the model learns to accurately detect facial paralysis from real-time webcam feeds and images.

Project Significance

1. Medical

Facial paralysis detection technology could help doctors and clinicians more accurately diagnose and treat patients with facial paralysis. This could lead to better observation of the development of the patients' condition in an objective way (Liu et al., 2021). It can also help millions of patients in lesser-developed countries like Bangladesh, who have no access to emergency medical solutions, by utilising IoT devices or mobile applications, which can expedite medical procedures (Hossain et al., 2022).

2. Knowledge

Developing a facial paralysis detection system based on deep learning not only contributes to the field of deep learning, advancing our understanding and capabilities, but also improves medical knowledge, enhances the objective and quantitative grading assessment of facial paralysis (Liu et al., 2020) and paves the way for the development of other automated diagnostic systems.

3. Government

The development of an automatic facial paralysis detection system can contribute to the deployment of more effective models to help medical professionals accurately determine facial paralysis, as a result simplifying and digitising the whole stroke detection process (Hossain et al., 2022). This technology could potentially be used in government-funded healthcare systems to improve the accuracy and efficiency of facial paralysis diagnosis and treatment. It may also have implications for disability benefits and support services.

4. Public awareness

By raising awareness of facial paralysis and the availability of detection technology, this project may help to destigmatize the condition and encourage more individuals to seek treatment. With the increasing incidence of facial paralysis, the diagnosis and recognition of facial paralysis becomes very important (Liu et al., 2021). It could also lead to increased research and funding for related medical conditions.

LITERATURE REVIEW

Overview of Facial Paralysis

Facial paralysis, or peripheral facial nerve paralysis, stems from cranial nerve 7 injury, affecting facial muscle control and causing drooping features, speech, and expression difficulties (Jiang et al., 2020). Trauma, infections, tumours, stroke, or underlying medical conditions can trigger it (Liu et al., 2021). Beyond physical challenges, facial paralysis affects social interactions and daily life, causing emotional distress (Yang et al., 2019). Current diagnostic methods rely on subjective observation, leading to variability. Advances in deep learning and computer vision offer promise for automated, objective evaluations, potentially revolutionising early diagnosis and effective treatment interventions.

Image processing techniques combined with deep learning are pivotal in enhancing the accuracy of facial paralysis detection. Pre-processing methods are applied to optimise image quality by reducing noise, enhancing contrast, and resizing. These techniques ensure that subsequent steps, such as feature extraction and classification, can effectively analyse and detect facial paralysis-related features. Deep learning models automatically extract relevant facial asymmetry and muscle weakness features, enabling precise detection and classification of facial paralysis (Liu et al., 2020). By leveraging image processing and deep learning, the accuracy and efficiency of facial paralysis detection systems are significantly improved.

Data augmentation is an effective way to improve the sufficiency and diversity of training data. It involves a range of techniques designed to enhance the quality of the training dataset by creating variations of the original images (Yang et al., 2022). These techniques include processes such as rescaling, rotation, shifting, shearing, zooming, and horizontal flipping. Data augmentation serves a crucial role in mitigating overfitting by diversifying the dataset and making the model more robust. It also assists in improving the generalisation capabilities of the deep learning model, ensuring that it can accurately detect and classify facial paralysis cases, even when presented with previously unseen variations in facial expressions and conditions.

Face detection plays a crucial role in identifying and extracting the facial region from input images. Various face detection algorithms and methods are used to accurately locate and isolate the faces. These algorithms employ techniques such as Viola-Jones, Haar cascades, or deep learning-based approaches like the Single Shot MultiBox Detector (SSD) or the You Only Look Once (YOLO) algorithm (Parra-Dominguez et al., 2021). Successful face detection enables further analysis and evaluation of facial paralysis. As part of the common approach, the extraction of facial landmarks plays a crucial role in facial paralysis detection as these key points serve as reference points for computing other measures, including distances, angles, and areas between the landmarks. These measures provide valuable information about facial asymmetry and muscle weakness, aiding in the accurate assessment and classification of facial paralysis.

Once the relevant features are extracted, classification algorithms are employed to distinguish between normal facial images and those representing facial paralysis. Deep learning models, including Convolutional Neural Networks (CNNs), are widely utilised for feature classification and have demonstrated exceptional performance in image recognition tasks (ten Harkel et al., 2023). These models are trained on large, labelled datasets, learning to recognize patterns and classify the input images into the appropriate categories. The trained models can accurately detect and classify instances of facial paralysis based on the extracted features, providing valuable diagnostic information for healthcare professionals in assessing and diagnosing facial paralysis cases.

Related Work

In recent years, researchers have made considerable progress in developing facial paralysis detection. There are some works related to facial paralysis. Hossain et al., (2022) developed a comparative study to detect facial paralysis using deep learning algorithms. They compared ResNet50, InceptionV3, and VGG16 on facial image datasets from Kaggle. ResNet50 achieved the highest accuracy of 96.63%, making it the best-performing model among the three.

Another related work is “Facial Nerve Paralysis Assessment based on Regularized Correntropy Criterion SSELMvc and Cascade CNN" by Tan et al., (2021). This paper introduces the FNPA-RCELM-CCNN method, which incorporates a landmark detection network, a feature extraction network, and a region-based CNN with LSTM. Achieving an accuracy of 85.5%, this method notably outperforms other approaches in facial nerve paralysis assessment.

X.L et al., (2020) developed the Region Based Parallel Hierarchy Convolutional Neural Network for Automatic Facial Nerve Paralysis Evaluation. The proposed method accurately detects and classifies facial paralysis severity, achieving recognition rates of 91.02% to 97.79%. The PHCNN-LSTM architecture outperforms other networks with an average accuracy of 94.81%.

Table 1: The summary of related work

Work	Method	Accuracy
Hossain et al., (2022)	ResNet50, InceptionV3, VGG16 on facial image datasets from Kaggle	96.63%
Tan et al., (2021)	FNPA-RCELM-CCNN method integrating landmark detection, feature extraction, region-based CNN with LSTM	85.5%
X.L et al., (2020)	PHCNN-LSTM architecture for facial paralysis severity detection and classification	91.02% - 97.79%

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METHODOLOGY

Project Framework

The project framework outlines the key components and activities involved in developing the facial paralysis detection application. It encompasses phases such as problem statement, data collection and processing, system design, and system testing. Specific activities within each phase include preliminary research, dataset training using CNN, system architecture design, and performance evaluation. The ultimate goal is to create an effective detection system using advanced techniques. The project will follow the waterfall model, a classic software development methodology, for systematic and sequential progression. Figure 2 illustrates the adapted waterfall model for the project, highlighting stages such as requirements preliminary study, data collection, model development, evaluation and validation, system implementation and system testing. The preliminary study involves initial research to gather relevant information on facial paralysis detection. Data collection assembles a diverse dataset, while model development creates a CNN model for detection. Evaluation and validation assess model performance, system implementation integrates the model into the chosen platform, and system testing ensures functionality and accuracy, with refinement as necessary based on results.

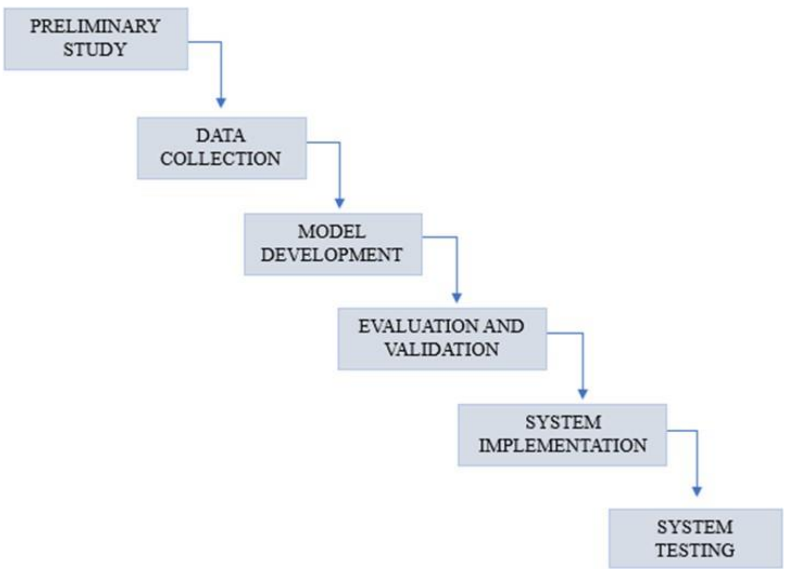

Figure 2: Waterfall Model for Facial Paralysis Detection

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System Design

The accompanying diagram, Figure 3 visually illustrates the sequential steps involved in facial paralysis detection, leveraging the InceptionResNetV2 model.

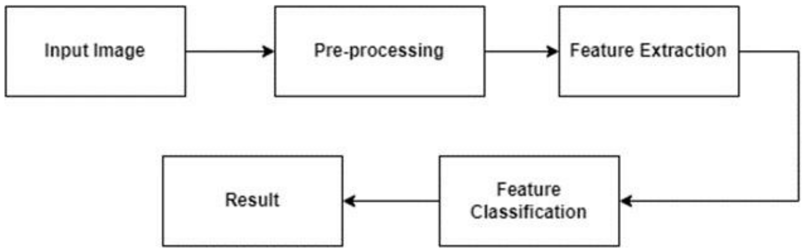

Figure 3: Facial Paralysis Detection Diagram

The initial phase involves providing the input image, followed by pre-processing techniques such as rescaling and augmentation. Subsequently, feature extraction extracts pertinent features from facial images to identify specific characteristics associated with facial paralysis. These extracted features are then utilised for classification using the InceptionResNetV2 model, which has been trained on a labelled dataset containing facial paralysis images. The final output, termed result, indicates whether the input image displays facial paralysis and potentially provides additional insights into its severity or type. This detailed representation offers insight into the systematic approach adopted for facial paralysis detection.

RESULT AND DISCUSSION

Result

In the experimental phase, we successfully implemented the facial paralysis detection system, showcasing its real-time detection capabilities. Figure 4 illustrates the system in action, demonstrating its ability to detect facial paralysis in real-time and Figure 5 showcases the system's accurate prediction of facial expressions from images.

Figure 4: Facial Paralysis Detection in Real-Time

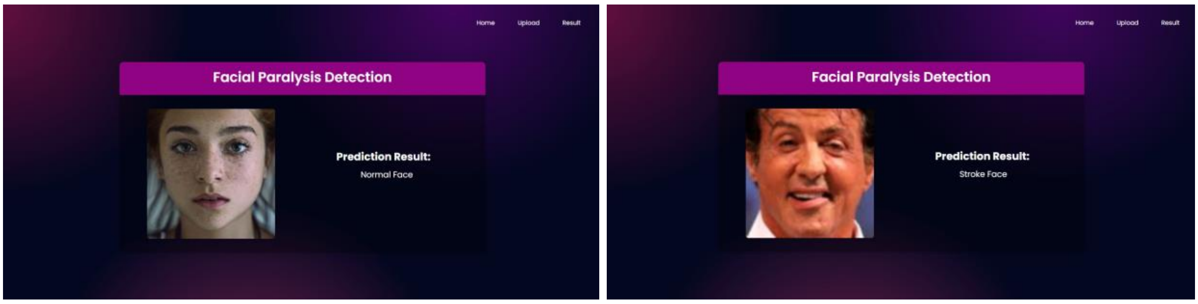

Figure 5: Facial Paralysis Detection in Images

Overall Performance Metrics

To evaluate the performance of the facial paralysis detection model based on the InceptionResnetV2 CNN architecture, several metrics were employed, including accuracy, precision, recall, and F1-score. As shown in Figure 6, the model achieves an accuracy of 92.67%, indicating its proficiency in making correct predictions. Precision stands at 94.44%, showcasing the model's accuracy in positive predictions, while recall reaches 90.67%, highlighting its ability to capture actual instances of facial paralysis. The F1 Score, at 92.52%, reflects the model's balanced performance in achieving precision and recall.

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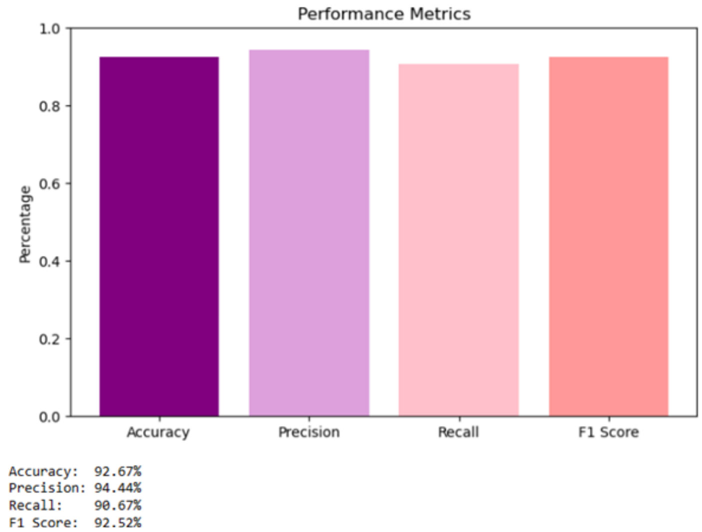

Figure 6: Performance Metrics Analysis

Confusion Matrix Analysis

The confusion matrix, illustrated in Figure 7, provides a detailed breakdown of the InceptionResNetV2 model's predictions. With 68 true positives (TP), the model successfully identifies instances of "Stroke Face." However, it incorrectly predicts "Stroke Face" in 4 instances (false positives, FP) where the actual label was "Normal Face." On the other hand, the model correctly identifies 71 instances of "Normal Face" (true negatives, TN). Nevertheless, it incorrectly predicts "Normal Face" in 7 instances (false negatives, FN) where the actual label was "Stroke Face." This breakdown offers valuable insights into the model's performance and its ability to accurately classify facial paralysis and normal faces.

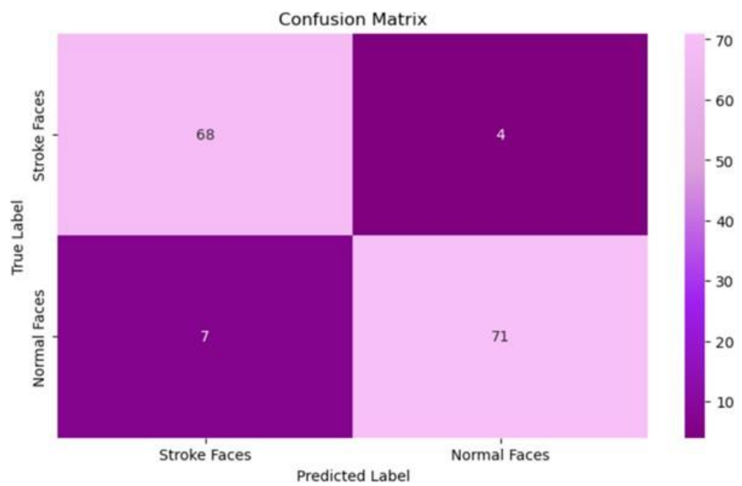

Figure 7: Confusion Matrix Analysis

Conclusion

The project, “Automated Facial Paralysis Detection using Deep Learning”, focuses on designing and evaluating a system for identifying normal and paralyzed facial expressions. InceptionResNetV2 emerges as the top choice with an accuracy of 92.67%, highlighting its effectiveness in distinguishing between normal and stroke faces and promising advancements in diagnostic processes and patient care.

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