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The Reliability, Safety, and Control Principle on Recognition of Facial Expression Through Deep Learning to Support Responsible AI Implementation Policy

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Abstract

Artificial Intelligence (AI) is a system that uses the power of science and technology to create a system that can think and act like humans. It is also a study of creating intelligent computers that can carry out tasks that typically need human intelligence. The use of AI often involves collecting vast amounts of personal data, and if this data is not adequately monitored and protected, it can lead to breaches of privacy and security as well as unethical. If AI is not addressed properly, it may lose out on the advantages and opportunities that these technologies may provide. In view of this, the Malaysian Government, through MOSTI, has launched National AI Roadmap 2021-2025, which also emphasizes Responsible AI practices, including the reliability, safety, and control of AI to minimize harm and challenges. In addition, with the shift from laboratory-controlled to demanding in the-wild circumstances for facial expression recognition (FER) and the relative success of deep Learning methods in multiple areas, deep neural networks are progressively being used to learn discriminative representations for automated FER. The latest deep FER systems mainly focus on two issues overfitting due to a lack of enough data and unrelated variations like lighting, head pose, and identity bias. In this paper, we propose a solution for facial expression recognition that integrates Convolutional Neural Network (CNN) and specific image pre-processing steps. CNN achieves better accuracy with given data. Yet, there are no available datasets with adequate data for facial expression recognition with deep architectures. Thus, the pre-processing technique is applied to extract only five expression-specific features from a face image detecting emotions such as happiness, surprise, sadness, anger, and normal. A sufficient number of Eigen face values are chosen. These Eigen faces can make up any image of training data when added with the right proportions; after all eigenvalues from each trained image are evaluated, a new input image can be processed by calculating the Euclidean Distance between the Eigenvalues of the input image and every training image within the help of MATLAB software the lowest distance will determine the current expression.

Keywords: Malaysia National AI Roadmap (2021-20250), Responsible AI, Reliability, Safety, and Control AI Principle, Deep Learning; Facial Recognition and Convolutional Neural Networks.

1. Introduction

The United Nations agencies have adopted artificial intelligence as an accelerator for realizing the 2030 Agenda for Sustainable Development for all countries to support opulence while protecting the world. Global financial reports show that artificial intelligence can change the output potential of the global economy, which can be a great changer for both developed and developing nations. The countries that pay no attention to these trends may miss out on the economic chance and stay competitive in this fast-transforming digital world. In addition, artificial intelligence has a perspective to expedite annual economic growth in 2035 added by modifying the nature of jobs and establishing new interactions between humans and machines.

This question defines the scope of what machines could do in the future and leads the direction of AI research. It only concerns the performance of machines and ignores the issues of interest to psychologists, scientists, and philosophers. Every aspect of Learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it. It does not matter whether a machine is really thinking or is just acting like it is thinking. This paper illustrates in detail the relationship between both humans and machines and the impact on the stakeholders.

Responsible AI is one of the crucial elements in order to promote and enhance the adoption of Artificial Intelligence in the country nationwide. If AI is not addressed effectively, it may lose out on the advantages & opportunities that these technologies may provide. Majorities of the global respondents agreed that their business is delaying the adoption of AI technology due to potential threats and risks. Many are seeking and anticipating for Standards & Safeguards with 62% believing that AI should be governed by the Government. (Source: Deloitte AI Institute and the Deloitte Center for Technology, Media & Communications-3rd Etd). AI's threats and risks may be tackled through the adoption of AI Principles for its ethical application. Principles in ethics are frequently used to safeguard humans from the negative consequences of digital technologies on their rights and to guide the development of all such technologies in a better way.

In 2022, the Government of Malaysia launched the Malaysia National Artificial Intelligence Roadmap 2021-2025, which comprises six strategic initiatives with 22 action plans. In line with UNESCO AI Ethics Recommendation above, the Government of Malaysia has introduced the Principle of Responsible AI under one of the strategic initiatives. There are seven AI principles introduced, which include fairness; reliability, safety, and control; privacy and security; inclusiveness; happiness; accountability and transparency.

In view of this, this paper focuses on the reliability, safety and control of AI principles. A recent deep FER system has primarily focused on two issues overfitting due to a lack of enough training data and expression-unrelated variations like lighting, head pose, and identity bias. In this paper, we propose a simple solution for facial expression recognition that uses a combination of Convolutional Neural Network and specific image pre-processing steps. Convolutional Neural Networks achieve better accuracy with given data which contributes to the reliability, safety and control of the AI technology that has been developed.

2. Literature Review

2.1 Artificial Intelligence (AI)

A branch of computer science called Artificial Intelligence (AI) creates an intelligent machine that can do activities that have historically required human intelligence. The study of creating intelligent computers that can carry out tasks that typically need human intelligence is known as artificial intelligence (AI), a subfield of computer science. According to Copeland (2023), a digital computer or a robot's ability to be controlled by a computer and do tasks frequently done by sentient beings is known as artificial intelligence (AI). The Malaysian

Government, through its AI National Roadmap 2021- 2025, defined AI as AI is a suite of technologies that enables machines to demonstrate intelligence, the ability to adapt to new circumstances, and used to amplify human ingenuity and intellectual capabilities through collective intelligence across a broad range of challenges. The main objective of AI is to develop intelligent machines that can work autonomously without the need for human intervention. This can be achieved by developing algorithms that can learn from data, identify patterns, and make decisions based on data analysis. The development of AI has led to the creation of various intelligent systems, such as speech recognition systems, autonomous vehicles, and intelligent robots (Dobrev, 2012). Artificial Intelligence (AI) has become an integral part of our lives and has made significant advancements in various fields, including healthcare, finance, and transportation. Referring to Vinuesa et al. (2020), AI also has managed to improve efficiency and reduce costs, which is advantageous for human development, economic progress, and human well-being.

2.2 Malaysia National Artificial Intelligence (AI) Roadmap 2021-2025

AI technologies have the potential to increase productivity, solve manufacturing and operation issues, increase the standard of living as well enhance the country's economic growth. In view of this, the Malaysian Government, through the Ministry of Science, Technology & Innovation (MOSTI), has developed and introduced the Malaysia National Artificial Intelligence Roadmap (2021-2025) in 2022. There are six strategic initiatives with 22 Action plans that are to be implemented for the next three years. One of the Action Plans includes institutionalizing Responsible AI to enhance the adoption of AI, where it highlighted 7 AI Principles. Further details on each of the AI Principles are shown in the following figure 1 below.

According to Zhu et al. (2021), responsible AI refers to the development and deployment of AI that is ethical, transparent, and accountable. This involves ensuring that AI systems do not perpetuate harmful biases or discrimination and that they are designed to prioritize the well-being and safety of individuals and society as a whole. AI ethics, on the other hand, involves the investigation and evaluation of the ethical implications of AI systems and their impact on society. This includes determining the reliability, safety and control of AI technology that is being developed. Both responsible AI and AI ethics are crucial for ensuring that AI is developed and deployed in a way that benefits society rather than causing harm. In addition, AI adoption also poses potential challenges and risks that we must consider. According to Artificial Intelligence Index Report 2023 published by Stanford University, the AI, Algorithmic and Automation Incidents and Controversies (AIAAIC) database has analyzed instances involving the unethical usage of AI, and it shows a 26-fold increase in the number of incidents and controversies from 2012 to 2021 as Figure 2 (Maslej et al. (2023). From this statistic, we can see that the trend was increasing due to the rapid advancement of artificial intelligence (AI) technology and the need for mechanisms to promote responsible AI.

Figure 1: Principle of Responsible AI

As AI continues to advance and become more integrated into our daily lives, it is essential that these principles are upheld to ensure that AI is used for the betterment of all. This paper will demonstrate the face recognition technology that is being created through deep Learning.

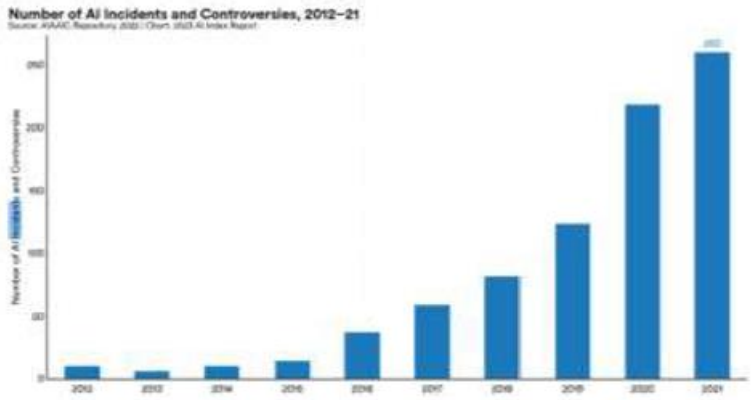

Figure 2: Number of AI Incidents and Controversies from 2012 to 2021
(Source: Artificial Intelligence Index Report 2023

2.3 Face Recognition Technology

During the 1990s, programmed face-recognition innovation moved from the research facility to the commercial world generally in view of the quick improvement of the innovation and now various applications use face recognition. These applications fuse everything from controlling access to secure zones to checking the personality on an identification. The most recent critical evaluations of this technology happened between September 1996 and March 1997 with the Face Recognition Technology (Feret). The Feret tests were innovation assessments of creating approaches to deal with face recognition. Exploration bundles were given a great deal of facial pictures to make and improve their system. These groups were tried on a sequestered arrangement of pictures, which required the individuals' system to process 3,816 pictures. [1] The Feret assessment estimated execution for both identification and verification and gave performance statistics for different image categories. The class included pictures taken around the equivalent day under the equivalent incandescent lighting. This class represented to a situation with the potential for achieving the most ideal exhibition with face recognition algorithms [2]. All of the going with three classifications ended up being dynamically more troublesome, with the last class comprising of pictures taken at any rate eighteen months separated. Table 1 summarizes the check execution results for the best calculations in every class. The results are from a database of 1,196 people. Despite the fact that the way that you can peruse a couple of general strategies for assessing a biometric system, such a biometric has its own unique properties [3]. This uniqueness suggests that each biometric must be addressed only when interpreting test results and picking a proper biometric for a particular application.

2.4 Related Works on the Face Recognition Technology

For years, researchers have been studying facial expressions. However, there was still space for improvement in every study. As a result, there are numerous opportunities in this region. The main aim of their study is to improve the accuracy of a specific dataset called FER2013 [4]. They used a convolutional neural network as the methodology for classifying seven specific emotions in their proposed model. [5] The effectiveness of convolutional neural networks in improving the accuracy of biometric applications was demonstrated in this study. However, the recognition rate of each class fluctuates because they were unable to sustain an equivalent or nearly equal recognition rate for each class. Although overall accuracy has been achieved at 91.12%, the recognition rate in classifying disgust and fear only stands at 45% and 41%, respectively. Researchers had previously developed a facial expression recognition method based on posed images in a static environment. However, [6] introduced the RAF-DB facial expression dataset, which contains photographs of people of various

ages and poses in a dynamic environment. To define 7 basic emotions, they used a deep locality-preserving CNN system. The RAF-DB and CK+ datasets were used to train their proposed model. Despite the accuracy of 95.78 percent, the identification rate for disgust and fear is just 62.16 percent and 51.25 percent, respectively. They described this as a continuation of their previous work. They used a deep convolutional neural network, [7] which is a mixture of convolutional neural networks and deep residual blocks, to describe the five basic emotions. They used the Extended Cohn Kanade (CK+) and Japanese Female Facial Expression datasets to train their model (JAFFE). Their research success has been described as better performance than the state-of-the-art approach and higher accuracy than other models. Accuracy has been accomplished at 95.24%. Their system is based on certain datasets since it is based on two of them. In addition, they could not classify emotions from images that carry geometrically displaced faces. Kohok & Kulkarni (2019) introduced a methodology for Facial expression recognition using CNN has been talked about. [8] A CNN model on the Facial expression recognition 2013 dataset was made and experiments with the architecture were conducted to achieve a test accuracy of 0.6012 and a validation accuracy of 0.8978. This cutting-edge model has been used for classifying the emotions of users in real-time using a webcam. The webcam captures a sequence of images and uses the model to characterize feelings.

[9] As we move towards an advanced world, Human Computer Interaction turns out to be significant. A lot of research has been done in this field over the previous decade. Face expressions are a key feature of non-verbal correspondence, and they assume a significant role in Human Computer Interaction. They compared two methods for extracting facial features [10]. The first is geometric fiducial point positions, and the second is the Gabor-wavelet coefficient fetch form. Following this contrast, they discovered that the Gabor wavelet coefficient fetch approach outperforms the other.

[11] They were able to determine the appropriate number of hidden layers, which is five to seven, in order to achieve a higher recognition rate. 90.1 percent accuracy has been reached. They confessed to having a lower recognition rate in the fear class, despite not showing individual class recognition rates.

3. Facial Landmarks Detection

This section will break down the methodology of the project, from the designing of the systems to face detection of facial expressions using deep Learning Convolutional Neural Networks (CNN) algorithm and how it will be implemented into the project. It will cover the programming language using MATLAB. The event flow chart of this system is illustrated in Figure 1. Firstly, the model takes an image for facial collaboration purposes and detects the current facial expression through a live webcam by acknowledging changes in facial landmarks.

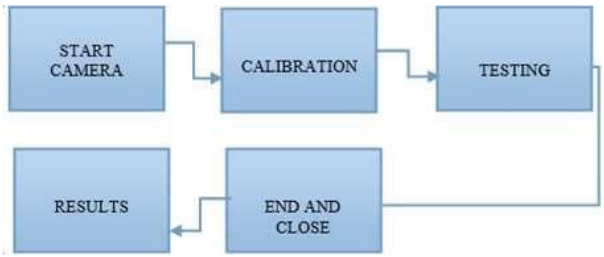

Figure 3: Flowchart of the face recognition system

The image is pre-processed in order to extract facial features, and once the facial expressions are extracted, the image is then cropped to detect the expression completely. The system then classifies whether a person is – angry, happy, sad, surprised, or normal by tracking specific muscular movements in the face, such as an increase in eye length or cheeks then generates the message according to the current condition. Table 1 explains how every facial landmark change means a different facial expression.

Table 1: Effect of Emotion on Facial Landmarks.

Emotions	Effect on Full Face	Effect on Lips
Happy	Normal	Horizontal Stretching
Sad	Vertical Squeezing	Horizontal Squeezing
Surprised	Vertical Stretching	Vertical stretching
Angry	Vertical Stretching	Horizontal Squeezing
Normal	Normal	Normal

3.1 Face Registration

Face detection, also known as Face Registration, is the method of detecting the position of a person's face in an image. OpenCV Cascade classifier was used to detect faces in the images [12]. After the face has been detected, the face portion has been cropped out to reduce background complexity and make model training more effective.

3.2 Grayscale Conversion

The images were resized to 48*48 pixels with three channels of red, green, and blue. Dataset images were converted to grayscale with only one channel to reduce the complexity of pixel values [13]. As a result, Learning has become relatively simple for the model. Gray scaling is the method of transforming a colored image input into an image, the pixel value of which depends on the intensity of light on the image. Gray scaling is performed because it is difficult to process colored images by an algorithm.

3.3 Image Normalization

Normalization of an image is performed to remove illumination differences in lighting and to obtain a better face image. Normalization has been applied [14] to the model dataset, which is a process that modifies the range of pixel intensity values to a certain limit. It is a process by which contrast or histogram of the images can be stretched so that it enables a deep network to analyze the images in a better way.

3.4 Image Augmentation

Face detection, also known as Face Registration, is the method of detecting the position of a person's face in an image [15]. The OpenCV Cascade classifier was used to detect faces in the images. After the face has been detected, the face portion has been cropped out to reduce background complexity and make model training more effective.

It is a statistical mechanism that uses an orthogonal transformation to convert correlated data (training faces) into UN-correlated data (Eigen face)/ principal component. The first principal component (Eigen face or Eigen vector) contains the maximum information of all the training images. Each principal component is orthogonal. A sufficient number of Eigen faces can be chosen. These Eigen faces can make up any image of training data when added with the right proportions and are called weights/Eigen Values. Once Eigen values for each training image are evaluated. Then a new input image is projected on the selected Eigen faces and consequently, its Eigen vectors are determined. Euclidean Distance is calculated b/w the Eigen values of the input image and every training image. The lowest distance determines the expression.

3.5 Facial Landmarks Detection

Facial landmarks detection is based on the following three steps. Face detection and cropping using the viola jones algorithm. Put some estimated landmarks on the cropped face. Pass the Cropped face and estimated landmarks to the trained neuronal network for landmarks detection. Draw the received landmarks on the original image.

4. Results and Discussion

This is an artificial intelligence program that gives the AI system the ability to learn from the environment automatically and uses the Learning to make better decisions. Machine Learning uses a number of algorithms to iteratively learn, explain and improve data with a view to predicting better outcomes. These algorithms use statistical techniques to detect patterns and then take action on patterns. We used deep Learning Convolutional Neural Networks (CNN) algorithm. Deep Learning it's the next Machine Learning generation. It is a Machine Learning sub-set. Deep Learning models can make their own predictions fully human-independent. For certain instances, machine learning models of the past also require human intervention to achieve the desired result. Deep learning models take advantage of artificial neural networks. The network's architecture is influenced by the human brain's biological neural network. It analyses data with a similar logical structure to the way a person might draw conclusions.

4.1 Deep Learning Machine Analysis

This section of the report covers the design concept as well as the results of the system simulation using MATLAB and SOLIDWORKS. This section also discusses the protocol and conclusions reached as a result of the findings. There are a sufficient number of Eigen faces selected. These Eigen faces, when combined with the appropriate proportions, may create any image of training data. They are referred to as weights/ Eigen Values. After that, the Eigen values for each of the training images are calculated. The Eigen vectors of a new input image are then calculated by projecting it on the selected Eigen faces. In Euclidean geometry, the distance between the Eigen values of the input image and each training image is determined. The expression performance is simulated in MATLAB using the lowest distance.

Figure 4: Application start-up in MATLAB

As shown above, in Figure 2, the application start-up menu guides the user through all steps in an arranged manner. The user must click (Start camera) to turn on the live webcam. The second step system requires you to click the (Calibration) button to detect the new user's facial landmarks and compare them with the trained database, then notify the user that calibration is done successfully. Then the user can click on the (Testing) button to start the live webcam broadcast system will notify the user of current facial expressions depending on different facial landmarks detected after cropping the image using the trained database, creating a new projected input image. Distance is calculated between all the Eigen values of the input image and every training image. The lowest distance determines the expression. The user can click the (End Testing) button to stop the process as well as the (Stop Camera) button in order to turn off the camera ending the process.

The application will request the user to sit tight for a moment in order to scan a quick image of the full facial landmarks. Facial landmarks are the key points on the face which are mostly used for the detection of the face in most applications; after notifying the user that calibration is successful, only then the live webcam can detect the user's facial expressions. There are several interesting applications of key point detection in human faces, which are facial feature detection, improved face recognition, head pose estimation, face morphing, virtual makeover,

and face replacement. The application detects the facial expression of happiness after detecting the user's face and using the viola jones algorithm to crop the image for landmark identification, send the cropped face and approximate landmarks to the qualified neuronal network drawing the received landmarks on the actual picture notifying the user with the current facial expression due to the application detection of normal full face and horizontal stretching of the lips. Figure 3 shows how the application detects various facial expressions after detecting the user's face and cropping the image with the viola jones algorithm. Send the cropped face and approximate landmarks to the qualified neuronal network for landmark recognition, which will draw the received.

Landmarks on the actual picture inform the user of the current facial expression due to the application detection of a normal full face as well as normal lips movement. The landmarks on the original image of the current facial expression are drawn due to the vertical stretching of the full face and vertical stretching of the lips.

Figure 5: Various facial expression results in MATLAB

However, as shown in Figure 4, the application is unable to find and estimate the key facial landmarks to display the current facial expression, which will stop the whole process due to the absence of the user's face notifying the user that no face is found in such cases the application is able to detect a small number of landmarks which is not enough to be calculated with a trained neuronal network for landmarks detection.

Figure 6: No face present detection result in MATLAB

5. Conclusions

In the end, we used a spectral imaging system in this project for face recognition. This spectral system contains a hyperspectral imaging system and a multispectral imaging system. Each works in a specific range and has different spectrum bands. Using these techniques, we were able to identify facial expressions recognition such as happiness and sadness, etc., using MATLAB program language and a coded webcam that can detect face variations with the aid of deep Learning Convolutional Neural Network (CNN) algorithm, which enabled the webcam to understand human facial expression better. This simulated research in MATLAB shows promising results that are compared with other studies to verify the performance that the application can act like a human brain, simultaneously detecting facial expressions and emotions. This study concluded, therefore, by applying machine learning and using a (CNN) trained database, the application is directly able to track face movement as well as scanning, cropping, calculating, and analysis providing us with the final expression as fast as possible in a correct manner.

In the future, society and humans will still be in the dominant position, and AI will assist humans in doing a good job and guiding deep learning machines or AI to develop into a model of human-machine cooperation. While foreseeing the huge potential of AI, be alert to the ethical and legal issues it brings. Research on it is conducive to safeguarding the interests of the people and national security, ensuring the safety and controllability of artificial intelligence; it is conducive to the introduction of punishment systems and measures for the malicious use of artificial intelligence and improving the legal system and moral and ethical norms for the safe application of artificial intelligence. Build a safe environment for the healthy development of artificial intelligence. Therefore, Responsible AI remains one of the important elements in promoting and enhancing the adoption of AI in the country nationwide. If AI policy on reliability is not addressed and implemented effectively, it may affect the AI's trustworthiness in the future.

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