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DEVELOPMENT OF FACIAL RECOGNITION-BASED TODDLER'S EMOTION PREDICTION SYSTEM

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ABSTRACT

Young children express their feelings through facial or verbal expressions that differ from person to person and are shaped by the environments where they live. Neglecting to understand and estimate how toddler emotions change can lead to delayed intervention timing, resulting in harm to their mental and social development processes. The study initiated the development of a system based on facial recognition processes to forecast toddler emotional responses. The random forest algorithm was used to build the system model, which received training from a dataset comprising 2,168 pictures showing both facial expressions of happiness and sadness. Mediapipe, a machine learning algorithm, was used for feature extraction. The model was then integrated into a user-friendly interface designed for ease of use. This interface captures a toddler's facial image and classifies their emotion as either happy or sad. In conclusion, the developed model demonstrated strong performance, achieving an accuracy of 84%. By providing real-time emotion predictions, the system can assist parents and caregivers in responding appropriately to a toddler's emotional state.

Keywords: *Emotion Prediction, Facial Recognition, Mediapipe, Random Forest Algorithm, Toddler Emotions.*

INTRODUCTION

Toddler stage in child development refers to the physical, cognitive, linguistic and socio-emotional development of a kid before attaining the age of eight (Manas, 2020). This stage is the foundation of infant development, during which youngsters learn and explore the environment through non-verbal means of communication. Children in the toddler period struggle to communicate vocally, but instead use emotions communicated through facial

expressions, which are the most common nonverbal communication techniques used (Verma & Verma, 2020).

Child development can hurt a child's social and mental development, perhaps leading to autistic spectrum disease if not addressed (Takahashi et al., 2021). Today's youngsters will be tomorrow's leaders for future generations, and any mental or social effects in today's generation will undoubtedly have impact on future generations (Mustafa & Salh, 2021). However, recognizing toddlers' emotions through their facial expressions can be difficult. Most toddler facial expressions are so obvious that minimal examination is required to predict mood, whereas others may be more subtle, mixed, or fuzzy (Verma & Verma, 2020). Several researchers have worked on emotion prediction system on anticipating emotions in real-time. (Zahara et al., 2020) was able to create a model using convolutional neural network (CNN) to predict and recognize emotions. In addition, (Kumar, 2021) created a hybrid of a decision tree and a Naïve Bayes deep learning model to forecast children's behaviour based on the prediction of emotions in real time. The Kumar (2021) model does not have a finite accuracy score because of the fusion of algorithms, in contrast to the CNN model produced by Zahara et al. (2020), which was implemented on a Raspberry Pi and had an accuracy of 65.97%. Since each algorithm recognizes emotions differently, it is not appropriate for use in real-time applications.

Research led the study to conclude that a toddler emotion prediction model based on face recognition is needed. This model should employ a single algorithm, have a higher recognition rate than the model created by Zahara et al. (2020), and have limited reliance on hardware.

By using artificial intelligence to create a toddler emotion prediction system based on face recognition, this study aims to lessen the impact of delayed responses.

REVIEW OF RELATED WORK

The toddler emotion prediction research falls into two broad areas, namely: (1) artificial intelligence (AI) face emotion recognition (FER) and (2) machine-learning-based child behaviour analysis. This review summarizes the most topical works in the field and determines the gap in the research discussed by the given study.

2.1 Facial Emotion Recognition based on AI

Automatic emotion recognition with deep learning and convolutional neural networks (CNNs) is very common. (Zahara et al., 2020) deployed a CNN-based FER system on a Raspberry Pi platform under the FER-2013 dataset that has an accuracy of 65.97%. Their experiment has shown that lightweight CNN architectures can be used to classify expression in real-time, but it also indicated the hardest parts about low accuracy and the reliance on external hardware.

Dalvi et al., 2021 also discussed the challenges of FER performance by noting the lack of data balance, occlusion, and biased teaching samples. They demonstrated that better preprocessing, e.g. removal of noise, and balanced datasets, contribute to model reliability. The results they obtained underscore how vital data preparation is in the construction of FER systems in children, whose facial expressions are less pronounced and more unpredictable compared to adult ones.

More recently, (Zimmer et al., 2023) proposed a Hybrid CNN-Fusion model that was specifically developed to perform child FER tasks. Their design unites the use of several networks to enhance the ability of detecting subtle facial action units that take into consideration ethical and accuracy issues when it comes to working with vulnerable child populations. Although the study enhances child-specific FER performance, it still has a complicated multi-network design, which can be a constraint to its application in a real-world caregiving setting.

These studies, combined with each other, demonstrate that despite the ability of CNN-based systems to classify emotions, the accuracy of predictions, the reliance on hardware, as well as a lack of training data specific to toddlers are serious issues.

2.2 Child Behaviour and Activity Recognition in Machine Learning

Some of these utilize machine learning to get a wider perspective of child behaviour. (Albert et al., 2020) applied the Hidden Markov Models and Random Forest classifier to identify toddler activities in free-play settings. Their model was moderate (64.8 percent), which proves that ML techniques have the potential to analyze children's movements and behaviour patterns.

Maniruzzaman et al., 2022 used several ML classifiers, such as the Random Forest and CNN, to determine factors related to ADHD. Even though they did not address emotion recognition, their findings affirm the appropriateness of ML algorithms for child-related prediction tasks and the usefulness of Random Forest in cases of classification that rely on behavioural characteristics.

All these studies prove that ML algorithms can effectively simulate the behaviour of children; however, it fails to give toddler-specific emotion prediction systems that can be used in real-time.

2.3 Developmental Prerequisites to the Recognition of Emotions

According to the developmental research, it is important to comprehend emotional communication when it is still young. Research indicates that the gestures, vocalizations, and expressions of infants attract varied responses on the part of caregivers and influence early socio-emotional development (Van Der Klis et al., 2023). Other results demonstrate that early emotional responsivity is linked to subsequent socio-emotional development, which highlights the importance of early acknowledgement and treatment (Noten et al., 2020).

Although the fact that this literature emphasizes the importance of the development of recognizing toddler feelings, it fails to provide the technological means to help caregivers in practical cases.

2.4 Research Gap

In the literature in the field of AI, machine learning, and developmental psychology, several distinct gaps become apparent:

i. Absence of toddler-specific FER models:

The current FER systems are based mostly on datasets of adult or older-child expressions and therefore cannot be accurate with toddlers.

ii. Reliance on sophisticated, or hardware-intensive systems:

FER systems based on CNN (Zahara et al., 2020) need external hardware or multi-network fusion models, which makes them less accessible to ordinary childcare users.

iii. Lack of emphasis on the real-time, lightweight emotional prediction tools:

Hybrid multi-algorithm systems (Kumar, 2021) do not have uniform performance in the run time, whereas other ML models are focused on behaviour or diagnosis, as opposed to emotion recognition.

The proposed research will fill these gaps by creating a single-algorithm, hardware-independent, and real-time facial recognition system to forecast the emotional condition of toddlers to facilitate the enhancement of responsiveness in early childcare settings.

METHODOLOGY

3.1 Data Acquisition

This stage is the preliminary procedure in any machine learning model development. The Data used in this study is acquired from Kaggle, and the data was placed in a folder with two subfolders. The first folder has a variety of child images with a total of 2,168 images, while the second folder is a collection of adult images, which is irrelevant in the development project.

3.2 Data Preprocessing

The images used for this study were preprocessed by classifying the images into different facial expressions of joyful or sad, and the preprocessed images were subsequently stored in different subfolders of the dataset. All subfolders have the same number of images, and the images show a clear facial expression to enhance the model's predictive accuracy.

3.3 Model Development

The model was developed with the use of modularization. The Python programming language of version 3.9 shows more compatibility with major libraries used. The libraries used involve Mediapipe, OpenCV, and Scikit-learn. Figure 1 shows the systematic block steps carried out in the development of the system.

3.4 Evaluation of Developed Model

The developed system is evaluated to check its recognition rate by splitting the dataset into train and test set. This is accomplished with the use of scikit-learn library that provided access to confusion matrix, which was used for performance evaluation of the system.

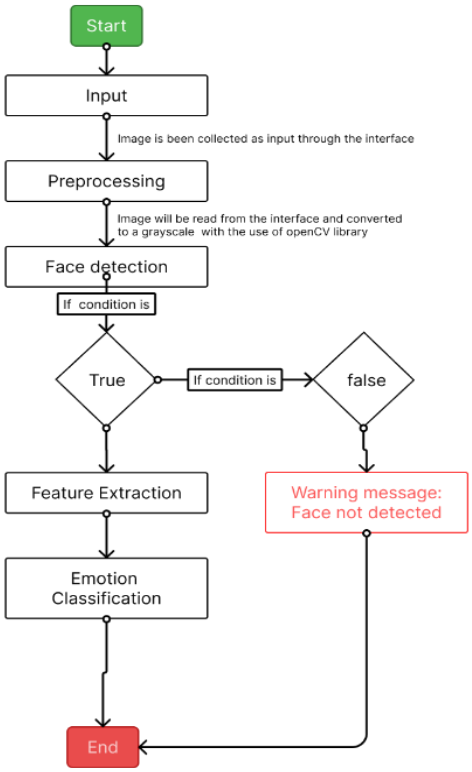

Figure 1: The Machine Learning Model Development Processes

RESULT AND DISCUSSION

This study acquired a dataset of 2,168 toddler's images from Kaggle and used it to develop a facial recognition-based emotion prediction system for toddlers. The data acquired involved images of toddlers expressing various facial expression required to train the machine learning model. This dataset is categorized into expressions of happiness and sadness. Each image was carefully processed to ensure clear facial expressions, enhancing the model's accuracy. The preprocessed, classified images were stored in subfolders with an equal distribution to maintain consistency. The system was developed by integrating cutting-edge technologies, such as facial recognition, with the necessary libraries like, opencv, picklet, mediapipe, numpy, and random forest classifier to create an innovative emotion prediction system for toddlers. An interface to facilitate user interaction with the system was developed by implementing OpenCV to read images in real-time.

The user interface shown in Figure 2 enables seamless communication between users and the system, allowing parents, caregivers, and relatives to effectively understand and respond to toddlers' emotions. Through this interface, users can upload images of toddlers' emotions for processing and classification by the system, which employs a random forest algorithm for accurate emotion recognition. Figure 5.0 show the classified toddler emotion uploaded by users.

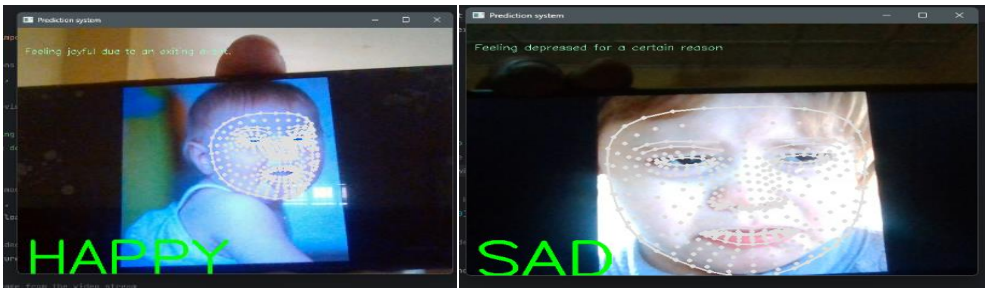

Figure 2: Above shows the interaction with a user and the system

Displayed above is Figure 3, illustrating classified toddlers' emotion provided by users. The generation of landmarks on the inputted images, facilitating the detection of key points like eyes, nose, mouth, and facial patterns, is attributed to Mediapipe.

CONCLUSION

In conclusion, by creating a facial recognition-based prediction system, our study solves the problem of comprehending and reacting to babies' emotions. With a dataset of 2,168 photos, the research obtained an 84% precision score using the random forest method as a prediction model. This creative method used machine learning algorithms and other artificial intelligence technologies to properly predict toddlers' emotions in real time. The

findings show promise for transforming early childhood development by facilitating prompt emotional responses in toddlers, improving their overall development and emotional health.

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