

¹ Fernandez, Janah
Rose R.

² Magparangalan,
Brigette Anne P.

³ Pades, Kent
Joaquin B.

⁴ Centeno, Criselle
J.

⁵ Lawan, Joan F.

⁶ Garcia, Thaddeo
S.

Convey: Developing a Facial Emotion Recognition System for Enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders



Abstract: - Children with Autism Spectrum Disorder (ASD) oftentimes have difficulty in both interpersonal and intrapersonal interactions. Most children with ASD lack emotional intelligence and cannot properly comprehend social cues and responses of the people around them. These social impairments are causing them to have difficulty in maintaining relationships thus, to combat these issues, the researchers presented an application with Facial Emotion Recognition (FER) technology using the deep-learning approach namely Convolutional Neural Network (CNN). Using the FER allows the children to perceive the emotions of their interaction partner at face value. The model used in developing the application sits at an accuracy level of 98%. In addition to the FER technology, the research implements a kind of mood meter that enables the children to plot their mood and a dashboard that tracks the accumulated plots. The tracker lets the children convey their emotions as well as help their interaction partner to understand them better. Furthermore, the application includes a recommendation system that suggests various relaxation and meditation techniques that the child can use to manage outbursts or spontaneous emotional activity. The Convey mobile application aimed to empower children that has ASD and help them lead a normal life.

Keywords: Autism Spectrum Disorder, Emotional Intelligence, Facial Emotion Recognition, Convolutional Neural Network

I. INTRODUCTION

Social interaction and communication are an integral part of a child's neurological growth, recognizing and understanding facial expressions are key to their development. Autism spectrum disorder (ASD) is a neurodevelopmental disorder that manifests in a variety of social impairment symptoms, such as difficulty in social-communication and behavioral challenges [1]. Children with ASD find it challenging to comprehend and react appropriately to social cues and facial expressions when compared with children with typical development. Their difficulty in recognizing facial emotions often leads to alienation from society and lack of fulfilling social relationships [2].

Based on the study, Facial Emotion Recognition systems (FERs) are crucial for assisting children with ASD in improving their social communication skills [3]. This kind of assistive technology analyzes facial clues, evaluate, and interpret emotions in real time. After facial emotion scanning, the system offers tips or suggestions that may encourage appropriate behavior for children with ASD. Aiming to help them recognize and comprehend the emotion of their interaction partner, Convey provides social guidance and understanding for children with ASD.

By developing Convey, a facial emotion recognition system that fulfills the unique requirements of children with ASD and their interaction partners, this project seeks to advance the field of assistive technology and enhance

^{1,2,3,4,6} Pamantasan ng Lungsod ng Maynila

1jrrfernandez2020@plm.edu.ph, 2bapmagparangalan2020@plm.edu.ph, 3kjbpades2020@plm.edu.ph, 4cjcenteno@plm.edu.ph, 6tsgarcia@plm.edu.ph

⁵ Quezon City University, jflawan@plm.edu.ph

social relationships for people with ASD. The overall welfare and social integration of children with ASD may improve as a result of the study's findings. Promoting meaningful connections, effective communication, and enhances emotional comprehension.

1.1 Objectives

1. Develop a facial emotion recognition system that will analyze the facial features of the child's interaction partner that will identify their current emotion. This will offer valuable insight for the child to understand emotions and behave accordingly.
2. Implement a child-friendly and interactive emotion self-assessment system that will enable the child to plot his/her current emotion in a mood meter. The system will also include an emotion tracker that consists of all the emotions that the child plotted throughout the day.
3. Integrate meditation and relaxation techniques, and coping strategies recommendation system that will help the child to reduce meltdowns and manage their emotions effectively.

1.2 Scope and Limitations

The study aims to develop a Facial Emotion Recognition System that is especially suited for children with Autism Spectrum Disorders (ASD) and their interaction partners. The system includes a facial scanner that will analyze the facial features and identify various patterns that are associated with different emotions as well as the changes with said features. The system also includes an emotion self-assessment system and a recommendation system for meditation and relaxation techniques and coping strategies.

The study will only use the six basic emotions which are: anger, disgust, fear, happiness, sadness, and surprise, additionally it will also include a neutral facial expression. These basic emotions are the primary need for the child to identify their emotions, these six are the foundation of the other emotions. In addition, the application will be only accessible to android smartphones.

The participants of the study are Children with Autism Spectrum Disorders (ASD) that are in the age bracket of 8 to 17 years old and fits the level 1 classification of the 3 functional levels of Autism, as well as their interaction partners. The system is limited to the certain amount of screentime that the child can use.

1.3 Significance of the Study

This study aims to develop a mobile application that can help children with autism spectrum disorder to easily recognize their emotions as well as that of their interaction partners.

This study is significant to the following:

1. *Children with Autism Spectrum Disorder (ASD)*. The study will have a substantial impact on the lives of children with ASD. Implementing the system will enable children with ASD to properly understand the emotions of people around them, enabling healthy communication and social environment. Their general well-being, social integration, and quality of life will be enhanced through improved emotional comprehension and improved social relationships.
2. *Interaction Partners*. Interaction partners are essential for the emotional and intellectual development of children with ASD, they may be family members, peers, teachers, or therapists. Convey offers interaction tools and instructions to help the children better comprehend and react to the emotions displayed by the people that they interact with and in return their interaction partners will also be able to cater to their needs better and help them in an in-depth manner.
3. *Researchers and Practitioners*. The study contributes to the body of knowledge about ASD and assistive technology. The results can provide light on how Facial Emotion Recognition Systems can help people with ASD better interpret emotions and engage with others in social situations. This can help direct future research and the creation of more sophisticated and specialized technologies for those who have trouble communicating and interacting with others.
4. *Society*. The study helps to advance social inclusion and understanding of people with ASD. It fosters empathy, acceptance, and deep relationships between people with ASD and the larger community by

addressing the difficulties in emotional communication and social interactions. It might make it easier for people with ASD to thrive and engage in social interactions by fostering a more welcoming and encouraging environment.

II. METHODOLOGY

2.1 Data Collection

A combination of quantitative and qualitative methodologies is used in the data gathering process for the study of the Facial Emotion Recognition System for improving interactions between children with Autism Spectrum Disorders (ASD) and their interaction partners.

Quantitative Data Collection: Quantitative data will be collected through structured surveys. In order to measure user satisfaction, perceived effectiveness, and efficacy of the system with precision, a survey questionnaire will be sent to a representative sample of users who interact with the system.

Qualitative Data Collection: Qualitative data will be acquired through open-ended survey questions and semi-structured interviews. Users will be able to offer qualitative input on their experience, recommendations, possible enhancements, and any problems they ran across when utilizing the system by responding to open-ended survey questions.

2.2 Sampling Techniques

The sampling technique chosen for this study is purposive sampling. The researchers have selected participants based on their age, diagnosis severity, cognitive ability, and interaction partners who frequently participate in the social interactions of ASD patients. A total of 30 respondents will be targeted for data collection.

2.3 Data Analysis Procedure



Fig. 1 Data Analysis Procedure of the Study

Figure 1 shows the data analysis procedure, this process consists of five steps, the initial stage is defining the problem which is causing misunderstanding between children with ASD and their interactive partners because of failing to recognize the facial emotion of the person they are talking to, resulting in ineffective communication. Next, researchers will conduct a survey to measure the effectiveness, efficiency, functionality, portability, usability, and how helpful the system is to the children with ASD. In addition, interviews will also take a part in collecting data. After collecting data, it will be filtered, which identifies the errors in the data and corrects it. This is a crucial part in this process since this ensures the accuracy and reliability of the data.

The fourth step in this process is analyzing the data, researchers will analyze the data using suitable techniques to check for patterns and relationships. Lastly, the final stage is where the interpretation of data happens. To effectively identify the results of the data, researchers can use various methods to visualize the interpretation such as charts and graphs. With the help of this procedure, it helps the researchers to decide wisely on what they should input on the system.

2.4 Development

The Convey mobile application was developed using an approach based on the Agile methodology. This is used to guarantee adaptability, cooperation, and incremental advancement during the system development process. The methodology will be structured around six distinct phases: Plan, Design, Develop, Test, Release, and Feedback.

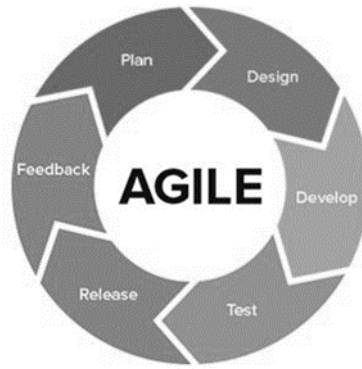


Fig. 2 Agile Methodology in System Development (Simsek, 2020)

2.4.1 Plan

In this stage, the team identifies the system requirements, defines the scope of work for a specific period and sets priorities. The team also determines all possible plans to meet the system's objectives. This stage will also include the tasks to be accomplished, estimate the effort required, and create a plan for the upcoming iteration.

2.4.2 Design

In this stage, the team creates the layout and architecture of the system based on the objectives and requirements identified in the first stage. This involves creating wireframes, prototypes, as well as making decisions on the technology stack and user interface design.

2.4.3 Develop

In this stage, the team starts building the system with Android Studio as the IDE. Using combination of languages for front-end and for the back-end development. Developers write code, integrate it into the main codebase, and continuously collaborate to ensure that the system will act as a single unit according to the plan.

2.4.3.1 System Architecture

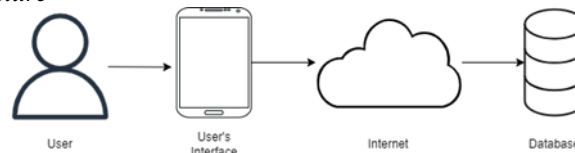


Fig. 2 Convey's System Architecture

Figure 2 illustrates the structure and flow of the application. The system consists of a linear flow with one main component which is the user interface that is designed to provide various functions to cater to the user's needs. The user interface is designed for the user's interpersonal and intrapersonal interactions. It has access to all the features of the system. To ensure seamless data management, the system incorporates a database where all the gathered information is stored. The database stores user profiles, the emotions plotted by the user, meditation and relaxation recommendations, and other relevant data.

2.4.4 Test

In this stage, the team conducts thorough testing of the system to determine if the system meets all the objectives and requirements. This will also include detecting bugs and issues to ensure that the system functions properly.

2.4.5 Release

In this stage, the team prepares the system for deployment. The system is then released to the intended client and users.

2.4.6 Feedback

In this stage, the team gathers feedback from the intended client or users who are using the system in the production environment. The developed system will be reviewed and be used for further improvements.

2.5 Evaluation

To ensure that the developed facial emotion recognition system for enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders performs according to the specified requirements, a comprehensive specification and evaluation of software product quality is needed. We can assess whether a software application is of good quality by employing a validated and well-liked evaluation tool. The developers of this study will use the ISO 25010:2011 software quality model.

Table I. ISO Characteristics used for System Quality Evaluation

		1	2	3	4	5
Functional Suitability	The Convey mobile application provides all the necessary functions for the facial emotion recognition feature.					
	The Convey mobile application correctly recognizes and identifies the emotion of the user's interaction partner.					
Performance Efficiency	The Convey mobile application meets response and processing speed for timely recognition of the facial emotion of the user's interaction partner.					
Usability	The Convey mobile application is intuitive, easy to use, and enables the user to effectively learn how to use the facial emotion recognition feature.					
	The Convey mobile application has a visually appealing and aesthetically pleasing user interface for facial emotion recognition.					

Reliability	The mobile application is reliable, consistent, accurate in recognizing the emotion of the user's interaction partner.						
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Table II shows the evaluation survey results that will be interpreted using the five-point Likert. Likert scale will help the researchers to evaluate and interpret the answers of the respondents.

Table II. Rating Scale for Interpreting the Evaluation Result

Numerical Rating	Range	Interpretation
5	4.21 – 5.00	Excellent
4	3.41 – 4.20	Very Satisfactory
3	2.61 – 3.40	Good
2	1.81 – 2.60	Fair
1	1.00 – 1.80	Poor

III. RESULTS AND DISCUSSION

3.1 Results

The questionnaire is categorized into two distinct parts, the demographic survey, and the ISO evaluation questions. Based on the specified population, the demographic survey only included the name (optional), age (8- to 17-year-old only), gender, and the child's ASD Level. The targeted population size is 30 respondents, below are the demographic questions asked to properly monitor the project.

A. Demographic Profile

Age Distribution of Survey Participants

The age distribution of survey participants shows that the largest age group to answer the survey are 17-year-olds comprising of 8 individuals which translates to 27.6% of the population. This suggests that a significant portion of the population is on the older side of the children's spectrum. While the smallest age group to have answered are 12-year-olds comprising of 2 individuals which translates to 6.9% of the population.

Gender Distribution of Survey Participants

The majority of the population, comprising of 17 individuals or 56.7% are male. 12 respondents, accounting for 40% of the population are female. And lastly a person which translates to 3.3% did not want to disclose their identity.

ASD Level of Survey Participants

This shows the different levels of Autism Spectrum Disorders (ASD) and its symptoms. 66.7% or 20 respondents identified to having Level 1 ASD with symptoms such as difficulty in understanding social cues, communication, social interactions. Children with Level 1 ASD are considered as highly functioning individuals. 33.3% or 10 respondents identified with Level 2 ASD symptoms that have significant difficulty in communication.

B. General Questions and Results

Question 1. Is it difficult for you to recognize the emotion of the person you are talking to?

In the context of this inquiry, 25 out of 30 respondents, constituting 83.33% of the total, acknowledged experiencing difficulty in recognizing the emotions of the individuals with whom they engaged in conversation, as they responded affirmatively. Conversely, 5 out of 30 respondents, representing 16.67%, reported not encountering challenges in discerning emotions during communication. Notwithstanding the proportion of respondents indicating ease in recognizing emotions, it remains evident that a substantial number of children with Autism Spectrum Disorder (ASD) encounter difficulties in perceiving the emotional states of their conversational counterparts.

Question 2. Is it important for you to have an application that will scan the emotion of your interacting partner?

In this inquiry, 28 out of 30 respondents (93.33%) affirmed the significance of possessing an application capable of scanning the emotions of their interactive counterparts. Conversely, the remaining 2 respondents (6.67%) expressed a lack of importance in having an application that recognizes the emotions of the individuals with whom they are interacting. In summation, the findings suggest Convey mobile application will play a pivotal role for children, facilitating their ability to discern the emotions of those with whom they engage in interactions.

Question 3. Does the emotional scanner help you to understand the emotion of the person you are interacting with?

In response to the query, 25 out of 30 students (83.33%) indicated that the emotional scanner assists them in comprehending the emotions of the individuals with whom they interact. While 5 out of 30 respondents reported that the emotional scanner did not provide assistance. This observation leads to the conclusion that a majority of respondents find the application helpful, though there exists a need for improvement, particularly in enhancing the accuracy of data pertaining to facial emotion patterns. Researchers are committed to undertaking comprehensive studies to enhance the accuracy of the emotional scanner, striving to achieve a level of precision comparable to real-world scenarios.

Question 4. How useful is the convey application?

In response to the inquiry, 15 respondents (50%) unequivocally affirmed the utility of the Convey application, signifying its substantial usefulness to them. Additionally, 7 respondents (23.33%) provided a rating of 4 on the Likert scale, indicating that they find the application useful. Conversely, the remaining 8 respondents (26.67%) offered a neutral response, positioning the application at the mid-point of the scale, suggesting ambivalence regarding its utility.

The diversity in responses serves as a motivational factor for researchers to undertake continuous enhancements and updates to the application. The objective is to refine its features and functionalities, striving to ensure that it becomes genuinely beneficial for the targeted demographic of children. This iterative process aligns with the commitment to optimizing the application's efficacy and relevance based on user feedback and experiences.

Question 5. How easy it is to use the application?

In the context of this investigation, 15 out of 30 respondents, constituting 50%, expressed that utilizing the application was deemed "very easy." In parallel, the remaining 15 respondents, also at 50%, affirmed that using the application was characterized as "easy." This collective response leads to the conclusion that the application is inherently child-friendly and readily accessible to its users. The parity in distribution between the two ease categories underscores the overall positive user experience and user-friendliness of the application, affirming its suitability for the intended audience.

C. Evaluation Results

The researchers employed the software quality approach outlined in ISO 25010:2011. The purpose of this study is to assess the system's Functional Suitability, Performance Efficiency, Usability, and Reliability.

Functional Suitability

Respondents were asked to assess the effectiveness of Convey mobile application in providing functions that meet stated and implied needs when used under specified conditions. The category delves into the perceived accuracy of Convey in detecting facial emotion of the children with ASD interaction partner, providing valuable insights into the application's functional prowess in addressing piracy-related concerns. The findings indicate a positive evaluation overall, with an impressive overall mean rating of 3.9, denoting a "very satisfactory" rating.

Performance Efficiency

Convey's performance efficiency, which has an overall mean rating of 3.67, which is "very satisfactory", shows that users can measure changes in emotional understanding and the caliber of social interactions by evaluating how the Facial Emotion Recognition System improves the social skills and emotional understanding of children with ASD.

Usability

The mobile application's usability received a "very satisfactory" overall score of 4.17 in the survey, which is encouraging. It emphasizes users who think Convey is straightforward, intuitive, and easy to use. According to this ranking, Convey mobile application successfully integrates emotion recognition capabilities with a Zen zone, emotional mood board, and user-friendly design, all of which improve the usability and general user pleasure of the application.

Reliability

With an aggregate score of 3.88, the survey results regarding the application's reliability are good and deemed "very satisfactory." It demonstrates that Convey mobile application takes into account elements like fault tolerance, data integrity, error handling, and uptime to guarantee dependable system operation free from frequent disturbances.

Table VI. The overall mean scores for the ISO 25010-2011 Evaluation.

Category	Mean	Interpretation
Functional Suitability	3.90	Very Satisfactory
Performance Efficiency	3.67	Very Satisfactory
Usability	4.17	Very Satisfactory
Reliability	3.77	Very Satisfactory
Overall Mean	3.88	Very Satisfactory

Table VI shows a high degree of satisfaction with the Convey application throughout ISO 25010 Assessment Features. Among the noteworthy results are 3.90 for functional appropriateness, 3.67 for effectiveness of performance, 4.17 for dependability, 3.77 for usefulness, and all indicating a "Very Satisfactory" outcome. With a mean score of 3.88 overall, the system exhibits superiority in fulfilling user requirements, highlighting its applicability, effectiveness, simplicity of usage, and dependability. Favorable comments from responders confirm that the system has been successful in reaching its goals with efficacy.

IV. CONCLUSION AND RECOMMENDATIONS

4.1 Summary of Findings

The application's quality was evaluated using the ISO 25010. The researchers handpicked four of the standard categories namely: functional suitability, performance efficiency, usability, and reliability. Using an evaluation form, the researchers surveyed 30 individuals for the population sample. The survey was limited to children from 8 to 17 years old and has an ASD Level of 1 or 2 as these levels are considered functional whilst Level 3 requires an extensive amount of support. The ensuing presentation encapsulates the key findings:

1. Convey: Developing a Facial Emotion Recognition System for Enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders mobile application accumulated an overall rating for functional suitability of 3.90 and interpreted as 'Very Satisfactory' remark.
2. Convey: Developing a Facial Emotion Recognition System for Enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders mobile application had an overall rating for performance efficiency of 3.67 while its interpretation is 'Very Satisfactory'.
3. Convey: Developing a Facial Emotion Recognition System for Enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders mobile application has garnered an aggregate usability rating of 4.17, denoted as a classification of 'Very Satisfactory'.
4. Convey: Developing a Facial Emotion Recognition System for Enhancing Interpersonal Interactions of Children with Autism Spectrum Disorders mobile application has accrued a comprehensive reliability rating of 3.77, characterized as a 'Very Satisfactory' evaluation.

4.2 Conclusions

The researchers' successful conclusion has been facilitated by their adherence to ISO 25010 standards. The researchers' aim to create Convey's Mood Board feature yielded encouraging outcomes. The application's evaluation shows that the goal was implemented successfully. Users gave Mood Board a high degree of satisfaction, rating it "Very Satisfactory" in all four categories—functional appropriateness, performance efficiency, usability, and reliability. Mood Board's users will be better able to identify and communicate their feelings if the app is developed successfully. In order to accomplish all of its goals, optimize the program, and uphold strict development standards, Convey mobile application will keep moving forward.

4.3 Recommendations

Through a thorough examination of usability, reliability, and overall effectiveness, this set of recommendations seeks to address identified areas for enhancement while aligning with the overarching objective of fostering improved interpersonal interactions for children with Autism Spectrum Disorders (ASD). The forthcoming recommendations are tailored to contribute to the sustained success and positive impact of the application within the context of its intended audience and objectives. The recommendations arising from this study are outlined as follows:

1. To enhance the user interface to make it more child-friendly and add visual elements that will make the application interactive and aesthetically pleasing for the user.
2. As technology advances, the data which are the facial emotions of people are also changing thus it is important to improve the accuracy of the emotion so that the user will be able to recognize it easily.
3. The future researchers can add more ASD features that can help these children to recognize and understand not just their interactive partners but also themselves. Accessibility is one of the main goals of this system, thus discovering new features that can assist the needs of the children.

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