E-Learning App Using Image Processing, Detection, Ranking, and Progress Monitoring for Preschoolers

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Abstract

With the world rapidly adapting to online education, preschoolers are left behind to cope with this new approach to learning. In reality, preschoolers require more engagement and interaction; they require hands-on activities/exercises to stimulate their learning progress. As a solution, the author came up with an e-learning application that implements machine learning and image/text recognition for a subtle and fun way of learning. The application has three basic learning activities such as the alphabet, numbers, and color activity. For the alphabet and number activity, the application will simply take the student's hand-drawn input from the built-in canvas, run it through the image processing/recognition and instantaneously allocate points for the student based on their answer. The color activity is slightly adventurous, where the students will take pictures of a particular color based on the given question, this allows the students to wander around their surroundings making it more interactive and fun. The application additionally includes the student analysis function, which is a detailed student management system with the capability to track student progress and identify their interest to find out their strengths and weaknesses in a particular subject based on the points and activity involvements. The application also has an in-app monitoring and ranking system along with individual student profiles that make student management easier for a larger group of students in a learning center or kindergarten.

Keywords

Machine Learning, Preschool education, Online learning, Android

Introduction

In the current era of online learning, there are many e-learning platforms that are available for high schoolers and university students. Some institutes are using their own online portals while the rest are using google and zoom, but such applications are not kid-friendly which is a big setback for preschoolers. Nevertheless, preschoolers must get used to this e-learning culture or it is going to be a big hindrance when they come across such technologies in their future. With the world

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changing rapidly, our education system has the potential to be converted into full-on online-based learning if such a possibility arises in the imminent future.

Instead of starting with computers, why not smartphones? A study by Simon Legget from "Childwise" shows that children have their own phones by the age of 7 (Media, PA., 2020). This might have sounded shocking decades ago, but nowadays it's normal. Parents give their children a phone to stop them from crying or to keep them distracted and as days pass by this becomes a habit, as a result, kids nowadays are used to handling smartphones even at a young age. With proper guidance we could use this opportunity to help kids learn through smartphones, turning what we think makes the younger generation vulnerable into a key learning platform starting with the preschoolers (Lieberman, M., 2019). Therefore, the author has decided to develop an e-Learning application for android devices that will be implementing image processing, recognition, and detection for student exercises and activities, replicating their day-to-today learning process into a mobile application. The primary purpose of this application is to provide a platform for preschoolers to learn and train in a more efficient way rather than sitting in front of a computer and scribbling on a paper. The application also comes with monitoring and ranking features that will help parents/teachers/instructors keep track of a student's progress and development more conveniently. This application is ought to be the all-in-one solution to smoothen out the transition process from traditional to online learning for preschoolers.

Methodology

Upon the completion of research and planning out the application workflow along with the design, the author conducted several interviews and surveys targeted at different demographical backgrounds including preschool instructors, teachers, and parents with kids from the ages 4-to 7. Both interviews and surveys helped the author to get a better understanding and idea from the point of view of a potential user.

To explain the overall workflow of the application, the use case diagram below in figure 1 shows every user-type interaction with the e-learning application in a nutshell. For clarity, the use case diagram is the breakdown of how different users utilize a particular system. The application contains three different logins, one for the students, teachers/instructors, and parents. The preschoolers use this app only to do activities and exercises under the guidance of either a parent or teacher. The parents will be able to check on their kid's overall progress and manage their profile, whereas the teacher/instructors have more features in order to manage a bigger group of kids. Teachers/Instructors basically can check on individual student progress based on subject and overall class ranking. They can also check on each student's activity points based on the subject or class as a whole. One of the most advanced features in this application will be the Student Analysis function. This function allows a parent or teacher/instructor to pinpoint an individual student's overall strengths and weaknesses on a particular subject and discover their interest. This helps out to identify what the student is good at and how to emphasize that particular interest of theirs for a brighter future. Below are the sample designs of the application user interface.

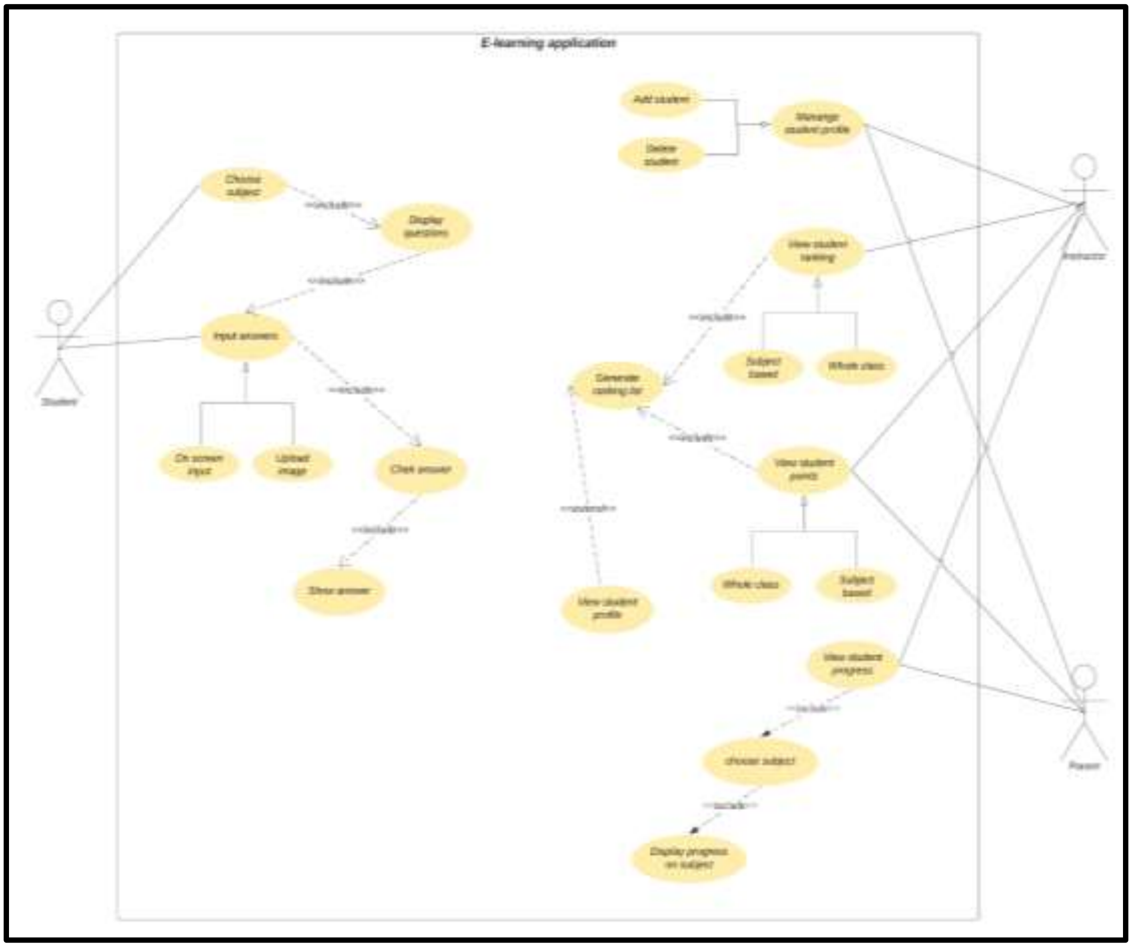

Figure 1: Application use case diagram

All the tools and software used in this project are either Google-based or developed by the Google developer/engineer team (Google Brain). The main application itself is developed using Android Studio, an android development framework that is free to use and flexible. For the database, the application utilizes Firebase's real-time database, which is a NoSQL database. As for the machine part of the application, the author uses the Firebase Vision text recognition API also known as ML kit for the built-in activities that use text and number recognition. The input from the student in the activity canvas will be processed using the on-device ML model that was integrated into the application as shown in figure 2 below.

Figure 2: Activity using FirebaseVisionTextRecognizer

The free-to-use version of this API uses an on-device ML model which results in lower accuracy, but the application does not process complex wordings or sentences since the application is targeted toward preschoolers. Meanwhile, the color activity uses image processing to identify the RGB and hue value using the custom build ML model developed by the author using TensorFlow lite. TensorFlow uses neural networking to train ML models. Python and C++ are the two languages used for the model developments, where the coding was using Google Colab. Google Colab is an alternative to Python IDE.

Figure 3: ColorFinder ML model

Currently, the application only supports a few colors (generic) such as red, blue, and orange (figure 3). For the Color Finder activity, after the student snaps a picture of their surrounding or a particular object, they will then have to tap on the particular color in the picture they took before clicking the submit button. After clicking submit, the application will analyze the selected color and identifies if the color selected was the right answer based on the given question. The samples of the ML model were imported from the custom color palette of the author from Google Drive. The data is then trained and tested using TensorFlow and Keras.

Results and Discussion

The application was successfully developed and was set for all the necessary tests such as unit, integration, system testing, and user testing. All the tests were documented in order to get user feedback and to make the final changes before it is deployed. Below are the sample user interfaces of the developed application.

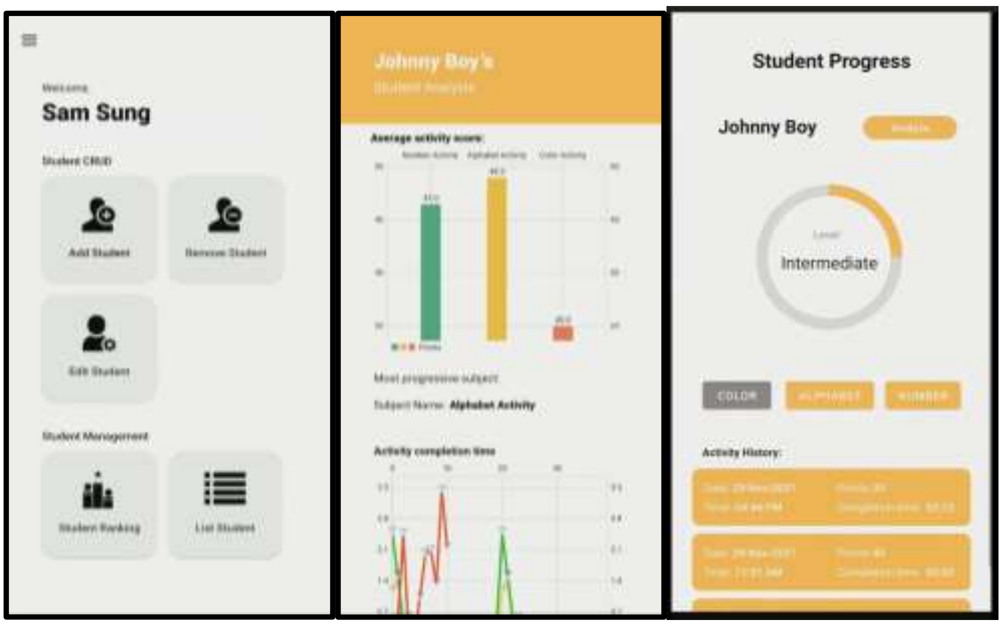

Figure 4: Sample UI

As seen on shown in figure 4 and 5, the application was developed based on the workflow explained in the methodology. The application has 3 different logins that will bring to the appropriate home screen along with the features and functions based on the user role. Parents and teachers are given a management center where they can manage student data in the app. For instructors and teachers, they have extra subject ranking features where they can monitor and analyze student progression based on individual points. The students have real-time point and grade updates since the application is using a real-time database. The student's progress will also be updated after the completion of an activity or exercise. To test the overall functionality and flow of the application, several tests were conducted such as unit, integration, system, and user testing. The application passed most of the tests with slight bugs here and there. The author acknowledged those bugs, fixed them, and tested them again. The re-testing took about a week to clear up, the goal was to eliminate bugs and improve the current ML model accuracy and speed. The difference between the model accuracy before and after the rebuild is shown below.

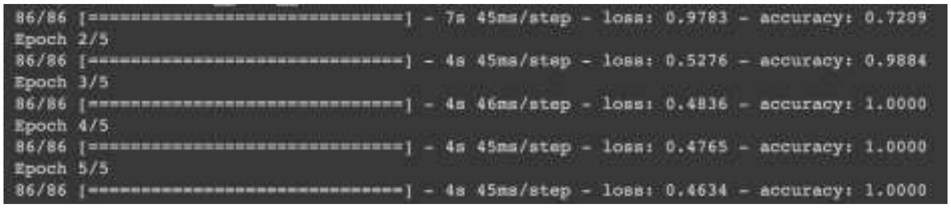

Figure 5: Initial model

Figure 6: Rebuilt model

As shown in figure 6 above, the rebuilt model has a significant improvement in the model accuracy, the 5/5 Epoch test average loss is 0.0033 compared to the initial model which had an average loss of 0.4634, which indicates the initial model had up to 50% chance of being inaccurate. Rebuilding the ML model along with some code modifications also made the result processing with the model faster. These were the only major changes made to the application prior to the internal testing. The application was able to meet all the features and functions implementation as stated in the methodology.

After successfully conducting all the internal tests and finalizing documents, the application was deployed for user testing, targeting users under the same demographic such as teachers, parents, and even kids (under guidance). After every test, the user was given a post-test Google survey that they will have to complete which extracts user feedback on the application into charts and graphs for easy analysis. The feedback from user testing was mostly positive, the targeted users were impressed with the application. As shown in figure 7 and figure 8, the overall impression of the application was great, and the users are happy to use it as one of their kid/student's learning sources.

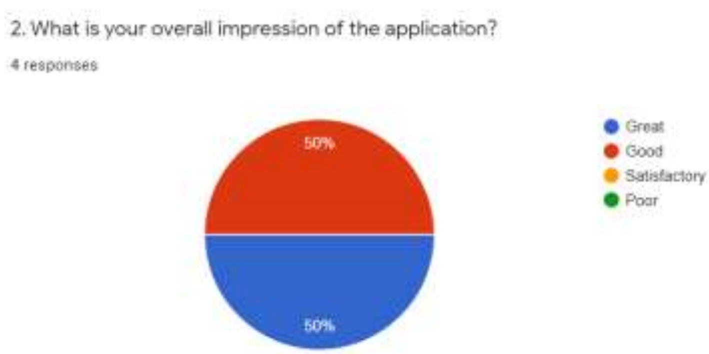

Figure 7: User impression of the application

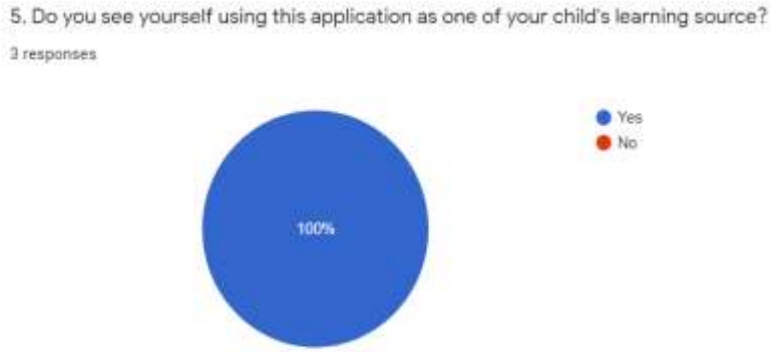

Figure 8: Using application as a learning source

Currently to separate the feature/functions usage between instructor and parent, the application is planned to have a pay-to-use limit known as the "Center Use" version only for learning centers and kindergartens. Normal parents will be able to use this application for free, because unlike parents learning centers will have more students, and only the "Center Use" version of this application is allowed to have more than 5 student profiles and be able to use the subject ranking feature. The purpose of charging this application for learning centers and kindergartens is primarily for application improvements and maintenance. The revenue from the paid version will definitely help the author improve the application by integrating other paid third-party services to turn the application into a legitimate replacement for the current learning method for preschoolers.

In terms of improvements for the near future, the author would like to add customizable question packs (only for the "Center Use" version). Essentially, instructors/teachers can add a custom activity just like the pre-built color and number activity, but with the customizable question pack, they will be able to add their own questions or quizzes which will use the same machine learning model to process the answers. Besides, the application could even support different languages using the paid version of the Google vision and implementing a new vocal training activity, where kids can learn to improve their communication skills in different languages.

CONCLUSION

In conclusion, the author has successfully developed the proposed e-learning application for preschoolers, and the results/feedback for the overall application was mostly optimistic, proving that this application is both reliable and efficient. This application also has a positive impact on the environment by eliminating the usage of papers compared to traditional learning. With future upgrades this application has the potential to substitute the current traditional learning methods of the preschoolers, saving both costs and resources.

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