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An Android Application for Tracking Students using GPS Technology

A.F.Elgamal [1], W.K.ElSaid [1], Walaa.M.Hassan [2]

[1] Computer Teacher Preparation, Faculty of Specific Education, Mansoura University
[1] Computer Teacher Preparation, Faculty of Specific Education, Mansoura University
[2] Education Technology, Faculty of Specific Education, Kafr-El-sheikh University

ABSTRACT

Children's safety represents one of the major concerns for families and societies because children need to be tended to all the time during their daily life activities, particularly when they leave home to attend school, go to the club for sports or go out for entertainment. In modern life, most parents have many daily duties and burdens because they have to go to their jobs and tend to their professional responsibilities and at the same time, they have to take care of their children and monitor them in all their life activities. Primarily, parents should monitor their children's presence and activities to avoid their exposure to dangers and to protect them from many unsafe situations. Moreover, the news of children kidnapping makes parents more concerned about their children's safety and improving children supervision without limiting their movement and their desire to explore their environment. This gave rise to the need for designing a system for tracking the location and activity of children with the help of modern technology, through using their smartphones with all embedded developed technologies like GPS, cameras, microphones and sensors.

Keywords: - Student Tracking, GPS, Smartphone Sensors.

I. INTRODUCTION

Information technology has caused the world to change quickly, and people are busy with their work and businesses, doing their best to achieve welfare for themselves and their families. Most parents spend more time at work, in their businesses, and in their professions than ever, and are always concerned about their children's welfare and safety. Most parents seek to follow and monitor their children's whereabouts and activities while they are away from them and from any place whatsoever. However, they cannot do this at the physical level because children go to different places and do various activities [1].

For example, parents continually worry for their children while they attend school until they are back home because of the people's growing awareness of the lack of public safety in various cities and the rise in the number of crimes against children. This gave rise to the idea of devising a system to enable parents to track their children's whereabouts and alert them by sending them a notification if their children leave the boundaries set for them [2].

The proposed tracking system is based on following moving subjects and providing a real-time chronology of position data for tracking analysis, utilizing a smartphone as the best instrument for developing such a system [3].

Recently, the number of smartphone users has exploded in the last decade because of the widespread perception that smartphones, which have become crammed with various applications, are indispensable for modern life. However, it is controversial whether it is appropriate to allow children to own smartphones despite the high percentage of children and teenagers who own smartphones in all countries [4].

In today's world, our life has undergone a significant transformation because of smartphones, which have made people constantly reachable and provided access to new forms of communication including video calls and messages. Even youngsters and teenagers consider smartphones to be an essential part of their life. There is considerable debate regarding whether it is practical or necessary to allow youngsters to own a smartphone with internet access because it is a mixed blessing. On the one hand, it enables parents to reach and contact youngsters at all times, so parents believe it to be very helpful and indispensable [5].

II. STUDY BACKGROUND

Due to the continuous development of smartphone technologies, tremendous ideas were developed to utilize every resource and technology embedded in smartphones. In our proposed application, we used several tools and built-in technologies to achieve the best performance of the proposed system in tracking and monitoring students. The following section provides a description of such tools and technologies.

II.1- ANDROID PLATFORM

Android is one of the most widely used and most popular operating systems worldwide. The Android operating system has been developed by Google and it is based on the Linux kernel. Android is on the rise because every year, millions of new users switch to Android platforms. The kernel, libraries, application framework, and applications are the four

fundamental components of the Android operating system. Android is primarily intended for touchscreen devices such as smartphones, tablets, and mobile phones [6].

II.2- GPS TECHNOLOGY

The Global Positioning System (GPS) is composed of a network of 24 satellites developed by the United States of America. This system was originally used in military services and was later introduced into other fields for civil purposes. The GPS satellites periodically emit low-frequency radio signals to the GPS receivers. The GPS receiver receives the signal from at least three satellites to be able to calculate the distance by utilizing a triangulation technique and determine the required position based on computing both the latitude and longitude. In fact, four satellites are required as a minimum to compute the three dimensions (latitude, longitude, and altitude) of a position. Once the location is determined, both the average speed and traveling direction can be calculated [7].

Figure.1 below shows the positioning process in three dimensions.

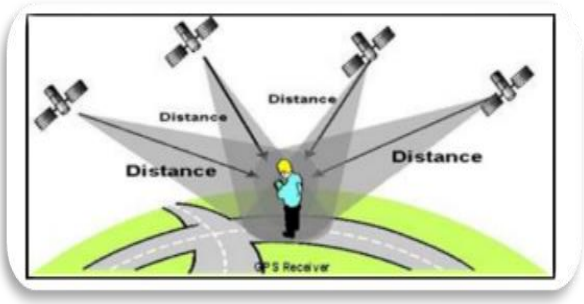

Fig.1: Determining Position in 3-D

II.3- FIREBASE SERVICE

It is the real-time database and backend services offered by Firebase. The application developer is given access to an API that enables application data to be shared among clients and saved on Firebase's cloud. In addition, the company offers client libraries for integration with Android, IOS, and JavaScript apps. It is supported by Google Cloud Storage, a reliable object storage solution that is provided for a reasonable price, with the possibility of images, audio, video, and other user-generated content being stored there by the developer[8].

III. RELATED WORK

In this study, the authors introduced a system that uses an Android device, which children can easily own, whereby the involved system automatically informs parents and teachers if the child leaves the school area. The designed system was based on an alert system, functioning as a virtual fence constructed for the children wherever they are located within the school area or the playground while they are doing their activities. The application creates a virtual fence giving parents, teachers, and school officials an automatic warning message through the app once the child steps (or is carried) outside the school area or playground. Once the warning message is sent out, action can be taken immediately to retrieve the child from the area outside the specified normal boundaries [9].

In this study, the authors introduced an Android application that only runs on Android devices or Android phones. The proposed system provides the exact location of the bus to the students and staff from their location. Basically, this application on the client side provides the coordinates by using Google Maps, sends the coordinates to the server, then the server sends SMS alerts to students who are registered in this service. In addition, the server provides a Graphical Map of the current Bus Location by having markers on the Map. It also runs in the background to allow students to use their phones for other activities [10].

In this study, the authors introduced an application that runs on Android devices and is available from the Google Play store (see the supplementary materials). It was designed to provide regular updates for circumventing the limitations associated with standalone location trackers. For example, GPS signals are typically inaccessible from inside a building, but the application can switch to other available sources that report location such as Wi-Fi and network signals. However, it should be noted that both signals are generally less accurate than GPS alone [11].

In this study, the authors introduced an application to track the whereabouts of children through smartphones that can be used by both parents and to design a device that can be used practically and children can be traced to the presence of wireless media by their parents. They found that the best method that allows tracking the presence, location, and accuracy is to use a Geo Positioning System (GPS). That resulted in this GPS being packaged in a flexible form to make it easier for parents to supervise their children within the range of areas accessible to them and locate the child's position when separated from their parents. Their system can send the location information of lost children on smartphone applications used by the parents [12].

In this study, the authors introduced a family tracker application to track family members. The application must be installed in all family member's smartphones, and these smartphones will use GPS services without the need for an internet connection, where the GPS is used to locate the child specifically and to track the child whenever s/he changes his/her place. The location is obtained by only depending on GSM by sending an SMS containing a link to Google maps showing the position information. In addition, the application has the ability to trigger a help SMS to parents, when the child is in a dangerous situation by using his/her headphone, which is considered a help message in real-time [13].

IV. PROPOSED SYSTEM

The details of the proposed tracking application are presented in three sub-sections: System Architecture, System

Development, and User Interface. Each of these sections will be discussed in detail below:

IV.1- SYSTEM ARCHITECTURE

The proposed system can be used from many types of users, who have the application installed on their smartphones. The main targeted user is the student, as s/he will be tracked and monitored by the rest of the users. All users interact with each other by sending real-time monitoring data through a real-time cloud firebase. Figure.2 below shows a conceptual diagram of the proposed system.

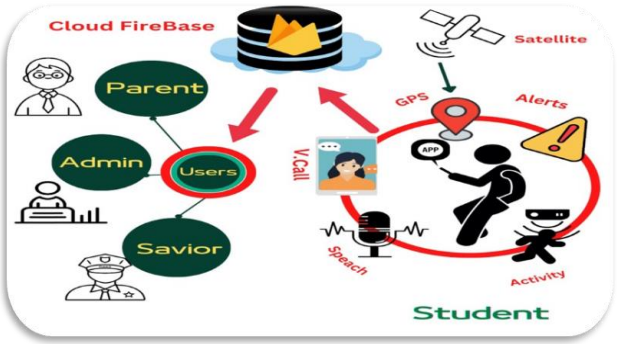

Fig.2: Conceptual Diagram of Proposed System

IV.2- SYSTEM DEVELOPMENT

The proposed tracking system was developed using a combination of hardware components and application software. Below, we will provide more information on both parts.

A- HARDWARE COMPONENTS

A set of physical components were used for designing the proposed tracking system. The most important of them are the following:

- **An Accelerometer Sensor:** The data of the acceleration sensor is used to know the nature of the phone's movements, as to whether they are violent, static, or normal.
- **A proximity Sensor:** The proximity sensor readings are used to see if the phone is likely to be in an open place, in the hand, or in the pocket.
- **A Microphone:** The microphone is used to pick up the sound and an additional microphone is used to pick up the noise. Some phones remove the noise picked by the additional microphone from the sound picked directly by the primary microphone.
- **A Camera:** The camera is used to take a picture without anyone noticing that the phone is taking a picture. Every time the front and back cameras switch, this means we have taken pictures using the front and back cameras; and every time a picture is taken, the phone keeps the images after the application compresses and reduces their size, to less than 200 kilobytes to save storage space. Finally, it sends them at the time of their capture to the Firebase database.

B- APPLICATION SOFTWARE

A number of programming tools were used for developing the proposed tracking system, The most important of them are the following:

- **Android Studio:** is used to provide a unified environment in which we create an Android mobile app. Structured code units allow us to divide our project into functional units that can be built, tested, and debugged independently.
- **Firebase Platform:** is used to track analytics, report and fix app crashes and create marketing and product experiments. It is the seat of communication, storage, database, and authentication and it stores the users' data and photos.
- **Platform Agora:** is used to support video calls and voice calls over the Internet. It offers a free development package to be used on a wide range of devices.
- **Location Service:** student safety tracking sends out-of-position data to the database, using built-in GPS, and the location update settings are set with a refresh timer (2 seconds). Even with a one-meter change in position, we can find out where and when. In addition to the sensor readings available, we can determine the speed at which the student was walking, and monitor his/her movements.
- **Activity Recognition:** All the capabilities of the phone, including sensors, are used to predict what the phone holder is doing. It is based on the use of all the device's sensors to recognize the activity carried out by the phone's owner (movement – rest – walking – running – riding a bicycle – riding a car).

Table.1: Status of Activity Recognition

Status	Description
IN_VEHICLE	The device is in a vehicle-like car
ON_BICYCLE	The device is on a bicycle
ON_FOOT	The device is with the user walking or running
RUNNING	The device user is running
STILL	The device is still (not moving)
TILTING	The device angle relative to gravity changed significantly
UNKNOWN	Unable to detect current activity
WALKING	The device user is walking

The speech recognition service from Google is used to hear everything that the microphone picks up and interprets the speech in classical Arabic and slang as well and then sends it to the database with its date. It also sends errors, so we can benefit from them if the sound is interpreted as noise, unexplained speech or a network problem.

IV.3. SYSTEM IMPLEMENTATION & RESULTS

The system implementation requires to install of the student's safety tracking application on all users' devices, including the parent's device, school administrator's device, savior's device, and student's device, after accepting all access permissions required for using the camera, microphone and the location service (GPS). After that, every user will pass through a registration process, as shown in Figure.3 below, depending on his/her position, by using their respective WhatsApp phone numbers to get a verification code, after which all users will be able to interact with one another through different functions. Figure.4 below shows a block diagram for the proposed system implementation.

Fig.3: Screenshot of Registration

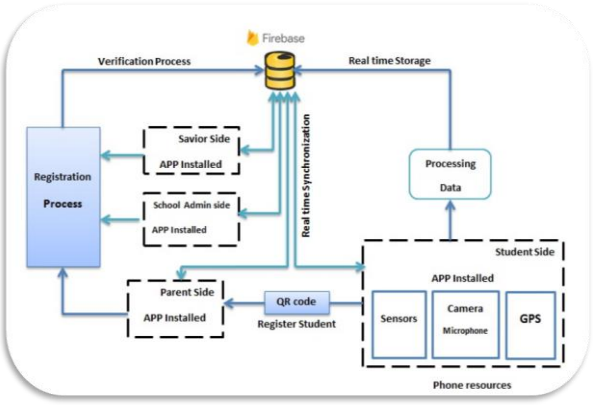

Fig.4: Block Diagram for The Proposed System Implementation

A- The Parent's UI and Tasks

The parent is required to perform a number of tasks, as follows as shown in Figure.5 below:

- Register his/her child, using the Qr code generated by the child's phone and enter his/her data;
- Record the child's appointments in his/her weekly schedule;
- Determine the location of the house where s/he lives with his/her child and determine its circular range;
- Make and receive a video call from the child;
- View phone data and captured photos;
- Receive all notifications; and
- Send the alert notifications to the police or ambulance.

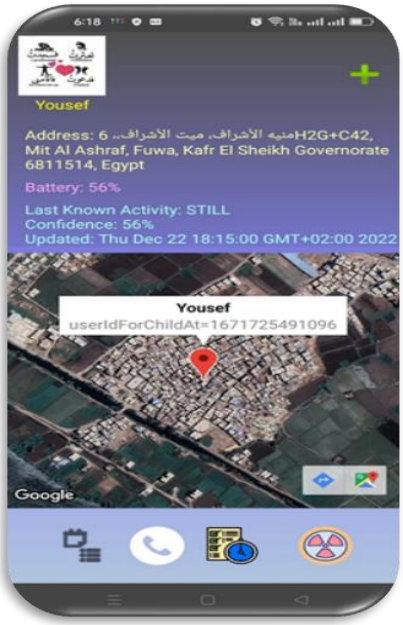

Fig.5: Screenshot of The Parent's UI

Figure.6 below shows a block diagram of the parent-student interaction.

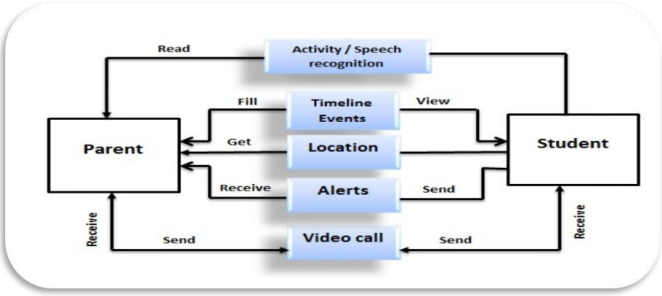

Fig.6: Parent-Student Interaction

B- The Admin's UI and Tasks

The administrator's role is the same as that of the parent during the time specified for him/her in the child's appointments. If the child has an appointment at a school, the school official can only see the following until the child's appointment ends, because some data is hidden from the official, such as the data recorded by the phone to respect the

child's privacy before and after the appointment. Figure.7 below shows the admin's UI, as follows:

- Special appointments for the child during the day;
- Alerts;
- The possibility of a video call;
- Signing;
- Current activity;
- Battery charge level; and
- Sending a warning to the guardian, the police and the ambulance.

Figure.8 below shows a block diagram of the admin-student interaction.

Fig.7: Screenshot of The Admin's UI

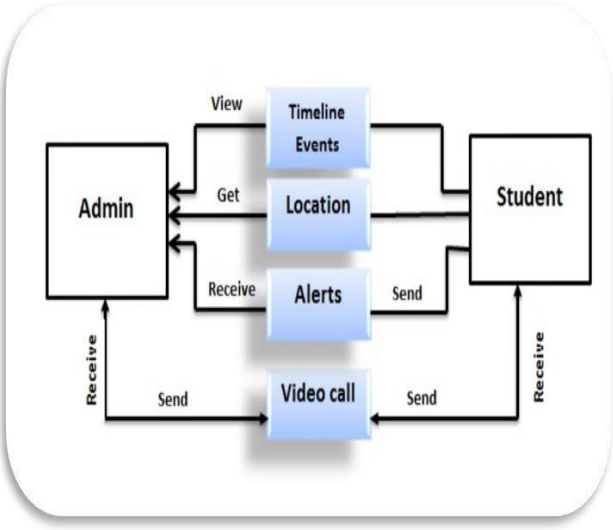

Fig.8: The Admin-Student Interaction

C- The Savior's UI and tasks

The savior can interact with the application as shown in Figure.9 below:

- Receiving alerts from students or guardians;
- Showing the location of students on a map; and
- Making video calls.

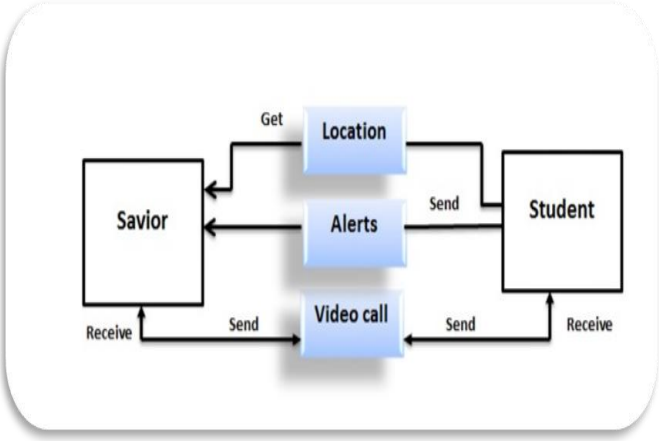

Fig.9: The Savior-Student Interaction

D- The Student's UI and tasks

The child's screen has four elements, as shown in Figure.10 below. The first is the yellow text at the top of the screen, which shows the next event or appointment to be attended by the child. The second is the timeline button, which displays a record of today's events or appointments with the start and end times, the place, and the person responsible for the place. The third element is for emergencies. Whenever the child feels unsafe, s/he can press this button to immediately send a warning to the guardian. The fourth is the video call button, and s/he presses it to make a voice and video call with his/her guardian.

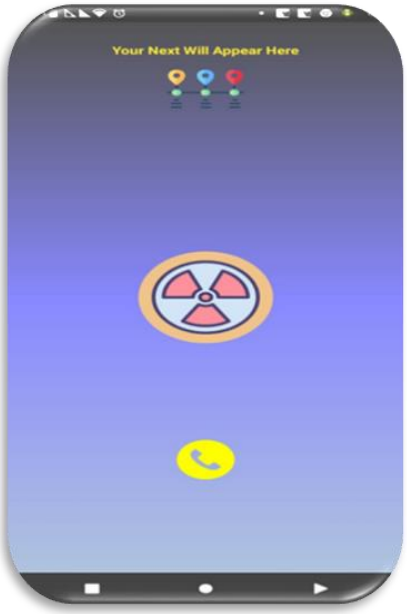

Fig.10: Screenshot of the Student's UI

V. ACTIVITY RECOGNITION RESULTS

All registered users have their accounts on firebase, which include their entire data, as shown in Figure.11 below.

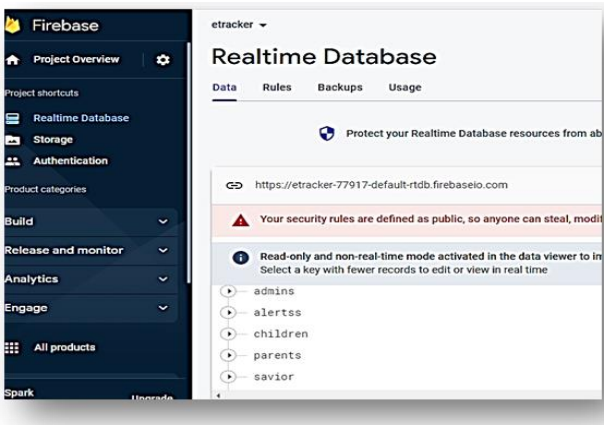

Fig.11: Screenshot of The Users Registered in The Firebase

Every student registered in the application has his/her data stored in his/her account registered in the firebase, including location data, accelerometer data, proximity sensor data, and light sensor data.

The student's safety tracking application can detect the student's motion through the accelerometer sensor readings stored in the firebase. Figure.12 below shows the student's data registered in the firebase.

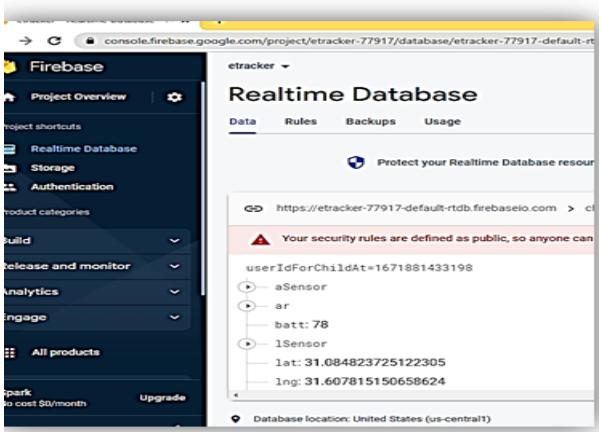

Fig.12: Screenshot of The Student's Data in The Firebase

All the data stored is analyzed resulting in the data shown in the application for students' guardians to take appropriate action to help the student in any situation. The screen appears to the parent in the order shown in Figure.13 below, as follows:

The map shows the current place and a yellow track is drawn, showing the student's movements and location, followed by the pictures taken by the student's phone, speech recognition, and the student's activities. If the speech contains words recognized by the system as dangerous or the student is in trouble, the application will send an alert to the parent to take action, as shown in Figure.14 below.

Then there is the sensors section, with the red color representing the x, y, and z axes. The accelerometer sensor: whenever its reading is fixed, this means that the student is not moving, and if the reading changes slightly, this means that s/he is moving normally. However, the reading of the three twisted axes means that s/he is moving violently. The light sensor gives us information about the nature of the place where s/he is staying or the place of the phone. It should be noted that in the sun, the readings will be high, while in a dark room, the readings will be low.

If s/he puts the phone in his/her pocket, for example, the reading will be almost zero, and so on. The proximity sensor has one axis, and it indicates whether there is something in front of the screen.

Fig.13: Screenshot of The Data Sections

Fig.14: Screenshot of The Alert Sent to The Parent

VI. RESULTS OF THE GPS READING ACCURACY

For measuring the proposed tracking application accuracy, the distances between the students' location coordinates obtained via the proposed Android application and the real readings on Google Maps were calculated and displayed in Table.2 below.

Table.2: Results of the GPS Reading Accuracy Measurement

Street	Real Location on Google Maps		Location Obtained Via Proposed App		Distance (m)
	Latitude	Longitude	Latitude	Longitude	
Industrial Technical School	30. 931551727102352	31. 111536327225	30. 931523767102352	31. 111536327225	**3**
Ahmed Orabi School	30. 933569271859774	31. 112440299170434	30. 933469271859774	31. 112440299170434	**11**
Al-Rahma Tower	30. 93394633656818	31. 107246120008514	30. 93394633656818	31. 107235120008514	**1**
Reading Institute	30. 942007554513157	31. 104675090915737	30. 942127554513157	31. 104635090915737	**14**
Faculty of Specific Education	30. 94848464785444	31. 099136316007494	30. 94847780798444	31. 099166916007494	**3**
Dantal Center	30. 94507120365391	31. 10209067579354	30. 94507120365391	31. 10219067579354	**10**
Girls Middle School	30. 937930070381558	31. 108818512504918	30. 937930070381558	31. 108871	**5**
Saad Zagloul Primary School	30. 937062156388258	31. 107670082715718	30. 9370321563	31. 1076460827	**4**
Al Noor School for the Blind	30. 938331025465633	31. 115669787708384	30. 938341	31. 115618	**5**

VII. CONCLUSION AND FUTURE WORK

This paper has utilized the free GPS technology and smartphone resources capabilities such as sensors, mics, and cameras for devising a new Android-based application for tracking children within a specified geographical range.

The proposed Android-based tracking application enables parents/elders to conduct real-time tracking of children/youngsters. The proposed tracking system was developed by utilizing a combination of hardware components and application software. The system has combined the hardware components and physical components to increase the accuracy percentage in the process of tracking children.In addition, the proposed application tracking was tested for accuracy and the obtained results proved to be within the accepted global scope.

Future work aims to improve the proposed tracking application and utilize more technologies to overcome the application limitations. For example, the improvement plan aims to add the ability to connect heartbeat rate and body temperature sensors in addition to other sensors appropriate for children. The system links the surveillance cameras inside schools to the program to add more intelligence techniques, such as facial recognition and body movements recognition technology to benefit from them in improving data and revealing identities. One more important improvement feature is represented in monitoring the phones of the child, his friends, and his colleagues by recognizing their pictures, sounds and movements.

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