Review Article
ISSN (Online): 2456-8651

International Journal of Engineering Science Technologies
July-August 2023 7(4), 1–18

UNDERAGE CITIZENS MONITORING APPLICATIONS - A REVIEW OF THE STATE OF THE ART AND GUIDELINES FOR FUTURE IMPLEMENTATIONS

Miguel Chaparra [1], Fernando Ribeiro [1,2], José Metrôlho [1,2]

[1] Polytechnic Institute of Castelo Branco, 6000-081 Castelo Branco, Portugal
[2] DiSAC - Research Unit on Digital Services, Applications and Content, 6000-767 Castelo Branco, Portugal

Received 07 May 2023
Accepted 08 June 2023
Published 24 July 2023

Corresponding Author
Miguel Chaparra,
miguel.chaparra@gmail.com

DOI 10.29121/IJOEST.v7.i4.2023.524

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Children's safety is a constant concern, both for parents and the institutions in which they are entrusted with care. There are several dangers and situations that can jeopardize children's safety. It is, therefore, important to have constant monitoring and preventive monitoring. This need, together with the technological means available nowadays, opens the way to the development of applications that allow better safety and monitoring of children's daily activities. The aim is to keep parents informed about where their children are and if there is anything they should be worried about. In this context, an analysis of the state of the art was carried out to identify the functionalities currently available to users of applications with this purpose. Through this analysis, essential functionalities were identified, such as real-time location on the map, location history, marking of safe areas and sending alerts. On the other hand, technological advances in various areas mean that there is room and opportunity to add value to what already exists and to contribute to answering existing problems. Therefore, in this article, besides the state of the art previously mentioned, it is also presented implementation lines for new mobile applications that may be developed in the future. The contributions of this article are, on the one hand to present what currently exists in terms of mobile applications to support the monitoring of children and on the other to propose lines of new features that current technology can provide in new applications.

Keywords: Child Tracking, Child Safety, Location, GPS, Software

1. INTRODUCTION

The safety of children is a constant concern, whether of their parents or the institutions they attend. It is therefore important to constantly monitor their safety. In this context, the existence of applications which allow the monitoring and identification of patterns of behavior which are out of the ordinary may represent an important contribution, helping those responsible for the children to track and identify anomalous situations.

According to the 2021 annual report published in Missing Children Europe. (2021), about 250,000 children go missing in Europe every year, with 83% of the

disappearances in the European union being runaways of their own accord, abductions, and disappearances in the context of migration. Similar situations happen elsewhere in the world. In 2021, the United States recorded over 337,000 disappearances, the United Kingdom recorded 46,000, Canada 28,000 and Australia 25,000 child disappearances International Centre for Missing & Exploited Children. (2021).

It is necessary to act and offer responses for the protection of these children who need support. However, this task is not easy. According to the Convention on the Rights of the Child published in UNICEF. (2002), "a child means every human being below the age of eighteen years unless, under the law applicable to the child, majority is attained earlier". The term child encompasses a very diverse age group with very distinct characteristics and needs.

One possible approach could benefit from the fact that smartphones are increasingly present in our lives and could be used as a tool to support child protection. Given the consent of the child, a mobile application can be used to track the child's location. In fact, children today are exposed to smartphones from an early age. At two years old a child can already hold a smartphone in their hands and even before that they are passive users in the consumption of multimedia content Yadav and Chakraborty (2022). From the age of two, children gradually learn to use smartphones and different types of applications Yadav and Chakraborty (2022). In the UK, according to Ofcom data, most children own a smartphone by the age of 11, with this percentage rising from 44% at age 9 to 91% at age 11 Oakes (2022). In Europe, a 2020 study conducted in 11 countries showed that more than 80% of children aged between 9 and 16 use their smartphone to access the internet daily David Smahel et al. (2020). Another study, also conducted in 2020 in the United States of America, reported that 60% of children are exposed to smartphones before the age of 5 and 51% of children have their own smartphone in the age group 9-11 years Auxier et al. (2020). Furthermore, 78% of parents of children who have their own smartphone before the age of 12 say that the main reason for this is to ensure contact with their children Auxier et al. (2020).

These facts justify the importance of studying the state of the art in terms of smartphone applications that allow tracking the location of children. These can help parents to remotely monitor the day-to-day life of their children in real time and help identify anomalous situations, allowing parents to be warned that something is out of the ordinary, so that they can act in good time to safeguard the welfare of their children. These may also extend the communication with the child. However, there are still some functionalities which can be explored and may make these applications efficient, such as the identification of anomalous patterns of behavior and the possibility of exploring the analysis of feelings/emotions of the children, through images, which may contribute to the clarification of the risk associated to the child's situation. This analysis may serve to reassure the parents about the child's real condition. This article presents the result of a research and analysis of the state of the art in terms of applications for tracking and monitoring of children, presenting its characterization and identifying opportunities for future developments leading to applications increasingly useful to achieve the objectives mentioned above.

2. STATE OF THE ART

This section presents an analysis of articles and applications regarding works that deal with the location of children, the location of family members and the location of elderly people in institutions. The conclusions obtained for the

identification of the essential functionalities for this type of applications are presented, as well as the aspects that may be innovative for the creation of new applications.

2.1. RELATED ARTICLES

This subsection describes the process required for the identification and analysis of articles related to child tracking and monitoring. Initially, the selection process is described, which keywords were used to obtain the results and how the articles were selected or removed from the study. Next, the selected articles are analyzed and summarized following a set of defined criteria and, finally, a comparative analysis of the functionalities of the systems described in the articles is performed.

2.1.1. SELECTION PROCESS

To identify the articles, a search was conducted on the Scopus platform with the aim of identifying papers already published in conferences or scientific journals that address people tracking as their main theme. The search resulted in a collection of papers that were submitted to a selection process, described below, to exclude articles out of context or irrelevant to the proposed study.

Scopus Scopus (2023) is a prestigious scientific database that combines abstracts and citations from the academic literature in a wide variety of knowledge areas. The use of this platform allows relevant and reliable searches and provides access to data, metrics, and analytical tools useful for the selection of results. Scopus offers an advanced search option that allows configuring and combining several keywords using logical operators such as AND, OR and NOT. It is also possible to filter by several fields such as the disciplinary area of the article, date of publication, title, abstract and keywords used.

When collecting the first sample of articles, the search fields of Scopus were defined with a combination of the following keywords: "Kid" or "Child"; "Track" or "Tracking"; "Application", "Program" or "Software"; "Location" or "GPS". These terms were selected as it is intended to evaluate child tracking systems. The search was applied to the title, abstract and keyword fields ("TITLE-ABS-KEY" filter) of articles with publication year greater than 2014 ("PUBYEAR > 2014" filter). The articles were further limited to the "Computer Science" and "Engineering" areas by applying the "LIMIT-TO" filter to the "COMP" and "ENGI" sub-areas respectively. Finally, the following search query was obtained: TITLE-ABS-KEY ((kid OR child) AND (track OR tracking) AND (application OR program OR software) AND (location OR GPS)) AND PUBYEAR > 2014 AND (LIMIT-TO (SUBJAREA, "COMP") OR LIMIT-TO (SUBJAREA, "ENGI")) ".

The application of this search query on 10 October 2022 led to a total of 127 results. The title and abstract of each article were read to select only articles based on outdoor tracking systems for children, elderly, women, or similar use. Articles that only base their system on indoor use were eliminated as they are limited to a small space and usually use Bluetooth technology for location identification.

After applying the process described above, the results obtained were reduced to 32 articles. With a further reading of these articles, it was possible to remove those that were out of context and had not been initially identified as such, as well as the articles of which access to the full reading of the document was unavailable,

reducing the sample to 26 articles. These were divided into two groups according to how they are implemented:

- Smartphones + external device (20 articles) - Group that covers most of the articles published with the purpose of tracking. These systems are based on the use of a smartphone application in conjunction with an external device for the collection of location data. Usually, the external devices used are Arduino or Raspberry Pi boards, Smartbands and Beacons.
- Smartphones (6 items) - Smaller group that uses the functionalities of a smartphone to collect location information, whether this is obtained by GPS (Global Positioning System) or mobile network.

Of these two groups, the one that most fits with the defined objective is the group that uses the LBS (Location-based Services) capabilities of a smartphone and no other external device to collect information. This resulted in a total of 6 articles to analyze whose focus is on tracking people to ensure their safety.

Figure 1

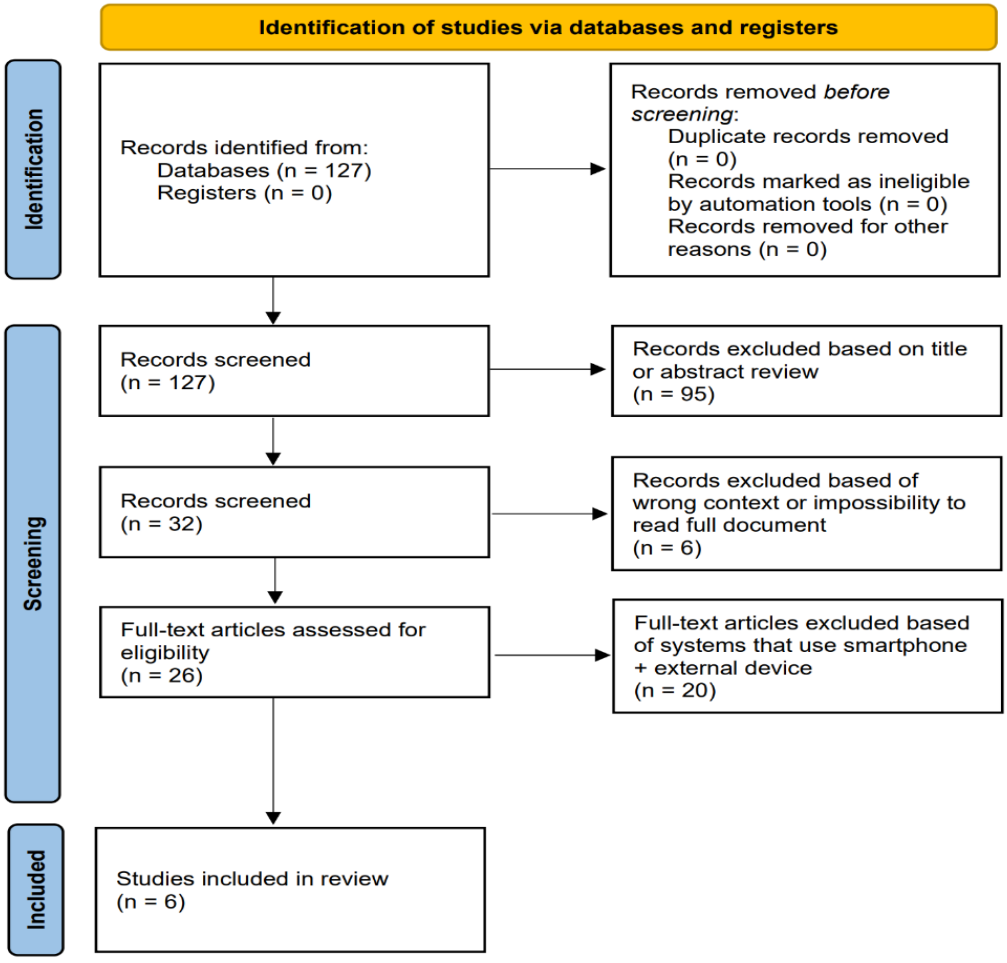

Figure 1 PRISMA Diagram Relating to the Phases of the Systematic Review.

Figure 1 represents the flow of information from the different phases of the systematic review previously described. That is, through the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) diagram PRISMA. (2023) it is possible to identify the number of results initially obtained when

applying the query, as well as the entire filtering process until the identification and respective selection of articles to be reviewed and analyzed in the next subsection.

2.1.2. ANALYSIS OF THE SELECTED ARTICLES

This section presents the results of the analysis of the 6 articles selected previously. Each of the referred articles was analyzed and is described considering the following criteria:

- Year of publication;
- Brief description of the objective of the work;
- Target audience for the application (children, elderly, etc.);
- Technologies used;
- Form of interaction with users (web, mobile or both);
- System functionalities;
- Results obtained.

The work described in Huynh et al. (2015), published in 2015, presents a CRLTMS (Cloud-based Real-time Location Tracking and Messaging System) focused on real-time location of children. The system consists of a push messaging service, web server, database, and GPS functionalities. CRLTMS consists of an Android application for the child's mobile phone that connects to the Internet to enable connection with the push messaging service and the server that stores the collected information. Parents can communicate by messaging and follow in real time the movement of their child through the web browser. The operation of CRLTMS is based on an Apache PHP web server and a MySQL database used to store the parent, child, and GPS location data. The application server is responsible for managing the data stored in the database and for sending and receiving push message requests from GCM (Google Cloud Message). GCM is a cloud push messaging service that allows sending and receiving messages in real time from one device to another. In this case, the GCM server processes all messages, delivering them to the Android app running on the child's phone. GCM supports two types of connections that can be used separately to send messages, HTTP (Hypertext Transfer Protocol) and CCS (Cloud Connection Server). For the presentation of the child's location to the parents, Google Maps API functionalities are used. The main used functionalities of Google Maps API allow the geographical encoding of the location (latitude and longitude) and presentation on a map. To frequently update, on the map, the child's location, without the need to update the whole web page, AJAX requests were used. After creating an account, parents can register the child's Android device in the system through a key that is generated and managed by GCM. Through the web browser, parents can follow the child's movement in real time and a history of the movement is also displayed. It is possible for parents to mark safe areas on the map. When leaving the marked limits, a push notification message is sent to the parents and to the child's device. Parents can also send messages directly to the child which, if offline, are stored and sent when the connection is established. To evaluate the developed system, the authors of this study prepared a test environment to compare the two popularly used forms of push messaging for Android, GCM and HTTP. Two test plans were made, one in 3G connectivity mode and the other connected by WiFi. In 3G mode all GCM messages were sent while HTTP had only 43% of messages sent successfully. Battery usage was also higher when using HTTP compared to GCM (12.15% and 9.6% respectively). In WiFi mode, HTTP consumed less battery than GCM (2.8% and 3.14% respectively), being the

difference between both very small. Even in WiFi mode, HTTP still had difficulties sending all the messages, unlike GCM, which reached again 100% success rate. Finally, the authors concluded that by using GCM to manipulate messages they can reduce battery consumption, reduce message latency, and improve user experience. They also conclude that the study conducted can be adapted and applied in various scenarios that are not limited to child tracking, such as truck tracking, logistics tracking, emergency medical service and in disaster alerts.

The work described in Song et al. (2021), published in 2021, presents a real-time positioning and monitoring system for elderly people. The proposed system was designed to be used in pensions and homes for the elderly to ensure their safety. It consists of an Android application and a program responsible for monitoring and supervising the elderly and employees of these institutions. The mobile application for Android devices was developed following the MVC (Model View Controller) architecture that allows for increased efficiency in application development. The application uses the Android LBS services for the collection of its user's location and can be installed on smartphones, smart bracelets, and other compatible devices. For the development of the monitoring and supervision program, the ASP.NET framework was used. The program data is stored in SQL Server 2012 and for the storage on the smartphone SQLite was used. To display the location on the map the Baidu Map API was used. The mobile application collects and stores the location in real time and sends this data to the monitoring and supervision program that is responsible for managing people (elderly and employees), paths, alarms, and fences. The communication between both is done through the HTTP protocol and the data transmission is done via REST (Representational State Transfer). At each update, 10 location information is collected, and the average value is calculated to obtain a relatively more precise location. The application is installed in the devices of the elderly and employees allowing that when an elderly person enters a risk area the system can determine and select the nearest employee to perform the rescue, thus ensuring the safety of that same elderly person. Through the monitoring and supervision program it is possible to add and remove safe and dangerous areas, internally called fences. When an elderly person crosses a fence area, a sound warning will be played, and an alarm sent to the system. Through the map it is possible to view in real time the location of the elderly and the staff, as well as view their movement history, thus allowing to quickly deal with any situation that could be dangerous. The system was simulated by several people and divided into several fences spread throughout the University campus and surrounding areas. After analyzing the results, the authors of the study concluded that all the test cases designed passed normally and the results were as expected. The authors also mention that the system was put into use for the first time in a real situation and that it is possible to adapt its use for the supervision of nurseries and schools.

The work described in Alam et al. (2022), published in 2022, presents a mobile application that allows parents to track the location of their children in crowded environments. Besides children, it is also possible to use the system to locate elderly people and people with disabilities. The main goal of the application is to locate lost people in the tourist and religious area of Al-Haram, Saudi Arabia. The application is only available for Android devices. The system requires internet connection and an active smartphone to function correctly. To collect the child's location the Android device's skills are used through GPS and GLONASS (Global Navigation Satellite System) or GPRS (General Packet Radio Service) technologies. The application also uses SMS (Short Message Service) to send messages. If the location is inactive, it is possible to use the mobile network to send the data. The Google Maps API service is used to represent and display the child's location on the map in real

time. The storage of the data necessary for the correct operation of the application is done through Firebase. Regarding the structure of the application, it is divided into 3 main modules:

- Main App Module - Contains the codes needed to perform the registration of new users, login, email verification, user profile, logout, among others;
- Geofence App Module - Responsible for map creation and geofencing functionalities;
- Google Cloud Messaging - Works as middleware, responsible for building the server and the logs.

After downloading and installing the program, parents can create an account and associate their children's device to it. Through the application, it is possible to follow the child's location in real time, as well as access their movement history. Through geofencing it is possible to mark on the map a safe area with a personalized radius. If it is not possible to access the location of the child's device, a warning message is sent so that the child re-establishes the connection with the internet and GPS. If, for any reason, the child leaves a marked safe area, a notification is immediately sent to the parents notifying them of the event. The authors of the study state that using the application described it is possible to reduce the number of missing persons and crimes such as kidnappings. People's trust and safety will increase to attract new tourists and foreign investors, thus benefiting the country's economy. In the future it is also intended to extend the functionality of the application to blockchain and IoT (Internet of Things) devices.

The work described in Vasudevan et al. (2022), published in 2022, presents an Android application with tracking features, hidden camera detector, alarm (siren), security updates and news page. The system is mainly aimed at preventing kidnappings and other problems that have been increasing in India. The Android app can detect hidden cameras within a radius of 15 meters through a magnetometer available on Android devices. The magnetometer can detect the frequency of a camera in the area and then warn the user that they may be being spied on. In case of emergency, the user activates an option in the app that will contact by voice call the friend/family member registered in the system. If nobody answers, the longitude and latitude of the user is obtained through the GPS and a text message with that information is automatically sent (every 5 minutes) to the nearest hospital and police station. If the user feels in danger, it is possible to activate an alarm (siren) in the application, which reproduces a loud noise to draw the attention of those around. The application has shortcuts to activate the siren by double-clicking the power button on the smartphone. To turn off the siren it is necessary to restart the device. Finally, it is possible to read directly from the application all the news about kidnappings, rapes and abductions that have happened in the user's current area, as well as in the whole of India. The authors of the study state that the developed application meets the established objectives but acknowledge that there are some disadvantages present in the current state. The disadvantages mentioned relate to the impossibility of storing the user's locations and the impossibility of using the application if the smartphone is switched off.

The work described in Khandoker et al. (2019), published in 2019, presents an Android application that has the main objective of ensuring the safety of its user and preventing crimes against women. Although the focus is on the safety of women, men and children can also use this application. The application called "LifeCraft" was developed with Android Studio 3.3.2 and Java JDK 11.0. The collection of the location is done through the GPS of the user's smartphone which can then be visualized through Geofire. All the application data is stored in the Firebase database. After

account registration and login, the system can be activated with a click, after which it will run in the background. It is possible to activate the SOS option by tapping or shouting a previously registered voice command, thus initiating the emergency service. During the emergency service the application sends a message with the user's name and location to the registered contacts. The location is sent every 5 minutes until the system is switched off. At the same time a call to the helpline in your country is made and the surrounding audio is recorded. The audio recording function serves to acquire evidence of a possible crime that may occur against the user of the application. The audios are recorded on the device and can be played back through the application itself. During the emergency service, the registered contacts (the same ones that receive the alert messages) can follow, in real time, the user's location on the map. The application also offers an offline emergency mode where it is possible to send the alert message with the user's name, but without their location. The audio recording and the connection to the helpline remain available, being impossible to follow your location in real time. Finally, it is possible to see the safe areas (police stations) directly on the application's map, not being possible to add new ones. In the future, the authors plan to add the option of marking dangerous areas and to develop a hidden camera and microphone detector. A hidden camera or microphone can be detected through the magnetic activity identified by the smartphone's magnetometer. To detect hidden cameras there are two further options. The first uses the smartphone's infrared sensor to identify white light and the second way uses the device's camera to detect light reflected from a hidden lens.

The work described in Kumar and M. (2018), published in 2018, presents a parental control application for Android devices. The application allows parents to read SIM card details and track their children's location. The application was developed with Android Studio and Java. The collection of the location is done through the LBS services of the child's smartphone, namely the GPS technology. The child's location is displayed on the map for the parents through the Google Maps API. The proposed solution allows parents to control their child's smartphone via SMS messages. For the correct operation of the application, the child's device must be turned on, have the application installed and GPS active. Through an SMS, coming from the parent's number, it is possible to force the child's smartphone to start a call to the parents, as well as activate a sound alarm that will only stop if the message "STOP" is sent to the child. Even if the application is closed, the smartphone will continuously play the alarm until the deactivation command is sent. Parents can view, via SMS, the messages received and sent by the child, as well as the primary SIM card information, details of the active smartphone and information regarding the network provider. As far as physical tracking is concerned, parents can track the child's location history through the application. The application was tested at the University campus. Assuming the GPS was on, the tests performed were successful. The authors refer that they intend to extend the functionalities and increase the efficiency of the application, without specifying what will be done to fulfil the referred future goals.

2.1.3. COMPARISON OF THE ARTICLES

Table 1 presents a brief comparison of the functionalities of the applications described in the articles previously selected and analyzed. The functionalities considered were the following: Location in real time (directly through a map or through frequent SMS messages - with intervals of less than 1 minute), Location history, Marking of safe areas, Alerts when entering/exiting safe areas (alerts that can be in the format of notifications or SMS messages), Sound warnings (in the

format of noises or voice messages), Direct messages (personalized or predefined text messages between terminals).

Table 1

Table 1 Comparison of the Applications Described in the Articles Regarding Functionalities.

Features/Articles	Huynh et al. (2015)	Song et al. (2021)	Alam et al. (2022)	Vasudevan et al. (2022)	Khandoker et al. (2019)	Kumar and M. (2018)
Location in real time	Yes	Yes	Yes	No	Yes	Yes
Location history	Yes	Yes	Yes	No	No	Yes
Marking of safe areas	Yes	Yes	Yes	No	No	No
Alerts when entering/exiting safe areas	Yes	Yes	Yes	No	No	No
Audible warnings	No	Yes	No	Yes	No	Yes
Direct messages	Yes	No	No	No	No	Yes

The 6 analyzed articles do physical monitoring of people, whether they are children or adults (women, elderly, etc.). Of the 6 articles, only article Vasudevan et al. (2022) does not present real-time location monitoring. The application of article Vasudevan et al. (2022) updates the location of the user in a high time interval, specifically every 5 minutes. Most of the developed systems allow viewing the user's movement history, whether this history is stored in online database or through history of SMS messages sent to the recipient.

Regarding the safe areas, only the first 3 articles analyzed present this functionality, as well as the respective alarm system for entries and exits of these demarcated areas. Regarding the sound warnings, only the system described in article Song et al. (2021) uses that functionality to warn, through voice message, that the user has left a safe area. The other systems make use of that functionality to reproduce a loud noise, with the intention of attracting the attention of other people in the area to the user that may be in a dangerous situation.

Regarding the sending of direct messages, this functionality is very little used in the analyzed systems. Despite the importance of establishing personalized communication between the two terminals, there are other popular solutions for that purpose, like SMS messages or chat applications such as Messenger, WhatsApp, or Telegram.

2.2. RELATED APPLICATIONS

This section presents the process carried out for the identification and analysis of related applications. Initially the selection process is described, which keywords were used to obtain the results and how the applications were selected or removed from the study. Next, they are analyzed and summarized according to a set of defined criteria and, finally, a comparison of applications is made according to their mode of use and functionalities made available.

2.2.1. SELECTION PROCESS

To allow for the analysis of applications with the theme proposed in this study, a search was conducted in the official Android and iOS application shops,

respectively, Google Play Store and App Store. The keywords used in the search filters of the respective shops were "kid tracking" and "kid tracking location". These terms were selected, since it was intended to analyze applications that act on the location of children. In both app shops, the results obtained were filtered by rating, and only applications with 4.0 stars or more were presented, with a maximum rating of 5 stars. To avoid selecting recent applications with low ratings and consequently high scores, only applications rated by more than a thousand different users were considered valid for this study. In this way, it was possible to obtain a more meaningful indicator of user opinion, preventing, for example, an application with only 2 5-star ratings and few downloads from being considered in the study.

To obtain the first sample of applications, only the first 3 valid results of each of the previously mentioned keywords were selected. Thus, a total of 12 results were obtained, 6 results from the Play Store and the remaining 6 results from the App Store. From the collection obtained, 3 duplicate results were removed, thus obtaining a total of 9 different applications. Each of the dedicated shop pages was then accessed to view the images of the application and read its description. After this brief analysis, the applications that were out of context were removed, resulting in a total of 7 applications to be analyzed.

Table 2

Table 2 Comparison of Applications in Terms of Portability and Cost.

Application Name	Platform(s)	Cost of Use
Family Tracker by Phone Number	Android	Free with limitations. Subscription system with all the functions.
FamiSafe - Parental Control App	Android and iOS	Annual subscription
Find My Kids: Family Tracker	Android and iOS	Free with limitations. Subscription system with all the functions.
Find my Phone - Family Locator	Android and iOS	Free with limitations. Subscription system with all the functions.
iSharing: GPS Location Tracker	Android and iOS	Free with limitations. Subscription system with all the functions.
Life360: Find Family & Friends	Android and iOS	Free with limitations. Subscription system with all the functions.
Spoten Phone Location Tracker	iOS	Free with limitations. Subscription system with all the functions.

In Table 2 it is possible to observe the platforms that allow running the referred applications, as well as the cost to have access to their functionalities.

2.2.2. ANALYSIS OF SELECTED APPLICATIONS

The 7 selected applications are presented Table 2. Each of the applications was analyzed and will be described considering the following criteria:

- Brief description of the use of the application;
- The way in which accounts are associated for the sharing of information;
- Target audience for the application (children, parents, family, etc.);
- Cost to unlock all features;
- System functionalities.

The application "Family Tracker by Phone Number" can be obtained free of charge SoulApps Studio. (2023). When starting the application, it is necessary to grant location access permissions, after which a map with our current location is displayed. Then it is possible to add a family member via a 6-digit code valid for one hour. No account creation is required to add a family member. The free version of the app features constant ads and has some limitations, and it is necessary to buy a

subscription to unlock all the features offered. The features differ between parents and children, with the following features available to parents:

- Add/Remove family members (children);
- View your child's location on the map in real time;
- View your child's location history;
- Mark safe areas on the map - You can choose the diameter of the area, as well as which alerts will be sent when crossing that barrier;
- Receive alerts when your child enters or leaves a safe area;
- Mark routes;
- Receive SOS alerts from your child.

The features allowed for children are:

- View location history;
- Send SOS request - A notification is sent to the parents with the location of their child, thus enabling their rescue. There are additionally other SOS options, such as through light signals with the torch and audible alarm.

The FamiSafe-Parental Control App can be downloaded at Wondershare Technology CO. (2023), requiring an annual subscription. When the user opens the application, he must create an account and log into it, on the parent's device and on the child's device. Then, depending on the device, choose who will use the application, parents, or children. When choosing the child, it is necessary to put the child's name and age and activate all the permissions required for the correct operation of the application. It is also possible to associate the father's device with the son's device by entering a 6-digit code. FamiSafe offers not only the monitoring of the child via GPS, but also monitors all access to content on the child's smartphone. The application allows:

- Add/Remove family members (children);
- View your child's location on the map in real time;
- View your child's location history;
- Mark the safe areas on the map;
- Receive alerts when your child enters or leaves a safe area;
- Mark routes;
- Obtain information on the speed at which the child is moving;
- Track smartphone usage time - Know how long a certain application has been used;
- Remotely block the use of your smartphone;
- Track activity on applications such as Youtube and TikTok - Allows access to the history of viewed videos;
- View which applications are installed or uninstalled by your child;
- Block explicit content on your smartphone;
- Block applications - Also allows you to send alerts to your child when they try to access blocked applications;
- Block inappropriate websites;
- View search history in browsers;
- Detect acts of online bullying and notify parents;

- Detect and block the writing of inappropriate words.

The "Find My Kids: Family Tracker" application has a version that can be used for free Geo Track Technologies (2023b). To unlock all functionalities, it is necessary to purchase a subscription. To use the application on the child's device it is necessary to install a second application, called "Pingo by Find My Kids", available for free at Geo Track Technologies. (2023a). For the correct configuration of the system, parents should install the main application "Find My Kids: Family Tracker" on their devices and install the auxiliary application "Pingo by Find My Kids" on the device of the child they intend to monitor. Through the main application it is possible to generate a 5-digit code that will be introduced in the child's application, thus formalizing the connection between both. It is not necessary to create an account to use both applications. There is also the possibility of adding a child through a smart watch with GPS available on the application's website Findmykids. (2023). The functionalities allowed to parents are as follows:

- Add/Remove family members (children);
- View your child's location on the map in real time;
- View your child's location history;
- Mark the safe areas on the map;
- Receive alerts when your child enters or leaves a safe area;
- Receive SOS alerts from your child;
- Access the microphone on the child's device and listen to the sound around them;
- Play an audible alert on your child's smartphone;
- It allows you to control the usage time of the applications installed on your child's device;
- Send and receive messages from the child via chat;
- Visualize activities done by the child, such as making a drawing and taking a picture of it for the parents to see.
- View the history of activities and alerts.

The features made available to children are:

- Send an SOS request;
- Send and receive messages from parents via chat;
- Perform activities such as, taking a picture of a drawing, watching an educational video, writing an essay based on a specific theme, clicking bubbles on the screen among others.

The application "Find my Phone - Family Locator" can be obtained free of charge from Family Locator LLC. (2023). Its goal is to connect all family members, be they parents, children or even friends. To unlock all the features, it is necessary to buy a subscription. When installing the application, it is possible to add members to the family group by entering a 12-digit code or by scanning a QR code. The group members can be anyone and have the same permissions and functionalities except for area tagging which is only available to the Administrator of the group. The main objective of the application is to connect people through their location. Therefore, the various users of the application have the following functionalities:

- Add/Remove members to the family group - You can add the device of any person, be it parents, children and even friends;

- Creation of new family groups;
- Viewing the location on the map in real time - You can view the location of all group members without distinction;
- View the location history of any member;
- Mark safe, dangerous or 'one visit only' areas on the map - Marking new areas is only available to the Group Administrator;
- Receive alerts when a family member enters or leaves an area;
- Send and receive messages via chat.

The application "iSharing: GPS Location Tracker" can be obtained for free from iSharingSoft (2023). The application is free without ads, but it has several limitations in use, requiring the payment of a subscription to unlock all its features. The aim of the application is to create a network of contacts that share members' locations with each other, be they parents, children, or friends. When installing the application, it is necessary to create an account, being offered complementary options to login through your Google or Facebook account. When creating an account, it is mandatory to associate a mobile phone number. Through the contact list it is possible to add friends to the group or share the download address of the application. Users of the application can:

- Add/Remove members to the family group - You can add anyone to the group via the contact list;
- Creation of new family groups;
- Viewing the location on the map in real time - You can view the location of all group members without distinction;
- View the location history of any member - The route with the movements of the selected person is displayed on a map;
- Mark safe areas on the map;
- Receive alerts when a family member enters or leaves an area;
- Send an SOS request to all members of the group;
- Send and receive messages via chat.

The application "Life360: Find Family & Friends" lIFE360. (2023) can be obtained free of charge. To unlock all features, such as location history, a monthly subscription must be purchased. When installing the application, it is necessary to create an account by entering the mobile phone number, e-mail, and password. To add new members to the family group, a 6-digit code must be entered. Like other applications analyzed earlier, Life360's main objective is to connect, through location, the people who are most important in our lives. The members of the family group can be parents, children, and friends. Users of the app can:

- Add/Remove members to the family group - You can add anyone to the group;
- Creation of new family groups;
- Viewing the location on the map in real time - You can view the location of all group members without distinction;
- View the location history of any member;
- Mark safe areas on the map;
- Receive alerts when a family member enters or leaves a secure area;
- Send an SOS request to all members of the group;

- To cancel the SOS request it is necessary to enter a previously defined 4-number PIN;
- Send and receive messages via chat;
- Obtain the speed at which the family member is moving - Track and generate reports based on driving speed;
- Detect car accidents and send emergency requests.

The "Spoten Phone Location Tracker" application can be downloaded free of charge at Applabel LTD. (2022). To unlock all the features offered it is necessary to purchase a subscription. The aim of the application is to connect, through real-time location, all family members, be they, parents, children or even friends. Users can:

- Add/Remove members to the family group;
- Create new family groups;
- View the location on the map in real time;
- View your location history;
- Send an SOS request.

2.2.3. COMPARISON OF APPLICATIONS

The analyzed apps seek to obtain the location of your loved ones so that, their safety is guaranteed by collecting and sharing their physical location. Despite being available for free on PlayStore and/or AppStore, all applications have an associated monetary cost in the form of weekly, monthly, or yearly subscriptions. By purchasing one of these subscriptions, users gain access to all the features of the application that were previously blocked/restricted in the free version.

Table 3 presents a brief comparison of the functionalities described in the previously selected and analyzed applications. The functionalities considered were the following: real-time location (directly through a map), location history, marking of safe areas, alerts when entering/exiting safe areas (alerts that can be in the form of notifications), SOS requests (possibility of sending requests for help to contacts/family members), audible alarms (in the form of noises or voice messages in order to draw attention) and direct messages (personalized or predefined text messages between terminals).

Table 3

Table 3 Comparison of the Applications in Terms of Functionalities.

Applications/Functions	SoulApps Studio. (2023	Wondershare Technology CO. (2023)	Geo Track Technologies. (2023b)	Findmykids. (2023)	iSharingSoft (2023)	lIFE360. (2023)	Applabel LTI (2022)
Location in real time	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Location history	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Marking of safe areas	Yes	Yes	Yes	Yes	Yes	Yes	No
Alerts when entering/exitin safe areas	Yes	Yes	Yes	Yes	Yes	Yes	No
SOS requests	Yes	No	Yes	No	Yes	Yes	Yes
Audible alarms	Yes	No	Yes	No	No	No	No
Direct messages	No	No	Yes	Yes	Yes	Yes	No

As mentioned before, the 7 analyzed applications allow physical monitoring of people, whether children or adults. Analyzing the previous table, it can be observed that all applications have real-time location, as well as history of locations. It is also possible to identify two very important features that were implemented in all applications except Applabel LTD. (2022). These are the option of marking safe zones and alerts when entering/exiting the respective areas. Another very popular functionality concerns the possibility of sending/receiving SOS requests, being present in 5 of the 7 applications studied. Sending audible alarms is only part of the functionalities of the applications SoulApps Studio. (2023) and Geo Track Technologies (2023b), which are focused on systems of control of children by their parents. Regarding the sending of direct messages, only the first two applications and the last one does not offer this option.

All applications, except for Geo Track Technologies (2023b), use a single application to monitor users, i.e., the same application serves both to send the information of the monitored person, as well as to present this same information to the person who monitors. Unlike the others, the application Geo Track Technologies (2023b) makes use of a second application that must be installed on the children's smartphone. This auxiliary application is responsible for collecting information and sending it for presentation in the parent's main application. The applications distinguish users through profiles, these being, administrator profiles, parents, children, or the set composed of the remaining family members and friends. The addition of children/family members is usually done by entering a code consisting of several characters or by reading a QR code.

3. DISCUSSION

The study presented here considered the analysis of 13 applications. These are 6 applications analyzed from 6 articles, resulting from a systematic review process that began with 127 articles and following the PRISMA methodology for conducting systematic reviews, and 7 applications with higher evaluation values obtained through official app stores. The main objective was to understand the real complexity of a child tracking system in terms of technological, functional, and social needs, as well as to identify future development opportunities to make these applications more useful and efficient.

The analysis shows that the applications make use of the LBS features of smartphones, namely GPS, to collect the information on the location of the monitored child so that this information can be transmitted to the parents' devices. Most of the studied systems use a single application divided into profiles that make it possible to distinguish the type of user and make the functionalities available according to that profile. The analysis also shows that there is a set of basic functionalities that are essential and are present in most of the systems analyzed: The location of the child on the map in real time; The history of locations; The marking of safe areas and the sending of alerts to those responsible when the child enters or leaves a safe area. Besides these features, there are others that can be explored, such as the reproduction of a sound alarm on the smartphone of the monitored child, to draw the attention of other people around to the child's safety, the possibility of sending SOS requests and the exchange of messages between responsible and child through a chat application.

This analysis has also identified some opportunities that can be explored to allow for the identification of situations that indicate that the child might be at risk. For example, the sole use of the criterion of the children being in or out of their safe areas as an identifier of a potential risk situation may not be sufficient. Being inside

their safe area does not in itself guarantee that the child is safe, just as being outside their safe area does not necessarily imply that the child is in a risk situation. In these cases, approaches that assess the child's emotional state can be very important to assess more reliably their real situation. These approaches are not explored in the analyzed systems. From the point of view of the children's guardians, the possibility to receive information about the child's emotional state can help to clarify the child's real situation. For example, the use of photographs (selfies) and the corresponding emotional analysis of the child would serve as a reassuring factor for their concerns, since if any serious situation occurs it is possible to identify it quickly and act accordingly. Another use for the use of photographs is the analysis and identification of the environment the child is in. These approaches can also be used to identify risky environments or to verify the legitimacy of the location received through the child's tracking system.

Another opportunity that can be exploited concerns the use of artificial intelligence to analyze the behavior, routines, and movement patterns of children to detect unusual behavior and thus alert those responsible. The aid of artificial intelligence is an asset which can help to identify potential risk situations more quickly and accurately, thus allowing problems to be prevented before they occur. These analyses may be carried out based on data collected by the application over time, namely the frequency with which the child visits certain places and the duration of its daily activities.

The importance of data protection legislation should also be noted. The use of sensitive personal information of children and their guardians requires the use of security measures to ensure the privacy of those involved in compliance with data protection active laws in the jurisdiction of the application, such as the GDPR (General Data Protection Regulation). To this end, it is important that secure connections are established, that information is transmitted in encrypted form and that it is guaranteed that this information is only used by those authorized to do so. Applications should guarantee the confidentiality of data and the privacy of users, while providing useful and innovative features for parents and carers.

4. CONCLUSION

This article presented an analysis of the main features provided by mobile applications aimed at tracking people, especially those used for monitoring children. With this analysis it is intended to identify the most common functionalities and strengths, but also to identify gaps and opportunities for future development to make these applications more useful in monitoring and identifying patterns of behavior that deserve greater attention. In this sense, this article also contributes with some guidelines for future development of applications with this purpose where Artificial Intelligence can also be an impulse and have a very important role for the emergence of new and efficient features that will help to overcome the scourge mentioned in the introduction of this article

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

REFERENCES

Alam, T., Hadi, A. A., & Najam, R. Q. S. (2022). Designing and implementing the people tracking system in the crowded environment using mobile application for smart cities. International Journal of System Assurance Engineering and Management, 13(1), 11–33. https://doi.org/10.1007/s13198-021-01277-7

Applabel LTD. (2022). Spoten Phone Location Tracker. App Store.

Auxier, B., Anderson, M., Perrin, A., & Turner, E. (2020). Children's Engagement with Digital Devices, Screen Time. Pew Research Center.

David Smahel, H. M., Giovanna Mascheroni, L. D., Elisabeth Staksrud, K. Ó., & Hasebrink, S. L. and U. (2020). EU Kids Online 2020: Survey Results from 19 Countries. https://doi.org/10.21953/lse.47fdeqj01ofo

Family Locator LLC. (2023). Find my Phone - Family Locator. Google Play Store.

Findmykids. (2023). Find My Kids Original Smart GPS Watch.

Geo Track Technologies. (2023a). Pingo by Findmykids. Google Play Store.

Geo Track Technologies, I. (2023b). Findmykids: Location Tracker. Google Play Store.

Huynh, C.-T., Nguyen, H.-Q., Pham, X.-Q., Nguyen, T.-D., & Huh, E.-N. (2015). Cloud-Based Real-Time Location Tracking and Messaging System: A Child-Care Case Study. Proceedings of the 9th International Conference on Ubiquitous Information Management and Communication. https://doi.org/10.1145/2701126.2701161

International Centre for Missing & Exploited Children. (2021). Missing Children Statistics: One Missing Child is One too Many.

iSharingSoft, inc. (2023). iSharing:Rastreador de Celular. Google Play Store.

Khandoker, R. R., Khondaker, S., Fatiha-Tus-Sazia, Nur, F. N., & Sultana, S. (2019). Lifecraft: An Android Based Application System for Women Safety. 2019 International Conference on Sustainable Technologies for Industry 4.0 (STI), 1–6. https://doi.org/10.1109/STI47673.2019.9068024

Kumar, P., & M., R. (2018). Location Based Parental Control-Child Tracking App Using Android Mobile Operating System. 2018 4th International Conference on Computing Communication and Automation (ICCCA), 1–4. https://doi.org/10.1109/CCAA.2018.8777612

lIFE360. (2023). Life360: Localizador Familiar. Google Play Store.

Missing Children Europe. (2021). Annual Review 2021.

Oakes, K. (2022). What's the Right Age to Get a Smartphone? BBC.

PRISMA. (2023). Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).

Scopus, E. (2023). Scopus. Retrieved June 22, 2023

Song, C., Kateb, F., & Keir, M. Y. A. (2021). Design of Intelligent Real-Time Safety Supervision System for Pension Institutions Based on LBS. Applied Mathematics and Nonlinear Sciences, 6(2). https://sciendo.com/article/10.2478/amns.2021.2.00047?tab=podgl%C4%85d-pdf

SoulApps Studio. (2023). Family Tracker by Phone Number. Google Play Store. https://play.google.com/store/apps/details?id=com.family.locator.find.my.kids&hl=en_US

UNICEF. (2002). Convention on the Rights of the Child text.

Vasudevan, K., Joliya, V. V, Aashry, L., & Brintha, N. C. (2022). Intelligent SoS Application with GPS Tracking and Hidden Camera Detection. 2022 6th International Conference on Trends in Electronics and Informatics (ICOEI), 964–969. https://doi.org/10.1109/ICOEI53556.2022.9777167

Wondershare Technology CO., L. (2023). FamiSafe-Parental Control App. Google Play Store.

Yadav, S., & Chakraborty, P. (2022). Child–Smartphone Interaction: Relevance and Positive and Negative Implications. Universal Access in the Information Society, 21(3), 573–586. https://doi.org/10.1007/s10209-021-00807-1