INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 4.295
(Volume 4, Issue 6)
Available online at: www.ijariit.com

Multipurpose child tracker with location predictor

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ABSTRACT

In India, 174 children go missing every day. The issue is disturbing for the society and even for parents. Whenever the child leaves the house there is always a second thought in parents' mind. To counter such doubts, a student tracker is formulated which not only provides live location of their ward but also helps in predicting and tracking their upcoming movements. The device is equipped with GPS, GSM and RFID modules with efficient backbone supporting the hardware.

Keywords— *Wearable technology, Safety, Tracker, Live location, Machine learning, Hidden Markov Model (HMM), Bayes theorem*

1. INTRODUCTION

In this era of technology children are exposed and prone to all kinds of threats. Children often fall in the trap due to peer pressure or jealousy and tend to commit acts that are way too far unimaginable. Even the cases of kidnapping and murders have increased substantially. This device is a smart tracker which is just the size of a normal school ID card equipped with GPS, GSM and RFID modules. Live location of the child is shared over the web to the parents/guardians with the help of GPS tracker and GSM Module. Moreover, the future locations can be predicted using the past results available in database. The algorithms such as Bayes theorem and Hidden Markov Model (HMM) efficiently use probabilistic functions and give the desired output.

2. COMPONENTS

The following components are used:

2.1 GPS module– NEO 6M

Fig. 1: GPS Module

The neo-6m module is a stand-alone GPS receiver featuring the high performance u-blox 6 positioning engine. The package is 16 x 12.2 x 2.4 mm in size. The compact architecture is best suited for battery operated mobile devices with less costs and space constraints. The neo-6m GPS receivers have excellent navigation performance in challenging environments. It provides horizontal position accuracy of ~2.0 m which is comparable to the field of sight and its time-to-first-fix is only 27 seconds [1].

2.2 SIM800L

Fig.-2 SIM 800L

SIM800L is a quad band GSM/GPRS module that works on frequencies GSM850 MHz and EGSM 900MHz. It also supports GPRS multi-slot class 12 and has capacity to support the GPRS coding schemes CS-1, CS-2, CS-3 and CS-4. It has a very small configuration of 24 x 24 x 3 mm which fits in all space requirements in users' application [2].

2.3 Node MCU

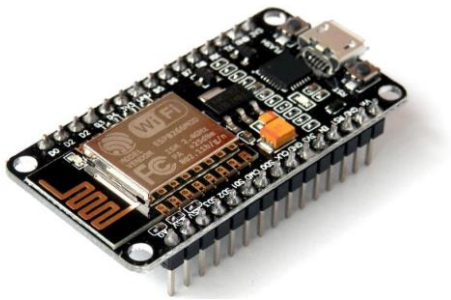

Fig. 3: Node MCU

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Node MCU is an open source LUA based firmware developed for ESP8266 wifi chip. By exploring functionality with ESP8266 chip, NodeMCU firmware is available with ESP8266 development board. It is a open source platform and the hardware design is open for editing and modifying [3].

2.4 RFID Tags

Fig. 4: RFID Passive Tag

A passive RFID (Radio frequency identification) tag is used which does not contain a battery. The power is supplied by the reader. Whenever the radio waves from the reader are encountered by a passive RFID tag, the coiled antenna within the tag forms a magnetic field. The tag draws power from it, energizing the circuits in the tag. The tag then sends the information encoded in the tag's memory [4].

3. WORKING

The backbone of the device is the internet and microcontroller chip. The captured location is stored in database and used by Machine learning algorithm. This is represented by the schematic diagram.

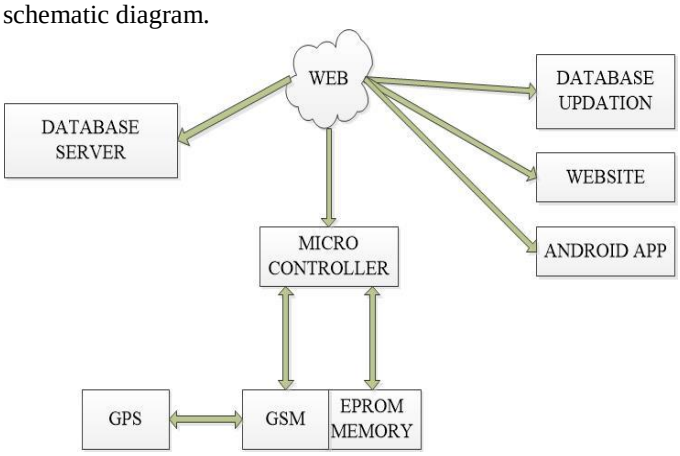

Fig. 5: Flow diagram

The All in one– Student Tracker is useful in the following situations:

3.1 Situation 1

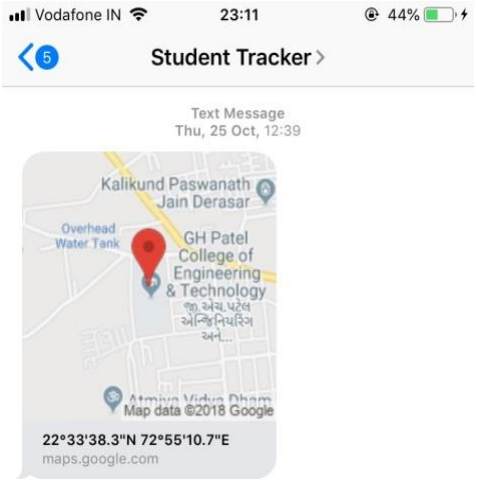

Fig. 6: GPS Module

Upon activation of the student tracker, a SMS is sent to the registered mobile number with the present location of the student. It contains GPS coordinates which can be viewed through the Google maps services. Following which the website needs to be opened and rest of the route can be monitored. Moreover, the device transmits the coordinated over the network using GPRS operational mode.

3.2 Situation 2

Real time tracking of children is done and the results are obtained on the website. Parent or guardian can login with the available credentials and monitor the route and ensure that their child is not moving in the unintended direction.

3.3 Situation 3

The RFID Readers are placed next to the door. While entering, the student needs to scan the card which is equipped with passive RFID tag following this another verification based on the GPS is done. At any time during the class the faculty creates the temporary window during which the available GPS devices (the IDs are already obtained by scanning RFID) are pinged and their present locations can be retrieved and stored. The data is then finally mapped with the present RFID tags report and the attendance can be marked efficiently without no interventions and disturbances in the class. This ensures that the teacher is least disturbed.

3.4 Situation 4

Library books are now-a-days recognized by the system using a barcode and the student ID card number is used to issue the books. After that the barcode is used to associate that particular book to the enrollment number (Identification number) of the student. Here, a passive RFID tag which is grain-sized is attached to the book. Any student who wants to issue the book, needs to enter the vicinity of the RFID reader available with the librarian with the book and the entry is made in the database. With this the human intervention is reduced or eliminated.

3.5 Situation 5

When the device which the child is carrying along runs out of battery or the network is not available then the algorithm can predict the location approximately and the parent can find the probability of the kid to be present at a particular place, based on the past records available. Moreover, the data can be classified using various ways according to the day, time, weekdays, weekends and many more.

3.6 Situation 6

Even if the network is available and the parent wants to know the next place the kid is going to visit that can be predicted using the device and the parent can schedule any particular event according to the probability.

4. PREDICTION OF LOCATION

Traditionally K-means clustering algorithm takes randomly selected user defined k numbers of centroids to form clusters. Each centroid compares and calculates its distance from remaining set of points. The nearest points to each centroid makes a cluster, for which, the average of the location is calculated. The average is used to find the next clustering set for the next iteration. This process keeps going on until the average stops changing. This process is repeated until no centroid is remaining [5]. This gives the location of child at particular place at particular time.

But the question of how the child is at a particular place still remains unanswered. K-Means does not give the trajectory nor the analysis of past data in its output. The model is modified to

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mark the places as "significant" when a particular time threshold is attained (times in table), here it is chosen to be 10 minutes and is stored with the coordinates in database. The database contains the fields like User ID, Coordinates, Date, Time and Location ID. The database then needs to be chronologically ordered according to the User ID and the amount of time a user has spent at a particular place. Thus the clusters are obtained which are the intermediate output. In the next phase Markov model is introduced to relate the values together and find co-relations and dependencies.

The Markov model are state transition models with the nodes as location. Moreover, Markov model states that future state depends on the current states and observational data but are independent of past states [17].

The probability tables are created containing the transition data using which the exact probability is calculated that gives a perfect idea about the present location of the child. The probability table for a particular child having ID 105 is plotted as.

Table 1: Probability Table

Location Id	Times	Frequency	Probability
510	1	1/44	0.02
120	2	2/44	0.04
25	23	23/44	0.52
125	5	5/44	0.11
36	6	6/44	0.13
421	6	6/44	0.13
255	1	1/44	0.02
Total visits	44		

The queries like "Where the child is on Monday at 10am?" or the question like "Where is the child at 4pm today?", if today is Thursday, still remains unanswered. This is the point where hidden Markov model comes into picture and the date and time fields are treated as hidden nodes [7]. Here the hidden states are introduced for each visible state and cluster is formed on which Bayes theorem is applied. For example, the probability of child on Monday can be calculated by:

$$P(x|Monday) = \frac{P(Monday|x) * P(x)}{P(Monday)}$$

This model can be further extended to incorporate the time component as well. 24 hours are divided into a well-defined equal number of periods say n. For example, 24 hours divided into 12 parts gives 2 hours in each division. For computation like "Where is the child on Thursday at 6pm?" the ID of that particular time can be applied for calculation. Like for 6pm it will be 9 when starting form 12 midnight. Bayes formula can be applied as.

$$P(x|Thrusday.9) = \frac{P(Thrusday.9|x) * P(x)}{P(Thrusday.6)}$$

The probability of child at a particular Location ID in the given time division can be obtained.

5. LITERATURE SURVEY

Prof. Idachaba put forward one system, where parallax GPS module is used to detect the location of lost items, child location and stolen cars. If the signals go below a threshold value, the user is sent at least five location of devices [8].

Wong et al. used Bluetooth technology to detect the range of children from parent and if it goes out of range, the parent is notified with an alert and location of the child [9].

Song et al. tackled the issue of kidnapping in his paper. The proposed system monitors and detects a child's location in real-time using ZigBee and GPS. The alarm data is transmitted to the remote center which is connected to a closed-circuit television (CCTV) system when the children are present in the school. The ZigBee is then used to track the location using the knowledge of signal strength by the received signal strength indicator (RSSI) [10].

Another proposed method [11] was to use the vision based tracking system using color segmentation to estimate the exact location. The image taken by KINECT sensor is transformed into red, green and blue color for feature extraction. The use of vision-based system minimizes the error in location estimation. Despite of such advantages, there is a downfall in using such system, the complexity in the analysis as the image acquisition and pre-processing of the image is converted into a small size to reduce the complexity and segmentation of image color as well as noise filtering is quite high. Also, the researchers working on [11] themselves have claimed that this system lacks robustness for aggressive maneuvers which is not suitable for portable use, especially for school children.

Another system developed by Saranya and Selvakumar used GPS and GSM to track a child they had a pre-recorded voice of the child stored in the database. If the sensor detects the child's cry for help, it compares the voice to the one stored in the database, the GPS module detects the exact location of the child and the GSM sends it to the parents via SMS [12].

More than one stage approaches are used by several researchers to predict the location. In [5] [13], the focus is on predicting user's location based on GPS data. It uses K-means to cluster the location. I have incorporated the usage of hidden Markov model to predict the exact place and time where a student can be found. Most of the work has been done to predict the current location but here it can also predict the "When?" component as well.

[14] has used DBSCAN [6] instead of K-means [15] to cluster data points, and using a variable order Markov model instead of hidden Markov model for predictions.

In [16] data mining approach is used to predict the future locations of moving object. The inventor mines the database of moving object to match the unseen trajectory with the extracted trajectory to select the best association rule.

6. FUTURE WORK

The product needs to undergo rigorous testing and hence the prediction of the algorithm needs to be more accurate. The device is set to be commercial product hence the costing factor needs to be more analyzed. Mechanism which uses only GPS without GSM needs to be developed so even without network availability the product can function well. The accessibility needs to be improved including the availability in remote, forest areas. The children should accept the device and be well accustomed with them.

6. CONCLUSION

Safety is the most important issue for everyone, especially safety of kids cannot be undermined. In this paper a model of All in one – Student Tracker is presented which consists of wearable, portable and multifunctional device. The computation of the predicted location is based on Hidden Markov model with Bayes Theorem. The situation in which the device can be useful is discussed. Paper mainly focuses on the development of the

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product and feasibility of the device. Furthermore, the device can also be useful for the elderly people and women.

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