SmartID Card for School going Children

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Credits: 4

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New Delhi

Student’s Declaration

I hereby declare that the work presented in the report entitled “SmartID Card for School going Children” submitted by us for the partial fulfillment of the requirements for the degree of Bachelor of Technology in Electronics and Communication Engineering at Indraprastha Institute of Information Technology, Delhi, is an authentic record of my work carried out under guidance of Dr. Vinayak Naik. Due acknowledgements have been given in the report to all material used. This work has not been submitted anywhere else for the reward of any other degree.

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Avikal Kohli Date: 18.04.2017

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Pavani Tripathi

Certificate

This is to certify that the above statement made by the candidates is correct to the best of my knowledge.

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Dr. Vinayak Naik Date: 18.04.2017

Abstract

We are going to make a Smart ID Card for children as all of us must have heard of a lot of cases of kidnapping, bullying etc among children and this is a solution against many of those problems. Since small children don't have smartphones we thought that attaching sensors to ID cards would be more effective. The system would not be bulky so that it can be easily carried by children. It would help us to keep a track of the location of the children and also start recording audio if it senses an anomaly. The system consists of a processor (which we narrowed down to Raspberry Pi 3), a sound card, a GPS sensor and an accelerometer. We have calibrated the sound card to record, store and play audio. The accelerometer now gives us the relative position with the GPS giving us the raw data of latitude and longitude. So the basic system is already in place and the data collection has been successful. We have tried to analyse the data that we obtained from the sensors. The GPS data was analysed with the help of Google Map APIs. The audios recorded using the mic and the sound card were sent through the speech recognition model. The overall system with a working GUI is now in place.

Acknowledgements

This project would not have been successful without constant support of Dr. Vinayak Naik. We thank sir for constantly guiding us throughout the semester and helping us in figuring out various aspects of our project.

Work Distribution

Major components of the work to be done this semester were as follows:

1. Using google APIs, show the complete route of the child and give a warning when diversion occurs.
2. Choose a speech model from the different ones and then train it with samples, collected on our own and then test the accuracy of the model. We will train the model with words like help etc. to send an alert to the parents when these word are recorded.
3. Using accelerometer readings we can find the speed of the vehicle. In case the vehicle crosses a predefined threshold, a warning will be sent to the parent.
4. Compile and display all the above using a GUI

Avikal Kohli worked on selecting the speech model and making it work as per our requirements. His work was to find an appropriate settings for the model so that it gives maximum accuracy. He also worked on removing the noise from the accelerometer readings and then classifying the data based on the acceleration and speed.

Pavani Tripathi worked on making the GPS data more useful. The aim was to plot the collected data on Google Maps using it’s API and then checking if the bus followed the same route or not. She also worked on creating the web app using Django.

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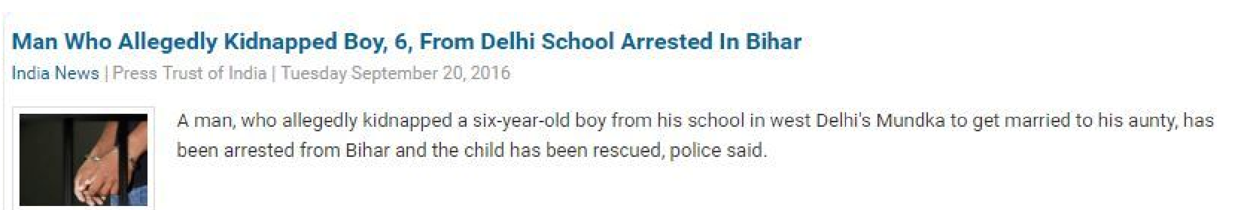
1. Introduction

1.1 Motivation

All over the world the crime rate is increasing tremendously. Everyday someone or the other is brutally murdered or kidnapped or robbed. These are just few crimes to name. The list is endless. To deal with this, everyday people are trying to use the ever changing technology to develop devices which can be used for the betterment of humanity.

With increasing number of rapes happening all over the world a lot of wearable devices like smart pendant or smart bracelets have been developed for women's safety. A lot of startups have come up who are developing such devices. Leaf wearables is one such Indian startup. They have developed a smart pendant which is connected to one's mobile phone via bluetooth. On perceiving threat the user taps the pendent twice and a message is sent to their loved ones containing the exact location of the user.

Currently, devices are being developed mainly for women's safety. But nowadays a lot of child kidnapping cases are being reported. In most cases the child is kidnapped from the school or after school. Recently a child was kidnapped from outside his school in Delhi. It took a lot of time to find the child. After a lot of effort and research the kidnapper was tracked down in Bihar. Such delays in finding the child need to be minimised. With increasing number of such cases being reported, we feel that a system which could ensure child's safety should be developed. Thus, we aim to create a Smart Identification Card for school going children which can be used for tracking children and monitoring their day to day activities. A system that could record voices around the child so that cases of child abuse can be reduced by alerting the parents whenever such a situation occurs.


Man Who Allegedly Kidnapped Boy, 6, From Delhi School Arrested In Bihar

India News | Press Trust of India | Tuesday September 20, 2016

A man, who allegedly kidnapped a six-year-old boy from his school in west Delhi's Mundka to get married to his aunty, has been arrested from Bihar and the child has been rescued, police said.

Figure 1: News about child being kidnapped from school

1.2 Problem statement

One may ask why can't we simply use a smartphone for this purpose. One can easily put a smartphone in a child's bag and it can do tracking and recording both.

To answer the above question we conducted a small survey of parents and children who are currently studying in Nursery or/to class 5. We asked the parents the following questions:

1) Are you comfortable giving your child a smartphone for safety purposes?
2) Are such young students allowed to carry mobile phones to school?
3) Would you prefer a device which could help protect the child so that you can avoid giving her/him a mobile phone?

On asking the above questions we got the following responses:

1) About 90% of the parents do not wish to give their child a smartphone at such a younger stage. The reason being, that the children so young do not understand that the phone kept in their bag is only for safety purposes. If one gives them a phone they will play games and/or watch movies on the phone. It is easy to say that you can tell them not to but they are KIDS, they will get tempted. And already most children are so addicted to TV, laptops, playstation, parents do not want to add another gadget to the list.
2) About 95% of schools do NOT allow school children so young to carry mobile phones.
3) About 85% of the parents said that yes they would definitely like to purchase such a device.

Thus, one challenge of developing this system is to design a system such that it does not make use of a smartphone for any purpose.

In terms of technology, our next challenge is to develop a small, power efficient and most importantly a cost effective device that can be attached to the child's ID card.

2. System

2.1 Components

Raspberry Pi board, GPS module, Sound Card with a mic and accelerometer are the major components, all integrated together to form the complete system.

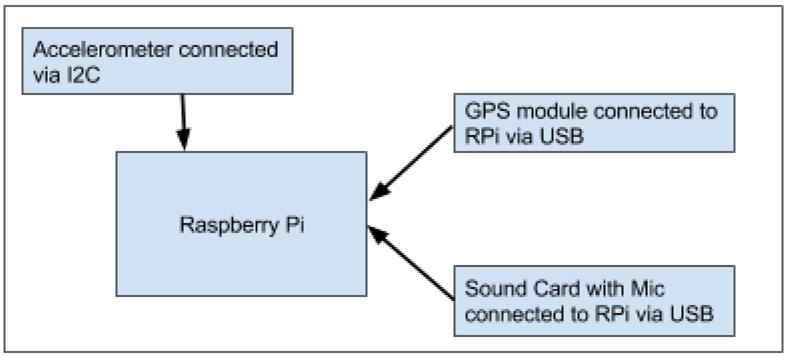


Figure 2: Flow diagram of the complete system

Arduino board and Raspberry Pi board are the most popular boards used by students and professionals for various research and engineering projects. For building the brain of our system we explored which one would be better for our purpose, Arduino or Raspberry Pi.

Raspberry Pi has many advantages over Arduino board. The major advantage being, that RPi is like a small computer. It is capable of doing multiple tasks at the same time just like a computer. Especially for our system, which will be using GPS, Mic, accelerometer, Wifi and other components, RPi was a better option. Also, since our final goal is to develop an identification card, our system should not be bulky and should not occupy much space and should weigh less. Since RPi has a built in Wifi module which will be required for our system when we make the it real time, this acts as an advantage for us. We thus decided to use Raspberry Pi 3 Model B, the latest RPi board.

We are using Adafruit Ultimate GPS Breakout - 66 channel w/10 Hz updates - Version 3 as the GPS module. For interfacing the GPS module with RPi there are two ways, one is using TTL-to-USB cable and the other one is via UART. But since using TTL-to-USB cable for interfacing is less complicated and inexpensive so we decided to interface the module using the this cable. This GPS module is very powerful and can work indoors as well. This was the major reason behind selecting this particular GPS module. But to make even more accurate readings we plan to further add an external antenna. This would guarantee accurate readings even when the child is sitting inside the class. For understanding the serial data that the GPS module provides we have used ‘gpsd package’. It essentially acts as a layer between one’s application and the actual GPS hardware, gracefully handling parsing errors, and providing a common, well-defined interface to any GPS module. Currently we are receiving data every one second. We plan to further increase the frequency to 10Hz. The main reason behind using GPS is so that the parents can track their child easily whenever they want to. Also, one can set routes for going to school from home and vice versa, and in case the bus or van goes off-route the parents can be alerted.

For recording audio we have used HDE 7.1 Channel USB External Sound Card Audio Adapter along with a mic connected to it. For recording the audio and playing it we have used Alsamixer, which is a built-in software inside RPi module. Alsamixer records audio and stores it in .wav format which is one of the most commonly used format for audio files. The reason behind recording the activity of the child is to keep a check about the environment the child is in. In case of any suspicious noise, the parents can be alerted and a strict action can be taken according to the situation.

For the accelerometer we are using the Generic Gy-521 Mpu6050 Accelerometer. It has both an accelerometer and a gyroscope however we're only using the accelerometer at the moment. It is connected to the Raspberry Pi through I2C method. To accumulate the data from the sensors we use a python code using the python smbus module. The accelerometer can be used to detect the speed of the child and so if the speed is too fast it might mean that the child is in a precarious position. It can also add on to the location of the GPS and in cases where GPS may not work (eg indoors) it can be used to generate the approximate location.

2.2 Cost and power Consumption

The total cost of the system is as follows:

S. No.	Device	Cost (in. Rs)
1	Raspberry Pi Model B RASP-PI-3 Motherboard	2,849
2	Adafruit ultimate GPS Breakout	3,899
3	HDE 7.1 Channel USB External Sound Card Audio Adapter along with a mic	249
4	Generic Gy-521 Mpu6050 Accelerometer	209
	Total Cost of the System	7,206

The power consumed by each device and the total consumed by the system is as follows:

S. No.	Device	Current Drawn	Voltage (in V)	Power
1	Raspberry Pi Model B RASP-PI-3 Motherboard	1.2A	5	6W

2	Adafruit ultimate GPS Breakout	20mA	3.3 - 5	Max. 0.1W
3	HDE 7.1 Channel USB External Sound Card Audio Adapter along with a mic	20mA	5	0.1W
4	Generic Gy-521 Mpu6050 Accelerometer	500 uA	5	2.5 mW

3. Adding Value to System

3.1 Using GPS data on Google Maps

We drove the car from IIIT-Delhi's academic building till Modi mill flyover and collected data using the GPS module. We took three different routes. The data, in this case the latitudes and the longitudes of the various points on the route were dumped in a .dat file.

The aim was to plot the data on the Google Maps. That is being done using Google Maps API. Incase an anomaly occurs address of the point at which the vehicle of the child detoured is reported in the message.

The challenges were:

1. The GPS data that we collected had a lot of noise. When we plotted the data on the Google Map we observed that a lot of points were off the road.
2. Finding the address of the exact point at which the vehicle detoured.

We studied various Google Map APIs and then narrowed down to the following:

1. **Reverse Geocoding API**:
   Geocoding means translating a human-readable address into a location on a map. But for our project we required the opposite. Thus, we chose reverse_geocode API to extract nearly the exact address of various latitude-longitude points.

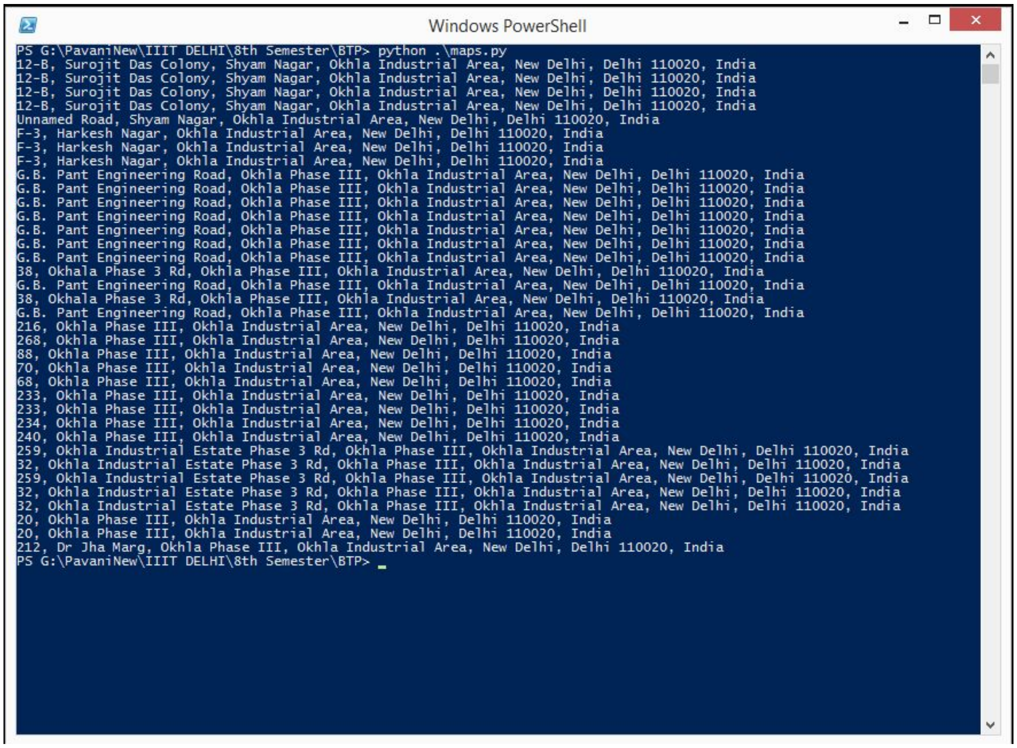
   There were 356 latitude longitude points that we recorded. After every 2 seconds the GPS module would report a new data point. On observing the data we realised that there was a lot of redundancy in the data. We realised that this was happening due to the following reasons:

   A. Whenever there was a speed breaker we had to slow down and in that time frame a lot of redundant readings would get recorded.

   B. On turns due to lower speed a lot of similar data points would get recorded

   C. Whenever a pedestrian would cross or there was some riksha in front of the vehicle a lot of similar points got recorded.

   Following screenshot shows the list of addresses that the vehicle crossed while we drove from the academic building of IIIT-Delhi to Modi mill flyover.



So we took every 10th point for our analysis. Even after clipping so many points one can see that the API still returns a lot of same addresses. The reason for this is that whenever a long stretch of road comes the API returns the same address for the whole road unless there are different house numbers along the road.

2. **Snap-to-road API**:
   The Google Maps Roads API allows one to map GPS coordinates to the geometry of the road, and to determine the speed limit along those road segments. It offers the following services:
   a. Snap to roads
   b. Nearest roads
   c. Speed limits

Currently for our application we have chosen snap to roads. This service returns the best-fit road geometry for a given set of GPS coordinates. This service takes up to 100 GPS points collected along a route, and returns a similar set of data with the points snapped to the most likely roads the vehicle was traveling along. Optionally, one can request that the points be interpolated, resulting in a path that smoothly follows the geometry of the road.

We passed approximately 50 points to the service. With interpolate variable value set to true, the service returned around 150 points. These points are all along the road.

3.2 Model for speech recognition

The speech model is used for two things. The first is to see if the recorded sound is higher than a preset decibel level and to give a warning if it is. This lets us figure out cases where the child may have shouted under distress due to bullying or other cases.

The second use of the model is to use speech recognition to recognize key words like help that the child may say under any distress. To do this we researched 3-4 speech models and upon the basis of accuracy and compatibility and on the reviews given to us we narrowed it down to CMU Sphinx which is an open source speech model made by the students at Carnegie Mellon University. In this, the voice features are extracted and passed through a model that contains an acoustic model (that contains the acoustic properties), a phonetic dictionary (for mapping the words) and a language model (to restrict the word search). We then trained the model and tweaked the parameters to arrive at a model that best suited our needs.

The model’s accuracy changed by about 20% depending on the surroundings. When we tested it in open areas such as playgrounds it’s accuracy was the worst and it was the best in closed indoor areas. The data provided to the model during testing had to be from different sources as the voice quality and modulation varies quite a bit from person to person and especially depends on the gender. Not only was the data from different people but also was taken in different areas.

3.3 Finding speed-limit problems using Accelerometer

We are using the accelerometer module to figure out sudden movements/jerks that the child might face. The difficulty in this was to create a threshold so that certain slow movements did not create a warning. After a lot of tests we reached a threshold that minimized false positives while at the same time gave a warning at actual points of interest. Also to remove noise a low pass filter was used as the accelerometer was highly sensitive.

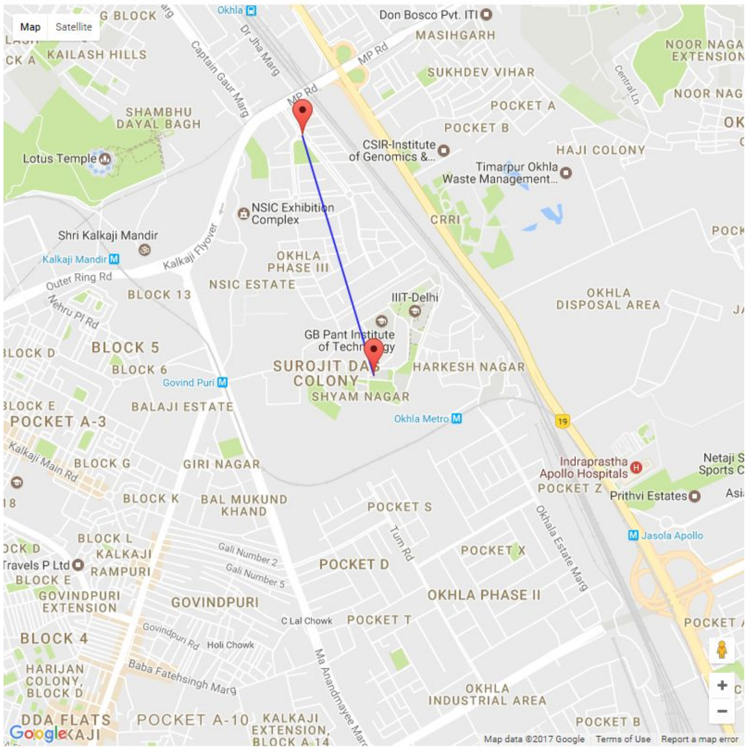
The threshold that we have kept lets a few false positives in such as when the child may trip by himself/herself. It was necessary to allow this as it is impossible to distinguish between a child being pushed and this and we felt it was better to give a needless warning than to let an event pass by as the child can always explain later what the issue was. The event can also be collaborated by the speech module as if there was a fight at the time there might be a warning generated by the speech module too.

4. Challenges Faced

- We collected the data by moving around in the car. Whenever we went around the area in which there were a lot of buildings or trees, the GPS signal would sometimes get lost. But with repeated trials we were able to collect the data on our chosen route.
- The issues faced in developing the speech recognition model were implementing the CMUSphinx model and improving its success rate. A major issue that was faced was making sure that the algorithm recognised the sound card and the microphone. Also the surrounding environment created a lot of noise.
- The major issue while analyzing the readings of the accelerometer was running tests in order to choose a threshold that gave the best possible results. Also we had to recognise the change in accelerometer readings caused by different kinds of movements.
- For developing the GUI the major challenge was to understand how the Django framework works and how everything gets linked together both the frontend and the backend.

5. Results

Google Map



Accelerometer Readings

Averge Acceleration throughout the journey: +- 0.1 km/min^2

Averge Speed throughout the journey: 25km/h

Audio Recordings

Total number of times a warning was reported: 2

The above screenshot is the very basic User Interface that we have created till now. Depending on the results of the algorithms run behind the app, we display the results on the web app.

The exact route taken by the vehicle is plotted on the google maps after removing the noise from the data with the help of snap to road google maps API service.

The average speed and acceleration of the vehicle were calculated and then are shown on the UI.

Finally, depending upon how many times the word “help!” was found on the recorded audio clips, we display exactly how many times did the child asked for help.

6. Future Work

In the coming semester we plan to do the following:

1. Improve the GUI by adding buttons that could give updated result of both when the child goes from school to home and when he returns back.
2. Currently the CMUSphinx speech recognition model does not give that good accuracy. In the coming semester we would like to work on improving the overall accuracy of the system by trying more ML classifiers.
3. Currently the speech model is only trained for the word “help”. If possible we can also train it with longer sentences or the word “bachao!”.
4. We can also make the system more cost efficient simply by using a lesser expensive GPS module. We can compare the results with the current module to see how much trade off is there in between cost and accuracy of the system.

7. References

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2. Tutorial for interfacing the accelerometer
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3. CMU Speech recognition model
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4. Django Tutorials
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5. Google Maps API tutorials
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