Secure Location Tracking System

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***Abstract*— This research is to create an effective GPS Projectile Vehicle Tracking System so that the police can use it to track suspect vehicles and speeding violators. The tracking system uses a GPS receiver to receive satellite signals, and then transfers the location information via Short Message Service (SMS) through mobile communication to an Android tablet. The Android tablet receives the SMS with location information and displays the location of the suspect vehicle on Google map. In this paper, the tracking system is proposed for the police to fulfill the function of tracking the target vehicles. Feature such as security and real time tracking are also devised to better assist policemen with accurate location information and better tracking efficiency.**

Keywords-GPS; Tracking System; Android; security;SMS

I. INTRODUCTION

Vehicle tracking system based on GPS technology has become a mature industry in recent years, providing users with accurate location information, hence great convenient and time saving. On the other hand, there has been a rise in the number of traffic violations and illegal vehicles thefts. In Singapore, the total number of traffic violations registered an increase of 10.6% from 332,206 in 2012 to 367,496 violations in 2013 [1]. Thus, providing policemen with tools or a Vehicles tracking system to better track/monitor the suspect vehicles with accurate location information can surely help to improve the work efficiency of the policemen.

II. WORKING PRINCIPLE OF TRACKING SYSTEM

A. *Descriptions of Two Devices*

In this paper, two Android-enabled electronic equipment with built-in computer programs designed to run on smartphones (Apps) to fulfill the said function are used in the proposed vehicle tracking system. Android is an operating system (OS) based on the Linux kernel, designed initially for the portable devices [2]. It is an open-source OS, allowing great convenient for users to create programs. In this work, two different Android Apps were written to fulfill the proposed system's requirements. The first App is used for tracking the suspect vehicle and sending SMS on location information of the pursued vehicle to the receiver; this App will be installed in the Tracking Device. The second App is used to convert the received information of the SMS sent from the Tracking Device into coordinates of longitude and latitude information and then display the location on the Google map. This App will be installed in the Control Device and will be specially designed based on Google map API [3]. The system diagram is shown in Fig. 1.

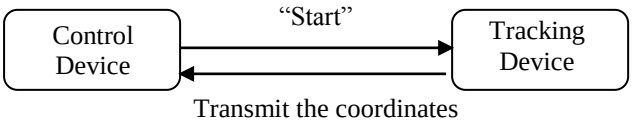

Fig. 1 Working principle between two devices

B. *Work Flow of GPS Projectile Vehicle Tracking System*

In the proposed tracking system, a small Tracking Device must first be thrown onto the suspect or speeding vehicle and be held in place, i.e. stuck onto the car surface, using magnet. Thereafter, a Control Device is deployed to display the location of the moving vehicle on Google map; others like mobile phone, tablet can also be used. In the system developed, only three simple steps are involved:

1) Tag the tracking device (with magnets) onto the suspect vehicle, and is to be thrown by the police.

2) After tagging the tracking device onto the suspect vehicle, use the Control Device to activate the Tracking Device to enable the Tracking Device to send back detail location information of the targeted vehicle.

3) After receiving the information sent from the Tracking Device, the Control Device display the location information of the targeted vehicle on a map for the police to track the suspect vehicle.

III. DESIGNING APP FOR TRACKING DEVICE

The tracking system aims to offer a positioning service in Android system. Phones were used for the tracking device. This application is based on the positioning and navigation service provided by the GPS system, which can locate the device's position and convert the GPS information into coordinates that include longitude and latitude information. After obtaining the longitude and latitude of the device, the system sends the information to the Control Device through

SMS. There are four modules in the tracking system: GPS Module, Data Processing Module, Setting Module, and GSM Module. The steps of operation are summarized below.

A. Getting the Coodinates from GPS Module

Firstly, the device gets GPS information from satellite. To obtain coordinates from the satellite, the code in Fig. 2 was used.

```
@Override
public void onLocationChanged(Location location) {
    double latitude = location.getLatitude();
    double longtitude = location.getLongitude();
    JSONObject object = new JSONObject();
    try {
       object.put("latitude", latitude);
       object.put("longtitude", longtitude);
   } catch (JSONException e) {
       e.printStackTrace();
   }

    mMessageView.setText(object.toString());
}
```

Fig. 2 Code for obtaining coordinates from satellite

B. Setting Parameters

The Setting Module sets the four parameters required in this application. The four parameters are: “To”, “From”, “Interval” and “Auto Send”. After setting the four parameters, their values are saved as the default setting through “Back” button. This step is based on Setting activity and Shared Preferences Manager. The code for setting is shown below in Fig. 3.

```
@Override
public void run() {
    while(true){
        try {
            Thread.sleep(second * 1000);
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
        sendMessage(phoneNum);
    }
}
```

Fig. 3 Code for setting time interval of Autosend

C. Receiving and Sending Messages

This part will be functional when the Tracking Device receives a SMS. It will check the phone number and message content of the SMS. If both are eligible, the Tracking Device will activate the Main activity and send messages to the Control Device. The code in Fig. 4 is used to send the coordinates to the Control Device.

```
private void sendMessage(String phoneNumber){
    SmsManager smsManager = SmsManager.getDefault();
    String msg = mMessageView.getText().toString();
    if(msg == null || "".equals(msg)){
        msg = " ";
    }
    smsManager.sendTextMessage(phoneNumber, null,msg, null, null);
}
```

Fig. 4 Code for sending coordinates data to Control Device.

IV. Designing App in Control Device

The Control Device is held by the police. The main function of the Control Device is to convert the coordinates of the SMS sent from the Tracking Device into location for display on the Google map App. This App should start another App in the Tracking Device by sending a “Start” message, and then extract the longitude and latitude information from the received SMS from the Tracking Device. The Control Device consists of both the GSM Module and Google Map Module. These two processing steps are elaborated below.

A. Receiving and Displaying Data

The procedure here is based on the GSM module. When the Control Device receives the SMS sent from the Tracking Device, the App in the Control Device will start up automatically. After obtaining the longitude and latitude information from the Tracking Device, the data will be displayed on the main interface of the App. The code for this part is shown below in Fig. 5.

```
private LatLng getLatlng(String msg){
    double latitude = 0;
    double longtitude = 0;
    try {
        JSONObject object = new JSONObject(msg);
        latitude = object.getDouble("latitude");
        longtitude = object.getDouble("longtitude");
    } catch (JSONException e) {
        e.printStackTrace();
        Toast.makeText(this, "Location data is Error!", Toast.LENGTH_SHORT).show();
    }
    return new LatLng(latitude,longtitude);
}
```

Fig. 5 Code for processing data from SMS

B. Dispalying the Coordinates on the Map

The procedure here is based on the Google Map Module. The App will convert the SMS into longitude and latitude for display on the map. The fulfillment of this function relies on Google Map Service. On the map, there will be a maker to point out the location of the Tracking Device, from which the police can track the device and know the location of the vehicle.

V. Further Improvement and Testing

In order to add on features such as security function and also to improve on the grip of the devices, two other Apps are developed: (1) security algorithm and (2) real time algorithm, which collectively, have helped to improve the efficiency of the police, enabling them to catch more suspect or speeding vehicles.

A. *Fulfilling "1 to N" Function*

To ensure security for the App in the Tracking Device, there must be a function that identifies the phone number of the received "Start" SMS; otherwise anyone can access the coordinates information by sending a "Start" SMS to the Tracking Device. On the other hand, the App in the Tracking Device may need to send the location SMS to not just one device but several devices, i.e. 1-to-N as there may be several policemen chasing the same suspect vehicle. A flow chart of the improved system is given in Fig. 6. This security function allows information sharing among policemen, which greatly improves efficiency. After testing, the interface for initial setup for users' access permission is illustrated in Fig. 7.

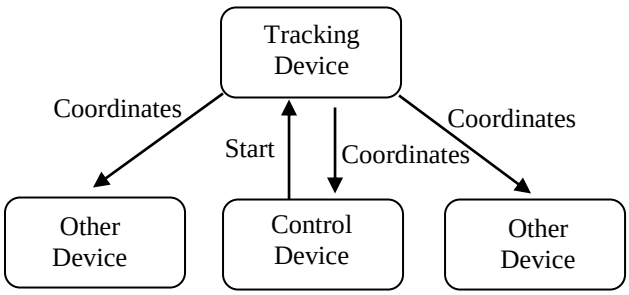

Fig. 6 Flow chart for multiple users' access

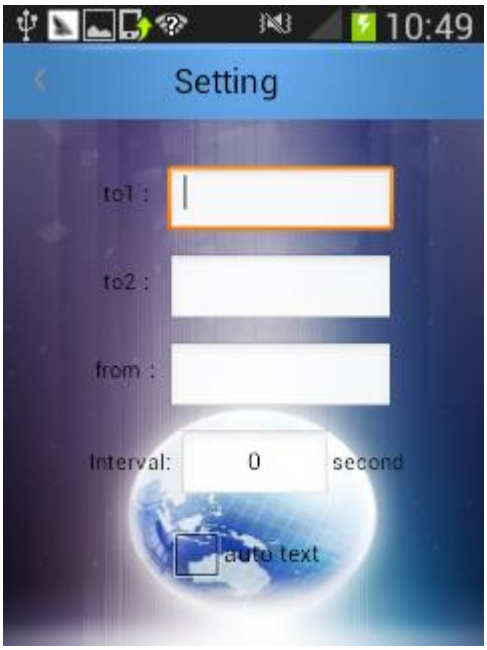

Fig. 7 The interface of setting

B. *Adding Stop Function*

It is important for the police to be able to control the Tracking Device well so that the Control Device is able to start and stop whenever necessary. Thus, when the receiver in Tracking Device receives a SMS from a valid number, there must be an identification on whether it is "Start", "Stop" or something else. The testing result is shown in Fig. 8.

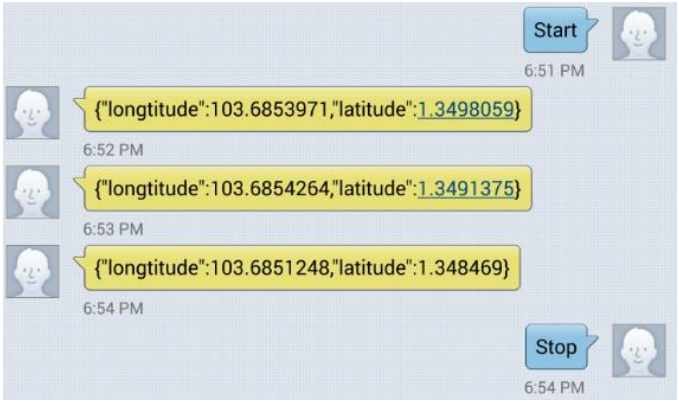

Fig. 8 Test results of control device

C. *Displaying Track and more Information*

The Google Map module will extract the content of the SMS, to quickly convert the coordinates to the right point on the map. In order to know more about the suspect vehicle or even to predict the next position of the vehicle, several functions have been added, showing details on the location. The added feature allows user to see the path of the target vehicle. Besides, the time and average speed are shown in each of the position which will make the police well master the action of the target vehicle and predict where it goes. In order to get the average speed rather than forthwith speed, the map must calculate the distance between coordinates [4]. Assume there are two points A and B as Fig. 9 shows, and the distance can be calculated by the formula in Fig.10.

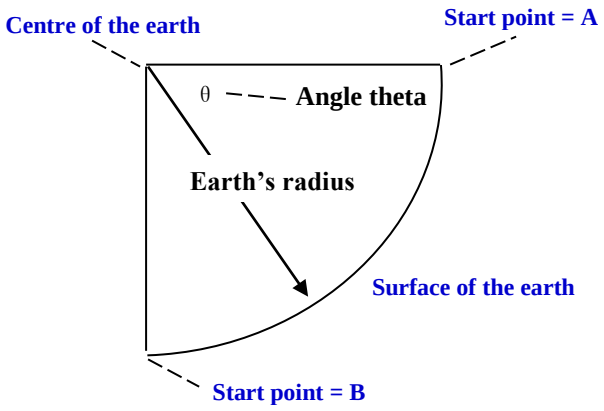

Fig. 9 Diagram illustrating distance between two points

Distance = 2*Pi*Radius/360*2*Arcsin(Part4), where:
Part1 = Cos(LatA)*Cos(LatB)
Part2 = Sin((LongA-LongB)/2)
Part3 = Sin((LatA-LatB)/2)
Part4 = (Part1*Part2² + Part3²)
Radius = 6 371.0 km

Fig. 10 Formula calculating distance

Shown in Fig. 11 is the tracked trails on the Google map after testing. The full program code may be provided if requested.

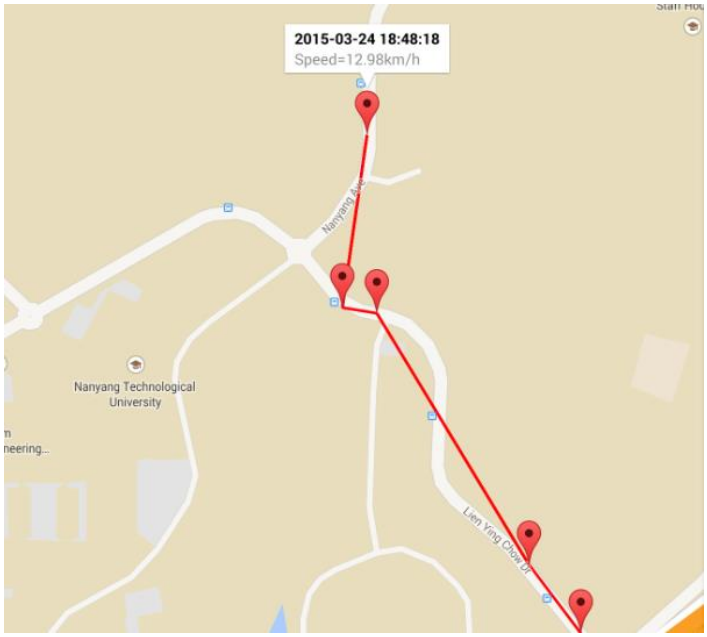

Fig. 11 Tracked trail on the Google map

VI. Conclusion and Future Work

A secured location tracking system that can accurately send real-time information about the target vehicle's locations to a Control Device is successfully developed. Specifically, the security functions for "1 to N" and "Stop" have improved the feasibility of the proposed tracking system. In addition, the tracking path and time-speed display help the police to predict the route of target vehicle. An extension for this project would be to identify suitable magnet to adhere the Tracking Device onto the surface of the suspect/target vehicle. With lighter and more powerful magnet package, the projectile function can have even better efficiency.

References

[1] Police news release. AUNUAL ROAD TRAFFIC SITUATION 2013. http://driving-in-singapore.spf.gov.sg/services/driving_in_singapore/documents/Annual_Road_Traffic_Stats.pdf

[2] Nimodia C, Deshmukh H R. Android Operating System[J]. Software Engineering, ISSN, 2012: 2229-4007.

[3] Svennerberg G. Beginning Google Maps API 3[M]. Apress, 2010.

[4] Flytec AG/Flytec USA. Turnpoint Discrepancies in Competition Scoring. 05.06.2008