

Promotion of Sustainable Transport by a Tracking System for Bicycles

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Abstract. The trend of delivering items by bicycle is getting more and more attractive for companies, particularly if they are based on metropolitan areas. Cities around the globe are already promoting and popularizing bikes and e-bikes as an efficient and ecological delivery and commuting option that can replace conventional motorized vehicles. Unfortunately, a side effect of encouraging the use of bicycles is the rate of bicycle theft.

To promote the use of bicycles for personal mobility or as mean for transport supply we propose a low-cost system to track stolen or vandalized and abandoned bicycles. Location data are displayed on Google Maps using markers.

Keywords: Tracking, ICT, Sensors, Wireless Communication

1 Introduction

The trend of delivering items by bicycle is getting more and more attractive for companies, particularly if they are based on metropolitan areas. The main advantage of this kind of delivery service is that bicycles can easily avoid road congestion and therefore collect and distribute packages or mail quickly throughout the city [1]. Additionally the costs for companies that rely on fleet of bicycles are much lower compared to the costs derived from conventional van- or truck transport. In line with this cities around the globe are already rethinking mobility systems by promoting and popularizing bikes and e-bikes as an efficient and ecological delivery and commuting option, that can replace the conventional motorized vehicles.

Unfortunately, a side effect of encouraging the use of bicycles is the rate of bicycle theft that has increased in recent years. In Austria 28.018 bicycles were stolen only in 2015. This number corresponds to the cases that were reported to the police, but the real number is estimated to be eight times higher with 22.0000 stolen bicycles per year. With around 6.224.000 bicycles, one bicycle out of 28 is stolen [2].

As this fact might undermine further efforts to promote biking we propose in this work a system relying on connected Information and Communication Technologies

(ICT) that makes it possible to collect data on mobility behavior to assess for example environmental impact or to localize bicycles in case of theft. A bicycle GPS tracker is also attractive to reduce insurance costs and to find a particular parked bike among others in huge parking lots.

2 Related Work

There are currently several products for tracking bicycles, which are already available to customers. As an example, we describe 3 devices that have a GPS module and a GSM module installed. The acquired location data can be transmitted through the following options:

- a) via a text message over the Global System for Mobile (GSM) communications that describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets.
- b) via a web-application over the General Packet Radio Service (GPRS) standard for mobile phones.

Velocate offers a rear light for bicycles, which allows tracking by using a pre-installed application that is available for smartphones with the Android and iPhone operative systems. The rear light contains the necessary hardware that consists of a battery, Bluetooth, a GPS module and a GSM module. The module has a motion detector. The application transmits the location information as soon as a theft or movement is detected [3].

An additional GPS antitheft tracker for bicycles is the Sherlock box that contains the same components as the rear light by Velocate but it is shaped in a different design. Here the device is manufactured in an elongated, cylindrical shape so that it can be placed in the frame or handlebar of the bicycle [4].

The GPS tracker by Spy Lamp 2 is hidden inside a bicycle tail light. It consists of a motion sensor, a GPS module and a GSM module. If a movement is detected, the location data is sent by SMS. The movement history and the live location can be seen on the manufacturer's website [5].

3 Technical Implementation

We propose in this paper a low-cost system to acquire mobility data and represent it in a map. To this end, we use a GPS module. To run dynamic web sites or servers the software bundles Apache, MySQL, PHP and Python are used. A Raspberry Pi reads the information and sends it wirelessly to a server in which it is stored for its later graphical representation in a map. The prototype uses the following standard components:

- Raspberry Pi 3 Model B

- Adafruit Ultimate GPS Breakout
- USB-TTL cable
- External battery
- Box for the Raspberry Pi
- Micro SD memory card
- Mobile WLAN router

3.1 Hardware

The Raspberry Pi is the core of the prototype. It has a processor with 4 cores each with 1.2 GHz computing power, a main memory with 1 GB, modules for Bluetooth and Wireless Local Area Network (WLAN) are also accommodated on the board and it offers four USB 2.0 ports as well as a Local Area Network (LAN) port. The power supply is provided by a Micro-USB socket [6].

The GPS Adafruit Ultimate GPS Breakout module is connected to the Raspberry Pi using a USB TTL cable. This connection supplies the module with power so that it can immediately start searching for the signals from the GPS satellites. If a signal can not be detected by the GPS and an exact position can not be determined, a red LED flashes once per second. As soon as a position can be calculated and read by the software, the red LED flashes only every 30 seconds [7]. The use of GPS for position determination allows accuracies of 13 m horizontally and 22 m in height [8].

A mobile Wi-Fi-router dials into the 4G network via a SIM card and establishes a connection to the Internet. This enables the Raspberry Pi to communicate permanently with the web server. The used battery has a capacity of 10,000 mAh. This battery supplies the Raspberry Pi with power via its USB output using a micro-USB cable.

3.2 Software

The Raspbian Stretch computer operating system for Raspberry Pi is installed on the SD memory card. The GPS coordinates are sent in a permanent stream via the USB TTL cable from the GPS breakout to the Raspberry Pi. A Python program takes the longitude and latitude values from the stream once a second and writes them into the local database.

The system is equipped with an Apache web server and a MySQL database. Furthermore, the scripting language PHP allows the execution of embedded HTML code. The GPS coordinates are stored in the database. In addition to the values of longitude and latitude, a location point and a timestamp of the recording time are added. If there is a connection to the Internet, the locally stored data is sent to a web server. Fig. 1 shows a section of the SQL-code to write the GPS values into the database.

```

try:
    # Execute the SQL command
    #pnr=21
    time='{:Y-%m-%d %H:%M:%S}'.format(datetime.datetime.now())
    fid=1
    lat=latte
    lng=longe
    cursor.execute("INSERT INTO tbltrack VALUES (%s,%s,%s,%s,%s)", (pnr,time,fid,lat,lng))
    # Commit your changes in the database
    db.commit()
    pnr+=1
except:
    # Rollback in case there is any error
    db.rollback()

```

Fig. 1. Section of the SQL-code that writes the GPS values into the database.

The data is transferred using client for Uniform Resource Locator (cURL), a program library for transferring files in computer networks. After the data is read from the local database of the Raspberry Pi, each record is converted into a double, integer or timestamp string using Typecast and writes the values in the database of the Web server. The code in Fig. 2 shows the PHP script code for inserting data into the MySQL database.

In case of an interruption in the transmission of the data the highest number, which the Web server has received is written in the text file, that is stored on the Web server. In case of a retransmission the text file will be read and the remaining values will be transferred to the Web server. To reduce the volume of data and at the same time being able to achieve a sufficient density, only one thirtieth point is transmitted to the Web server.

The Google Maps Application Programming Interface (API) was used to visualize the data. As Google maps are already pre-installed on many mobile devices and Google provides HTML code to place markers on them [9].

```

$pnr = (int)$_POST['pnr'];
$lat = (double)$_POST['lat'];
$lng = (double)$_POST['lng'];

$query = "INSERT INTO tbltrack set pnr='$pnr', lat='$lat', lng='$lng';";
$db->query($query);

```

Fig. 2. PHP script for inserting data into the MySQL database.

4 Results

Fig. 3 shows an excerpt from inserted data into the MySQL database. This dataset consists of the location point, the recording date, the bicycle ID and the latitude- and longitude information. Fig. 4 visualizes the collected data through markers indicating a route on the map.

| LocPoint | TimeStamp | BicycleID | Latitude | Longitude |
|----------|---------------------|-----------|-----------|-----------|
| 2606 | 2019-02-17 13:27:34 | 1 | 48.341826 | 16.330477 |
| 2607 | 2019-02-17 13:27:35 | 1 | 48.341827 | 16.330478 |
| 2608 | 2019-02-17 13:27:36 | 1 | 48.341828 | 16.330479 |
| 2609 | 2019-02-17 13:27:37 | 1 | 48.341829 | 16.330480 |

Fig. 3. Excerpt from the MySQL database.



Fig. 4. Graphic visualizing the collected data through markers indicating a route on the map.

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