Archives of
Transport System
Telematics

Volume 9

Issue 3

September 2016

Mobile system for recording road weather conditions

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ABSTRACT

A prototype of the "Mobile System for Recording Road Weather Conditions" has been made in the context of research and development work done on behalf of APM PRO Sp. z o.o. The system is used to record data collected from MARWIS - mobile sensor of surface condition produced by Lufft Company, a GPS receiver, accelerometer, and the instantaneous vehicle velocity from CAN bus. Its task is also processing the obtained information to standardized form and transfer it to an external database.

KEYWORDS: road weather condition, mobile systems, prototype

1. Introduction

From the point of view of safety and car transport efficiency, the current information about the road conditions is very important. Because of significant spatial changeability of these conditions resulting among others from relief, differences in traffic intensity, exposing the street to sunshine etc. [1, 2, 6, 7], the data from stationary weather stations are not sufficient. Data from road weather stations can be of course assisted by proper weather prediction systems. Such prediction, however, requires a knowledge of series of input parameters and proper model calibration for the local conditions. Moreover, regarding the provision of continuous information access to the weather station, mobile recording systems can constitute a great source of data during breaks in weather stations operations [5]. This article presents a prototype of Mobile system for recording road weather conditions. This system allows to collect information about road weather conditions along the route of vehicle equipped in proper sensors. Thanks to such solution the weather information from stationary weather stations, recorded in a given road section, will be cyclically completed by data regarding the road conditions along the transit route. The system measuring devices can be mounted, among others, on special maintenance vehicles (e.g. patrolling given road sections), passenger transport or road management vehicles, e.g. ploughs or salt spreaders.

2. System assumptions

In regard to the system presented in the article, it was assumed that the basic task would be to record data acquired from the mobile surface conditions sensor and the vehicle spot speed from the CAN bus. Moreover, the system should process recorded data in order to achieve a standardised form of data and send them to the external database. As part of the works a prototype of the device was built along with communication interface and data gathering system.

The main assumption during the works on the prototype was to base it on the central driver put into place in form of a single-board computer. Such approach requires implementation of proper, dedicated software to serve for communication protocols and data gathering mechanisms from:

- Lufft MARWIS mobile road conditions sensor
- GPS receiver,
- accelerometer,
- CAN bus via OBD II diagnostic interface.

The system should also perform data transfer to external SQL Server database.

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3. Implementation of the prototype

Raspberry Pi 2B microcomputer was used as central driver that allows implementation of the assumed system functionality. Schematic diagram of the prototype presenting the most important elements of it and used communication protocols is presented on Fig. 1. Elements that are inside the frame were built in common housing (Fig. 2). Basic technical parameters of the prototype are presented in table 1.

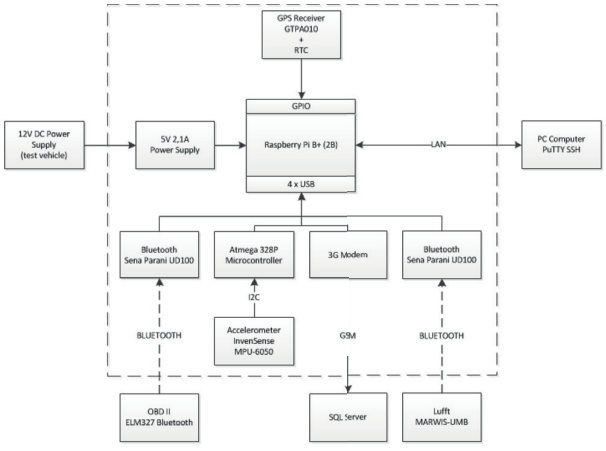

Fig. 1. Schematic diagram of the prototype hardware layer [own study]

Fig. 2. Picture of the prototype [own study]

Table 1. Prototype basic technical parameters

Parameter	Description
Housing length	190 [mm]
Length with antennas	215 [mm]
Housing width	150 [mm]
Housing height	75 [mm]
Housing mass	750 [g]
Input power voltage	12 [V]
Maximum power consumption	6 [W]
Connection socket	12V lighter socket plug

Due to the use of Raspberry Pi minicomputer, the measuring system has the ability to communicate by one of following standards: RS485, USB, Bluetooth and Ethernet Base-T. In the described prototype not all protocols are used, however their existence can allow a development of the system in future. Thanks to the use of OBDII diagnostic system interface, data acquisition for vehicle CAN bus is possible. A GPS receiver was connected to one general input/output in Raspberry Pi minicomputer. Because Raspberry Pi does not have a built-in real-time clock, such clock was integrated with the GPS receiver. An accelerometer designed by APM PRO sp. z o. o. is used for acceleration measurement. It uses the INVENSENSE MPU-6050 module and Atmega 328P micro controller, which connect via I2C protocol. Communication with the OBDII diagnostic interface and the mobile road conditions sensor is done via Bluetooth wireless interface. The prototype uses SENA PARANI-UD100 device which allows data transmission at distance of 300m. The prototype was also equipped in 3G modem that allows the use of fast 3G internet. Due to such solution prototype's effective communication with data base installed on external servers is possible. Prototype is powered by a car's lighter socket plug. The housing has a feeder equipped in two USB A sockets with output parameters: nominal voltage - 5V DC, maximum summary current intensity - 2.1A. These parameters provide power for the Raspberry Pi microcomputer with all built-in peripherals. Additionally, the prototype has a separate car lighter socket plug for connecting the MARWIS sensor. Such solution allows to supply the whole system from a single lighter socket.

In order to provide proper work for the accelerometer, a level line was installed on the outer housing (Fig. 2) that allows to level the prototype. Additionally a sticker was placed on the prototype, informing about the in-vehicle prototype placement that would ensure the correctness of the vehicle linear and crosswise accelerations.

Also a small ThePiHut USB hub was installed in the prototype. It is equipped in seven ports to which one can connect any device in USB 1.1 or 2.0 standard. Hub is dedicated to work with Raspberry Pi minicomputer. The use of an external memory in the form of a Pendrive was predicted. It is designed to gather and preserve data for their temporary archiving in case of any communication errors with the external server.

4. The recording system software, data processing and export

In order to reach full system functionality, the prototype has installed author software that uses libraries available under free of charge licence. Software is started from the central unit level managed by the Raspbian 7 system, part of the Linux systems family. This operating system was implemented with a configuration script that allows to control of software in the form of scripts:

1. to manage measurement data recording,
2. to process recorded data, including coordinates correction,
3. responsible for data export to the external database systems.

As part of software for measurement data recording scripts were installed for following devices:

- vehicle CAN bus with use of Bluetooth 2.0 wireless data transmission interface; software for reading OBD II engine diagnostic system data and selecting in real time information regarding spot speed and ambient air temperature,
- MARWIS Mobile system for recording road weather conditions, also with the use of Bluetooth 2.0 wireless data transmission interface; software uses manufacturer's data transmission protocol UMB 1.0, allowing at the same time to set the read frequency,
- GPS receiver that communicates with central unit via serial transmission,
- triaxial accelerometer, also communicating with the central unit via serial communication with the simultaneous guarantee of higher read frequency than for other devices.

Also local archiving was performed as part of each script. Data are stored until they are successfully sent to the external server. Fig. 3 presents a basic algorithm block scheme according to which data downloading applications work.

Software for recorded data processing, including coordinates correction, covers:

- software which performs averaging of acceleration measurement values for each axis as part of analysed time windows for road conditions recording set by the frequency of this status read,
- software that realizes correction algorithms - implemented measurement system that uses data from CAN bus and from accelerometer allows a higher resolution and precision in positioning measurements done by the mobile system for recording road weather conditions; position correction algorithms incorporate three basic cases:
- vehicle correction from GPS in case the vehicle is in stop,
- increase of resolution of location in the road surface condition parameters in case of continuity of the GPS signal in traffic, including acquisition of information about road grade line inclination, height difference between following measurements and air temperature necessary for implementing development works of other systems for short term weather forecast,
- securing information about location of the road conditions measurement result in case of losing a GPS signal.

The last implemented group of software are scripts responsible for integrating all measurement data and their export to external systems. Created scripts allow to send data to database system of the Multimodal Traffic Monitoring System (MTMS) and SmartView [3] database software. The MTMS platform is product of APM PRO sp. z o.o., whereas SmartView belongs to Lufft - the manufacturer of MARWIS [4] sensor. Implemented algorithms ensure data stability and their synchronisation on the driver-database level. Data buffer mechanism is also an important element. It is very important if there is a loss of communication with the Internet. Data safety is guaranteed by the private VPN network used with OpenVPN software.

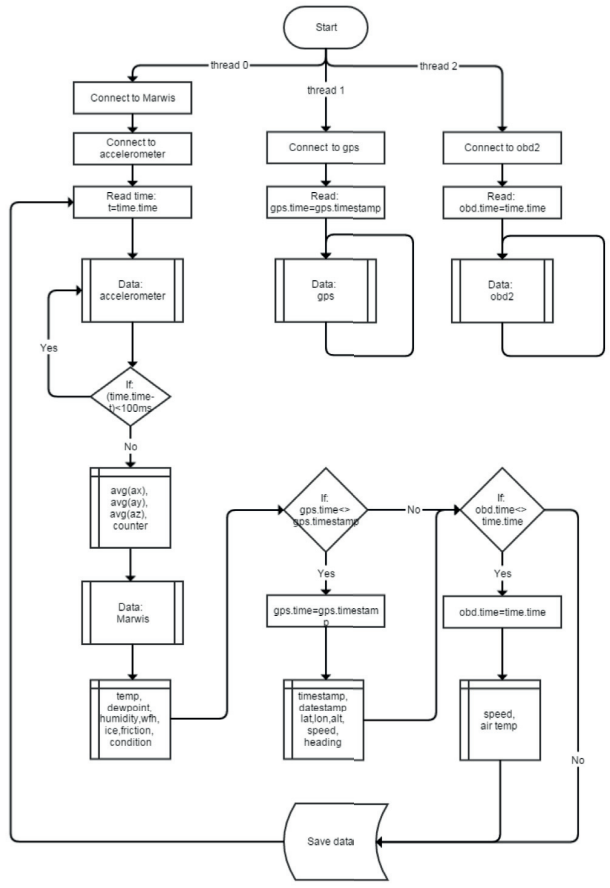

Fig. 3. Basic block diagram of the data acquisition algorithm [own study]

5. Database

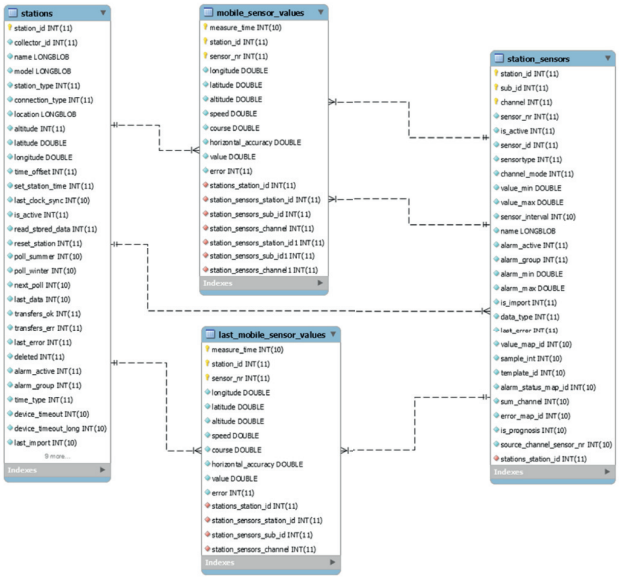

Fig. 4. The EER database collector model [own study]

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Because the presented prototype was created with help of the APM PRO sp. z o. o., it was adapted to communicate with database used by this company. Therefore, in order to ensure compatibility with products offered by the APM PRO, that is the MTMS platform and the SmartView application, two independent databases were created. The first one, named collector, is a representation of the SmartView application structure, where the second one - OnDynamic - guaranties coherence with the MTMS. Fig. 4 presents a model of the collector EER database model.

The system was also equipped with mechanisms that trigger data directly to the external systems and data correctness algorithms. Additionally, as part of the system, a cyclic removal procedure of data older than a given time interval was implemented. Data removal mechanism has also the ability to save archive data to CSV file.

6. Conclusion

Currently the prototype undergoes testing by APM PRO sp. z o. o. As part of tests a number of passages was done with vehicles equipped in the discussed prototype – Fig. 5. On the basis of collected data, an analysis is being conducted regarding the improvement of the system, mainly ensuring a proper reliability in regard to the communication between particular system elements.

Fig. 5. Test vehicle equipped in system prototype [own study]

The authors of the prototype hope that the final product will find its use both in winter maintenance units and in private transport companies. Integration of mobile road condition units with track parameters recording system allows to gather current information about the road surface. This information can be helpful for road administration and can be a valuable guide for all drivers, thus contributing to traffic safety improvement. Access to data acquired by the system could be allowed via public internet applications. Currently talks are held regarding commercialization of the prototype on the Polish, German, English and American market.

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