Transactions of the VŠB – Technical University of Ostrava, Mechanical Series
No. 1, 2015, vol. LXI
article No. 1993

Marián HRUBOŠ[*], Tomáš MRAVEC[**], Emília BUBENÍKOVÁ[***]

IMPLEMENTATION OF RFID DATA INTO TRAFFIC FLOW MONITORING SYSTEM

IMPLEMENTÁCIA RFID DÁT DO SYSTÉMU NA MONITOROVANIE DOPRAVNÉHO TOKU

Abstract

This paper describes the implementation of data obtained from RFID tags in the system for monitoring traffic flow. This approach uses a data fusion from camera systems (classically used for video detection, segmental measurement and so on) and RFID reader. The disadvantage of classic cameras systems for measuring speed is the need of good visibility. This problem can be eliminated by the merger of data from the camera system and other identifiers, which can be obtained from the car. Today, RFID tags are used for convenience of transport and for the identification of parts in the production of automobiles. Therefore, we decided to use as other identifying information processed data from some RFID tags placed in the structural parts of the car. Subsequently, we can use data fusion for accurate and relevant identification of the vehicle during bad weather. Subsequently, these data can be used in transport applications as is the estimation of the travel time.

Abstrakt

Táto práca sa zaoberá implementáciou dát získaných z RFID tagov do systému na monitorovanie dopravného toku. Tento prístup využíva fúziu dát z kamerových systémov, klasicky používaných na video detekciu, úsekové meranie rýchlosti a pod. a čítačky RFID tagov. Nevýhodou klasického kamerového merania úsekovej rýchlosti je nutnosť dobrej viditeľnosti, kvôli kamerám. Tento problém je možné odstrániť fúziou dát z kamerového systému a ďalších identifikačných údajov, ktoré je možné získať z automobilu. V súčasnej dobe sa používajú RFID tagy pre zjednodušenie transportu a identifikácie jednotlivých častí automobilov vo výrobe. Preto sme sa rozhodli použiť ako ďalší identifikačný údaj práve spracované údaje z niektorých RFID tagov umiestnených v konštrukčných častiach automobilu. Následne fúziou dát dosiahneme presnejšiu a relevantnejšu identifikáciu prechádzajúceho vozidla aj v prípade zlého počasia. Následne je tieto údaje možné použiť v dopravných aplikáciách určených napr. na odhad času potrebného na prekonanie danej vzdialenosti.

Keywords

RFID, localization, traffic flow, camera.

[*] Ing. PhD., Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic, tel. +421 41 513 3351, e-mail marian.hrubos@fel.uniza.sk

[**] Ing., Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic, tel. +421 41 513 3309, e-mail tomas.mravec@fel.uniza.sk

[***] Ing. PhD., Department of Control and Information Systems, Faculty of Electrical Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic, tel. +421 41 513 3344, e-mail emilia.bubenikova@fel.uniza.sk

1 INTRODUCTION

In recent years automatic identification procedures (Auto-ID) have become very popular in many service industries, purchasing and distribution logistics, industry, manufacturing companies and material flow systems. Automatic identification procedures exist to provide information about people, animals, goods and products in transit. Inductively coupled RFID (Radio Frequency Identification) systems are being used for marking of goods, animals, for electronic access control systems to building, train and bus tickets etc. [1].

In railways, the unified European train security and control system, the ETCS (European Train Control System) is used. The ETCS will facilitate interoperable cross-border traffic and improve the competitiveness of railways by implementing the latest train control technology. One of the main subsystems is Eurobalise, which is based on the principle of RFID. The power supply to the system is taken from a passing traction unit by inductive coupling at the ISM frequency 27.115 MHz. Data is transferred to the tractive unit at 4.24 MHz, and the system is designed to reliably read the data telegram at train speeds of up to 500 km/h [1], [4].

2 RECEIVED SIGNAL STRENGTH (RSS)

RSS-based ranging techniques rely on the fact that the strength of radio signal diminishes during propagation. As a result, the understanding of radio attenuation helps to map signal strength to distance. Let P_r denote the received power at distance *d*. The value of *Pr* follows the Friis equation [2]:

$$P_r = P_t \left(\frac{\lambda}{4\pi d} \right)^{\eta} G_t G_r, \qquad (1)$$

where *Pt* is the transmitted power, *Gt* and *Gr* are the antenna gain of the transmitting and receiving antennas, respectively, λ is the wavelength of the transmitter signal in meters and η is the path loss coefficient, typically ranging from 2 to 6 depending on the environment. In ideal free space is η=2.

Depending on the use given to the RSSI values to estimate locations, two main approaches can be distinguished:

“fingerprinting”, where a pre-recorded radio map of the area of interest is leveraged to estimate locations through best matching,

“propagation based”, in which RSS is employed to estimate distances computing the path loss.

The methods that use the signal propagation in an environment that is not available (see it), it can reach up to 50% of the error as a result of reflections, reflection, or absorption. [3].

3 MEASUREMENT OF THE ANTENNAA

The proposed RFID system works on frequency 868 MHz (UHF band). The geometrical distribution of the elements in the area of measuring the radiation characteristics is shown in Fig.1 As a RFID reader antenna has been used Motorola AN400 RFID and as a tag reader was used Motorola FX7400.

Motorola AN400 is RFID antenna. The AN400 antenna offers a new level of operational efficiency in areas previously too large to accommodate RFID technology. Its wide read field and high-speed RF signal conversion allows fast and accurate communication of EPC-compliant passive tag data. The high-performance area antennas are easy to mount on ceilings and walls to create superior read zones around shelves, doorways and dock doors – anywhere boxes and pallets are moving into and out of a facility [5].

Antenna characteristics [6]:

- Dimensions: 71.7 cm L x 31.7 cm W x 3.8 cm D,
- Casing: Aluminum with polycarbonate cover,
- Polarization: Two circular polarized patch array,
- Connectors: 2 type “N” female connectors,
- Isolation: -37 dB.

Motorola FX7400. The Motorola FX7400 RFID reader sets a new standard in design for indoor customer-facing and carpeted environments — packing best-in-class RFID features into a sleek, attractive form factor that is less than half the size of a typical fixed industrial RFID reader. With a low profile and impressive array of integrated features and functionality, the FX7400 makes RFID cost-effective for business class applications such as item-level inventory management, IT asset management and more. The FX7400 is easy to mount and manage. The reader simply snaps into the supplied bracket. Deployment is automated with ShowCase II, Motorola’s new remote configuration and management tool [7].

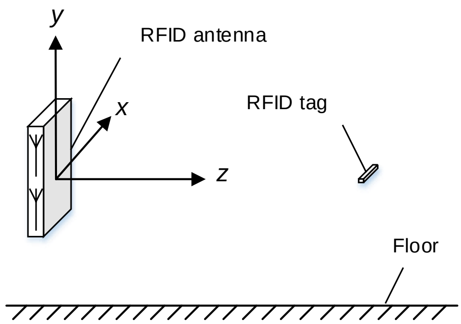

Fig. 1 Geometric layout of elements in the area for measuring radiation pattern

The measurement of the antenna radiation characteristics by Fig.1 it was done for all directions *x*, *y*, *z*.

The resulting measured radiation characteristic in *x* direction (for y=0 and z=0.5 m) has been approximated using a polynomial curve of the fourth order (Fig. 2 left):

$$f_x = p_4 x^4 + p_3 x^3 + p_2 x^2 + p_1 x + p_0, \qquad (2)$$

where p_4=1115, p_3=41.04, p_2= -262.6, p_1= -16.44 a p_0= -39.88.

The resulting measured radiation characteristic in *y* direction (for x=0 and z=0.5m) has been approximated using a Gaussian curve of the third order (Fig. 2 right):

$$f_y = a_1 e^{-\left(\frac{(y-b_1)}{c_1}\right)^2} + a_2 e^{-\left(\frac{(y-b_2)}{c_2}\right)^2} + a_3 e^{-\left(\frac{(y-b_3)}{c_3}\right)^2}, \qquad (3)$$

where a_1= -47.95, b_1=-0.6522, c_1=0.4278, a_2= -8.741, b_2= -0.05447, c_2=0.1356 a a_3= -56.31, b_3=0.787, c_3=1.025.

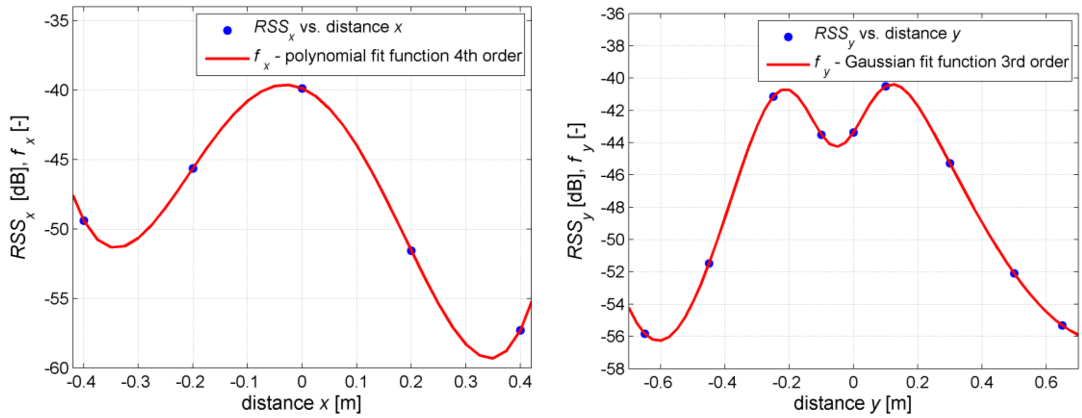

Fig. 2 Polynomial fit function of f_x (left), Gaussian fit function of f_z (right)

The resulting measured radiation characteristic in z direction (for x=0 and y=0m) has been approximated using a Gaussian curve of the third order (Fig. 3 left):

$$f_z = a_1 e^{-\left(\frac{(z-b_1)}{c_1}\right)^2} + a_2 e^{-\left(\frac{(z-b_2)}{c_2}\right)^2} + a_3 e^{-\left(\frac{(z-b_3)}{c_3}\right)^2}, \tag{4}$$

where a_1= -49.28, b_1= 2.84, c_1= 3.792, a_2= -10.09, b_2= 0.9032, c_2= 1.026 a a_3= -7.724.10^{14}, b_3= 9.562, c_3= 1.329.

Under the conditions, we measured the maximum reading distance of the RFID tag for used gain 20 dB. RFID reader has maximum gain 29 dB, so the maximum reading distance can be increased if is necessary.

The measured values were approximated by individual curves f_x and f_y. Thus, we have obtained the missing values and we could get the 3D graph f_{xy}, which describes the spatial radiation characteristics of antenna (Fig. 3 right).

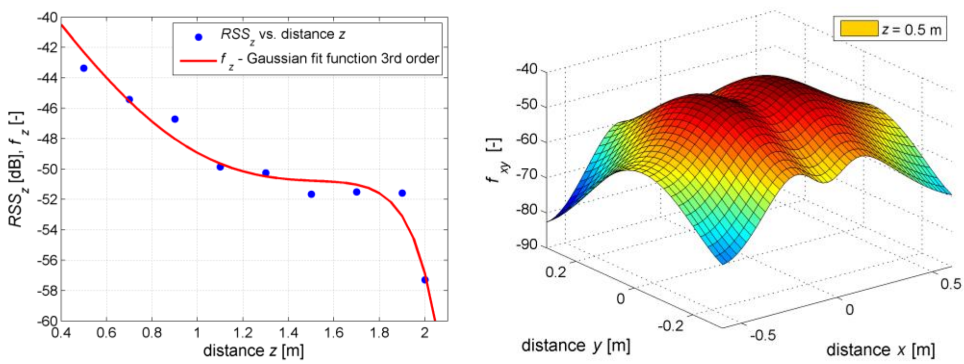

Fig. 3 Gaussian fit function of f_z (left), 3D graph of f_{xy} (right)

4 PRACTICAL IMPLEMENTATION

Based on the findings from individual measurements and knowledge of the use of video detection, we propose the use of RFID tags for measure estimate the time necessary to overcome the distance arrangement of the following devices (Fig. 4). Location accuracy can be increased by using multiple RFID antennas (in our proposal involves two antennas for each direction). It allows locating the RFID tag placed in the car using the Friis equation (1). In the case of moving vehicles each identified by a RFID tag will be moved from one measuring position to the second (from the pole A to pole B). Vehicle speed we are able to calculate from the known distance between the measuring positions and time of travel the vehicle.

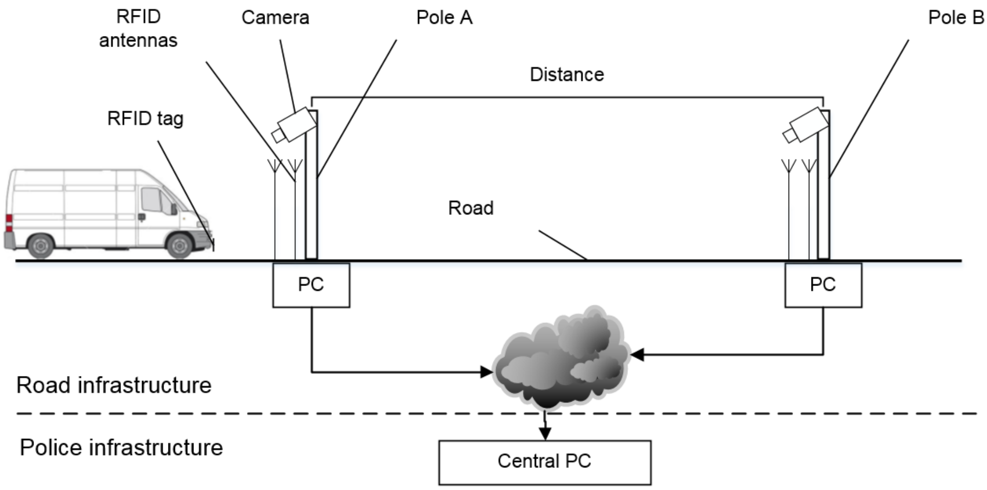

Fig. 4 Principal system schematic

A block diagram of the proposed application (Fig. 5) uses data fusion of RFID readers and camera system for detecting vehicle registration plate. Users of the system can access the data after processing and storing data. Users can be - police (penalties for speed limit), the statistical office (static data on the number of vehicles that passed section, etc.) or users via WEB interface (monitoring congestion, travel time, ...).

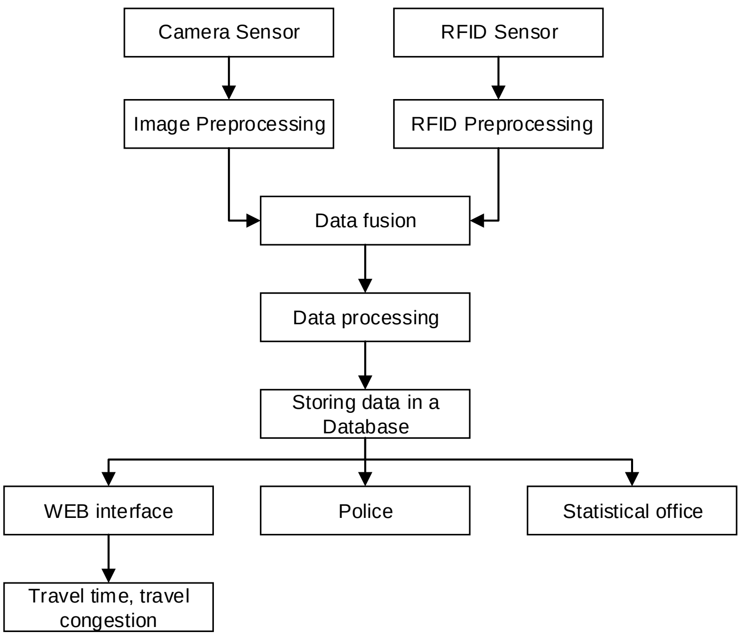

Fig. 5 Block diagram of the proposed application

5 CONCLUSIONS

In this paper we focused to the possible use of RFID tags intended for transport applications (eg. for the measurement of selected parameters of traffic flow) using data that can be stored, respectively retrieved from RFID tags (embedded in the vehicle during production or subsequently) in conjunction with the video detection. Video motion detection is technique currently used to measure the car speed. This extension will increase the accuracy of detection of the vehicle even in bad weather conditions (poor visibility in the case of snowfall, heavy rain) in which conventional camera systems have less ability to detect vehicles.

ACKNOWLEDGMENT

This work has been supported by the Cultural and Educational Grant Agency of the Slovak Republic (KEGA) Number: 008ŽU-4/2015: “Innovation of HW and SW tools and methods of laboratory education focused on safety aspects of ICT within safety critical applications of processes control”.

REFERENCES

[1] FINKENZELLER, K: RFID Handbook Fundamentals and Applications in Contactless Smart Cards, Radio Frequency Identification and Near-Field Communication, Third Edition. John Wiley and Sons, Ltd. Chichester, UK, 2010, ISBN 978-0-470-69506-7. http://dx.doi.org/10.1002/9780470665121

[2] SYED A. AHSON, MOHAMMAD ILYAS.: Location-Based Services Handbook: Applications, Technologies and Security. CRC Press, 2011. 313 pages. ISBN 978-1-4200-7198-6.

[3] YUNHAO LIU, ZHENG YANG: Location, Localization, and Localizability: Location-awareness Technology for Wireless Networks. Springer Science+Business Media, LLC 2011. 154 pages. ISBN 978-1-4419-7371-9.

[4] RFID made easy. Application note AN411, EM Microelectronic-Marin SA. Marin, Switzerland, 2002. [online] http://www.emmicroelectronic.com/webfiles/product/rfid/an/an411.pdf

[5] https://www.zebra.com/us/en/products/rfid/rfid-reader-antennas/an400.html#mainpartabscontainer=support-downloads

[6] RFID Antenna Family, [online] URL http://www.barcodesinc.com/pdf/Motorola/rfid-antennas.pdf

[7] MOTOROLA FX7400, [online] URL http://www.barcodesinc.com/pdf/Motorola/fx7400.pdf