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Mobile applications for driver and pedestrian assistance

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Abstract — **In this paper two applications, which fit into the current trend of the development of mobile devices, are described. The first is designed for the driver and the second for the pedestrian assistance. Two traffic events like traffic lights change from the red to the green and vehicle approaching to pedestrian are detected. Proper warnings are generated and the suitable reaction is performed. The car may start movement without unnecessary delay and the pedestrian may change the movement trajectory in order to avoid an accident. Thus, the proper traffic flow and urban safety improvement are supported. Results of initial experiments show a high efficiency of proposed mobile solutions.**

Keywords — mobile applications; driver assistance systems; pedestrian assistance systems; vision systems; video processing

I. INTRODUCTION

Nowadays, mobile devices are used in many areas of human life. Among them, there are two groups of applications: designed for driver and for pedestrian assistance. Mobile systems for these two target groups include navigation and health monitoring. Optimization of fuel consumption and detection of road hazards are reserved for vehicles equipment.

Drivers are navigated using system which is accompanied with parking assistance functionality [1]. It provides information about available parking spaces. Mobile software is used for car detection and tracking [2] and obstacles detection [3]. It improves the road safety. Collision and lane departure warning systems are other examples of vision-based driving assistants [4]. The presence and density of fog are detected using mobile platform [5]. In this case, the visibility distance and recommended safe speed are calculated. Detection of speed limits signs and warning the driver about exceeding are implemented in system described in [6].

The eco-driving assistant assesses the efficiency of driving style [7]. Data are acquired via diagnostic port of vehicle and sensors of mobile device. The other method of reduction of fuel consumption is based on detection of traffic signs. It gives to the driver advices about the required deceleration [8]. There is an application which helps amateur drivers with gear changing based on car engine parameters from on board diagnostics [9]. It also provides the assistance in case of vehicle breakdown.

It is possible to monitor and detect of the fatigue, the phone, drunk, high fever, and angry while driving [10]. The system which detects and alerts of typical drunk driving maneuvers performed by the driver is presented in [11]. It is based on accelerometer and orientation sensor of Android mobile phone. Application for monitoring of driver's health is based on sensors located in the vehicle and on the body [12].

Pedestrian are aided by the navigation system which guides them by giving instructions in order to reach the correct destination [1]. Information from Internet about tourist attractions and recommendations are also provided [13]. There is an mobile system designed especially for navigation in indoor environment [14]. It utilized various sensors and map data. As example the barometric sensor is used for recognition of floor. The system described in [15] provides pedestrian tracking. It classified the gait to walking, jogging, or running type and may be used for estimation of walking distance in healthcare and guide applications.

Examples of systems, discussed above, have already been implemented in mobile versions. Some applications for driver and pedestrian assistance are still implemented and tested only in versions on desktop computers. Implementation of traffic lights detection on PC is described in [16] and in [17]. Advanced methods of vehicle detection and tracking are presented in [18] and in [19].

The authors proposed the analysis of video sequences in order to improve urban traffic [20]. Their first approach to system for driver assistance was presented in [21] and for pedestrian assistance in [22]. Tests were performed in Matlab programming environment. The PAS abbreviation for pedestrian assistance systems was proposed in order to distinguish them from DAS (driver assistance systems) [23]. Similarly, it is quite possible that in future cyclist assistant systems (CAS) will also be introduced. Moreover, there is another application of mobile devices equipped in camera. Smartphones may collect data about threat events and provide it to the database of emergency notification system as additionally information source [24, 25]. It may facilitate to send the appropriate rescue unit.

In this article, the authors propose the driver and pedestrian assistance systems implemented on mobile device, more precisely smartphone equipped with Android operating system. After an introduction in this section of a paper, the concept and implementation of proposed mobile assistance systems are described in Section 2. In Section 3 the experimental results are presented. Final remarks are formulated in the last section, Section 4.

II. Concept and Implementation

The general idea of proposed approach to mobile assistance systems is presented in Fig. 1.

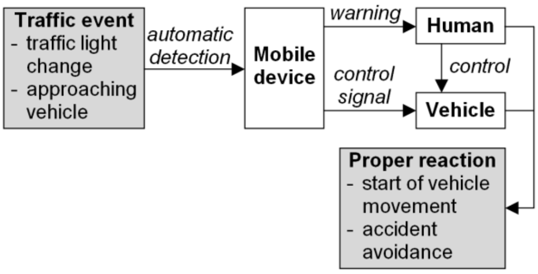

Figure 1. General idea of proposed mobile assistance systems

Each of presented mobile systems automatically detects a traffic event which occurs. It may be a change of traffic lights from the red to the green for the car which is located stationary before the intersection or a vehicle approaching to a pedestrian in an unsafe manner. These events are important for the proper traffic flow and urban safety. The driver or pedestrian is warned by the alert of mobile device. In case of traffic lights change a control signal may be also transmitted to an onboard car equipment. This may be important especially for vehicles equipped with start and stop systems which can be pre-prepared for starting. Finally, the proper reaction is performed. The car driven by human may start movement without unnecessary delay. The pedestrian may change the movement trajectory in order to avoid an accident.

Techniques implemented by the authors on mobile devices are an enhanced version of systems presented in [21, 22]. They use algorithms modified in order to ensure a greater effectiveness.

A. Traffic lights changes detection

Figure 2 illustrates an improved algorithm scheme for proposed mobile system which detects traffic light changes from the red to the green. It informs and reminds the driver about possibility of movement. The car equipment may be ready for start earlier than without use of such system.

In the first step of the algorithm the frame is loading. Then, the image is transformed to the HSV color space. In the next step the gaussian filter is used. This part of algorithm did not occur in [21] and is added because it allows to reduce the noise and unnecessary details.

Recognition of circles is based on binarization with taking into account thresholds for the red light and then, for the green light [21]. Circles are detected using the Hough transform. Then, there is a verification if in a previous instance of the loop the red light was detected. If so, the program checks whether the green light was detected.

Then, the algorithm determines whether the circle corresponding to the green light belongs to the same indicator that the red circle. This operation is a significant improvement in comparison to the method presented in [21]. Implementation mentioned in the introduction ([16, 17]) included conditions based on proportion of lentgh to width and area of the trafic lights in order to extract the traffic lights from the environment.

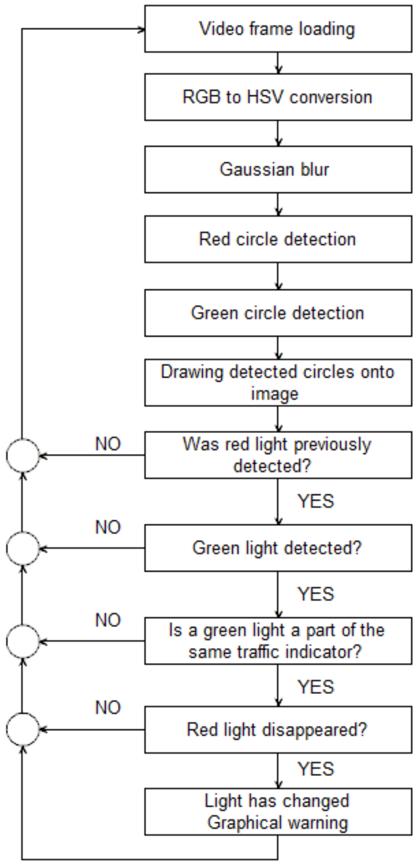

Figure 2. Block diagram of traffic light changes warning system

In this step of the algorithm, the authors focus on conditions for searching the second light (the green) of the same indicator object. It will be described based on the typical indicator, which is illustrated in Fig. 3.

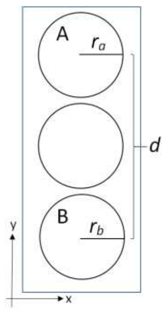

Figure 3. Typical indicator with the red light (A) and the green light (B)

The circle A corresponds to the red light and the circle B corresponds to the green light. Coordinates of the center of the circle A are x_a and y_a, and the center of the circle B are x_b and

y_b. The radius of the cirle A is r_a and the radius of the circle B is r_b. The distance d between centers of these circles must meet the following conditions:

$$c_1 \frac{r_a + r_b}{2} < d < c_2 \frac{r_a + r_b}{2}. \quad (1)$$

Values of coefficients c_1=2 and c_2=5 were chosen experimentally. They determine the distance between centers of circles in relation to their radii. When checking this condition, we take into account the average of the radii of circles corresponding to the red and to the green light. In theory, the circles radii should be identical, but there is a possible difference between the size of the detected circles in an image. This is due to geometrical distortions of an image recorded by camera, what is illustrated in Fig. 4.

Figure 4. Illustrative geometrical distortions in an indicator image

There are additional, experimentally proved, conditions that must be met in order to determine whether the green light is the part of the same indicator as the red light. They are referred to the coordinates of the center of the green light circle as follows:

$$y_b < y_a \quad (2)$$

and

$$x_a - \frac{r_a + r_b}{2} < x_b < x_a + \frac{r_a + r_b}{2}. \quad (3)$$

The last step of the algorithm, which allows automatically determine the change of the light, checks if a red circle, which was detected earlier, disappeared. The program checks whether the current video frame contains a red light circle in the location of the red light previously detected. Coordinates of the previously detected circle are equal to x_1 and y_1, and the circle that is detected in the current image frame are x_2 and y_2. Radii of these circles are r_1 and r_2, respectively. An alarm is activated if the red light circle is not detected in the current frame or if the red light circle is detected in the current frame but it does not meet the following conditions:

$$x_1 - 0.5r_1 < x_2 < x_1 + 0.5r_1, \quad (4)$$

$$y_1 - 0.5r_1 < y_2 < y_1 + 0.5r_1, \quad (5)$$

and

$$r_1 - 0.5r_1 < r_2 < r_1 + 0.5r_1. \quad (6)$$

Value of the tolerance criterion, equal to 0.5, was chosen experimentally.

B. Approaching vehicles detection

Figure 5 presents an algorithm scheme of the system which detects vehicles approaching to pedestrians and warns about the threat.

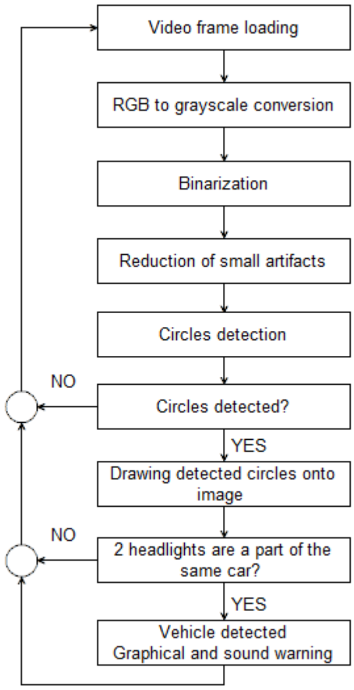

Figure 5. Block diagram of approaching vehicle warning system

As it was mentioned before, advanced methods of vehicle detection and tracking, described in [18] and in [19] were implemented mostly on PCs. The authors of this paper executed all the steps of algorithm on mobile device and focus on the rapid detection, on a single video frame, in emergency situation.

The detection of car lights starts with an acquisition of image from a smartphone camera. Then, colors are converted to grayscale levels. After mentioned initial part of the image processing algorithm, the binarization specifies locations of light sources corresponding to vehicle headlights. Binarization threshold value (254 if maximal possible value is 255) was determined experimentally in order to detect light sources which are the brightest points of image. At the next stage, the small artifacts are removed using filtration, in order to reduce the noise and unnecessary details as a step which did not exist in [22].

After the extraction of light sources from the image, the circles corresponding to headlights are detected. For this purpose, the Hough transform is used. Founded circles are drawing onto image. Headlights are detected if two circles are found and, additionally, in comparison to the algorithm described in [22], the following geometrical conditions must be met:

$$y_l - 0.1h_l < y_r < y_l + 0.1h_l, \quad (7)$$

where:

- y_r is the vertical coordinate of the center of the right car headlight,
- y_l is the vertical coordinate of the center of the left car headlight,
- h_l is a an image vertical resolution,
- 0.1 is a value of the tolerance criterion, which was chosen experimentally.

As the end of execution of the algorithm, the graphical and sound warning about approaching vehicle is generated.

III. EXPERIMENTAL RESULTS

Experiments on proposed systems were conducted by the authors using smartphones with Android as an operating environment.

A. *Traffic lights changes detection*

Application for detection was tested on 63 situations of traffic lights changes. Illustrative display of smartphone with running application is presented in Fig. 6.

Figure 6. Screenshot from smartphone display while the application detects traffic ligths change

Each processed video sequence contained one change of a light on indicator, from the red to the green. Various weather conditions were recorded: sunny day, medium cloudy day, mostly cloudy day and night. Results of this experiment are presented in Tab. 1.

The mean detection rate is almost 80%. Thus, it is an important improvement in comparison to 50% obtained in [21]. However, the following problems with detection were observed:

- in improper light conditions (weak distinctness) the vertical road sign was detected as the green light,
- the sky was sometimes detected as the green light but, in most cases, conditions related to the indicator geometry caused exclusion of incorrect detections of the green light,
- at night, due to weak parameters of the camera of mobile device (too bright and a big noise) it was difficult to distinguish colors of lights, which affected on the low effectiveness,
- the color of the light was sometimes wrongly detected because of poorly visible color on indicator or improperly adjusted automatic white balance on camera.

TABLE I. RESULTS OF EXPERIMENT CONDUCTED ON MOBILE APPLICATION FOR DETECTION OF TRAFFIC LIGHTS CHANGES

Weather conditions	**Number of traffic lights changes (*LC*)**	**Number of detected traffic lights changes (*DLC*)**	**Correctly detected traffic lights changes**		**Incorrectly detected traffic lights changes**	
			Number (*CD*)	***CD*/*LC* [%]**	**Number (*ICD*)**	***ICD*/*DLC* [%]**
Sunny	27	26	20	74.07	6	23,08
Mostly cloudy	12	11	8	66.67	3	27,27
Medium cloudy	13	16	12	92.31	4	25,00
Night	11	19	9	81.82	10	52,63
Total	**63**	**72**	**49**	**77.78**	**23**	**31,94**

B. *Approaching vehicles detection*

Application for detection of approaching vehicles was tested on 39 situations of vehicles approaching to pedestrian. Illustrative display of smartphone with running application is presented in Fig. 7.

Figure 7. Illustrative screenshot from smartphone display while the application detects headlight of approaching vehicle

The current results for our mobile application, presented in Fig. 8, show that the effectiveness of detection is almost 90%. This value is slightly better than described in [23], where tests were performed on a desktop computer in Matlab programming environment.

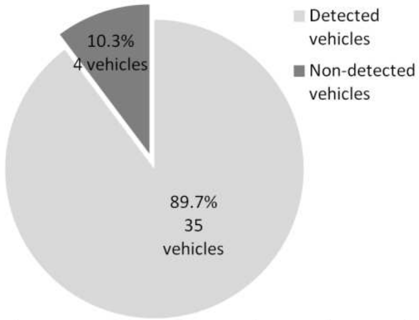

Figure 8. Display of smartphone while the application detects traffic ligths change

Problems with detection were caused by:

- the lower effectiveness in the full sun due to a lower contrast between traffic lights and environment,
- some other lights with quasi-circular shapes, like street lamps may be sometimes detected.

IV. CONCLUDING REMARKS

The authors proposed mobile applications that support the driver and pedestrian in order to improve traffic and ensure urban safety. Immediate detection of green light will increase the capacity of junctions. Pedestrians, warned about oncoming vehicles, will be able to leave the collision way in the safe manner. Techniques fit into the current trend of the development of mobile devices. Conducted experiments have shown a high effectiveness of proposed solutions. The next step will be based on improvements in detection algorithms in order to reduce the level of false detections. For this purpose, the authors plan to conduct many tests in different lighting and weather conditions that will allow to better adjust the parameters of the algorithm.

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REFERENCES

[1] T.S. Chou, I. Ku, C.H. Wu, L.C. Hsu, Y.S. Lin, Y.T. Chen, T.Y. Huang, C.T. King, "CaNPAs: A Campus Navigation and Parking Assistant System", IEEE International Conference on Systems, Man and Cybernetics, SMC, 8–11 Oct. 2006, Vol. 1, pp. 631–638.

[2] A. Acharya, J. Lee, A. Chen, "Real Time Car Detection and Tracking in Mobile Devices", International Conference on Connected Vehicles and Expo (ICCVE), 12–16 Dec. 2012, pp. 239–240.

[3] R. Itu, R. Danescu, "An efficient obstacle awareness application for Android mobile devices", IEEE International Conference on Intelligent Computer Communication and Processing (ICCP), 4–6 Sept. 2014, pp. 157–163.

[4] J. Pangyu, A.V. Vesa, A. Rarau, S. Nedevschi, "Real-time driving assistant application for Android-based mobile devices", IEEE International Conference on Intelligent Computer Communication and Processing (ICCP), 4–6 Sept. 2014, pp. 205–210.

[5] M. Negru, V. Benea, S. Nedevschi, "Fog assistance on smart mobile devices", IEEE International Conference on Intelligent Computer Communication and Processing (ICCP), 4–6 Sept. 2014, pp. 197–204.

[6] C. Pritt, "Road sign detection on a smartphone for traffic safety", IEEE Applied Imagery Pattern Recognition Workshop (AIPR), 14–16 Oct. 2014, pp. 1–6.

[7] V. Corcoba Magana, M. Munoz-Organero, "Artemisa: An eco-driving assistant for Android Os", IEEE International Conference on Consumer Electronics – Berlin (ICCE-Berlin), 6–8 Sept. 2011, pp. 211–215.

[8] M. Munoz-Organero, V.C. Magana, "Validating the Impact on Reducing Fuel Consumption by Using an EcoDriving Assistant Based on Traffic Sign Detection and Optimal Deceleration Patterns", IEEE Transactions on Intelligent Transportation Systems, 2013, Vol. 14, Issue 2, pp. 1023–1028.

[9] A.V. Khanapuri, A. Shastri, G. D'souza, S. D'souza, "On road: A car assistant application", International Conference on Technologies for Sustainable Development (ICTSD), 4–6 Feb. 2015, pp. 1–7.

[10] L. Yueqi, Y. Chunlan, X. Xinyuan, "Study of wireless safety monitoring system for driver based on information fusion technology", IEEE International Conference on Vehicular Electronics and Safety (ICVES), 28–30 July 2013, pp. 23–26.

[11] D. Jiangpeng, T. Jin, B. Xiaole, S. Zhaohui, X. Dong, "Mobile phone based drunk driving detection", 4th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth), 22–25 March 2010, pp. 1–8.

[12] K. Rozanowski, Z. Piotrowski, M. Ciolek, "Mobile Application for Driver's Health Status Remote Monitoring", 9th International Wireless Communications and Mobile Computing Conference (IWCMC), 1–5 July 2013, pp. 1738–1743.

[13] A. Smirnov, A. Kashevnik, N. Shilov, N. Teslya, A. Shabaev, "Mobile application for guiding tourist activities: tourist assistant – TAIS", 16th Conference of Open Innovations Association (FRUCT16), 27–31 Oct. 2014, pp. 95–100.

[14] S. Beomju, L. Jung Ho, L. Hyunho, K. Eungyeong, K. Jeahun, L. Seok, C. Young-su, P. Sangjoon, L. Taikjin, "Indoor 3D pedestrian tracking algorithm based on PDR using smarthphone", 12th International Conference on Control, Automation and Systems (ICCAS), 17–21 Oct. 2012, pp. 1442–1445.

[15] M. Alzantot, M. Youssef, "UPTIME: Ubiquitous pedestrian tracking using mobile phones", IEEE Wireless Communications and Networking Conference (WCNC), 1–4 April 2012, pp. 3204–3209.

[16] Chunhe Yu, Chuan Huang, Yao Lang, "Traffic light detection during day and night conditions by a camera", IEEE 10th International Conference on Signal Processing (ICSP), 24–28 Oct. 2010, pp. 821–824.

[17] M. Diaz-Cabrera, P. Cerri, J. Sanchez-Medina, "Suspended traffic lights detection and distance estimation using color features", 15th International IEEE Conference on Intelligent Transportation Systems (ITSC), 16–19 Sept. 2012, pp. 1315–1320.

[18] I. Sina, A. Wibisono, A. Nurhadiyatna, B. Hardjono, W. Jatmiko, P. Mursanto, "Vehicle counting and speed measurement using headlight detection", International Conference on Advanced Computer Science and Information Systems (ICACSIS), 28–29 Sept. 2013, pp. 149–154.

[19] Q. Zou, H. Ling, S. Luo, Y. Huang, M. A. Tian, "Robust Nighttime Vehicle Detection by Tracking and Grouping Headlights", IEEE Transactions on Intelligent Transportation Systems, 2015, Vol. PP, Issue 99, pp. 1–12.

[20] J. Balcerek, A. Chmielewska, A. Dąbrowski, D. Jackowski, A. Konieczka, T. Marciniak, P. Pawłowski, "Recognition of threats in urban areas by means of the analysis of video sequences", Proc. of Multimedia Communications, Services and Security, MCSS 2010, IEEE International Conference, Kraków, 6–7 May 2010, pp. 41–48.

[21] J. Balcerek, A. Konieczka, T. Marciniak, A. Dąbrowski, K. Maćkowiak, K. Piniarski, "Automatic detection of traffic lights changes from red to green and car turn signals in order to improve urban traffic", Proc. of Signal Processing: Algorithms, Architectures, Arrangements and Applications SPA'2014, IEEE Poland Section Chapters Signal Processing, Circuits and Systems, Poznań, Poland, 22–24 September 2014, pp. 110–115.

[22] J. Balcerek, A. Konieczka, T. Marciniak, A. Dąbrowski, K. Maćkowiak, K. Piniarski, "Video processing approach for supporting pedestrians in vehicle detection", Proc. of Signal Processing: Algorithms,

Architectures, Arrangements and Applications SPA'2014, IEEE Poland Section Chapters Signal Processing, Circuits and Systems, Poznań, Poland, 22–24 September 2014, pp. 100–103.

[23] J. Balcerek, A. Konieczka, K. Piniarski, K. Maćkowiak, T. Marciniak, A. Dąbrowski, "Automatyczne systemy wizyjne usprawniające ruch drogowy i zwiększające bezpieczeństwo" ("Automatic vision systems for improvement of traffic efficiency and safety"), Elektronika – konstrukcje, technologie, zastosowania, no 4/2015, pp. 7−13.

[24] J. Balcerek, P. Pawłowski, A. Konieczka, S. Drgas, A. Dąbrowski, M. Kmieciak, "Database of emergency telephone calls – system tools for real-time registration and metadata searching", Proc. of Signal Processing SPA'2010, IEEE Poland Section Chapters Signal Processing, Circuits and Systems, Poznań, Poland, 23–25 September 2010, pp. 89–94.

[25] A. Dąbrowski, S. Drgas, P. Pawłowski, J. Balcerek, "Development of PUEPS corpus of emergency telephone conversations", Proc. of the Language Resources for Public Security Applications Workshop (LRPS 2012), 8th international conference on Language Resources and Evaluation (LREC 2012), Istanbul, Turkey, 27 May 2012, pp. 8–12.

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