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June 3-4, 2016

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3-4 JUNE 2016, BITOLA, R. MACEDONIA

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Welcome address and opening remarks

“Honorable Minister of Information Society and Administration of the Republic of Macedonia, honorable Vice-rector, distinguished members of the academic and research community, distinguished members of the business community, ladies and gentlemen:

It gives me great pleasure to extend to you all a very warm welcome on behalf of the Faculty of Information and Communication Technologies (FICT) at the 6th International Conference on “Applied Internet and Information Technologies” here in Bitola.

It is an appropriate time to renew contacts and discuss problems of mutual interest with colleagues from surrounding countries of the region and countries from (literally) Mexico in the west to Vietnam in the east. It is the year when the University in Bitola celebrates 1.100 years of the repose of our patron, St. Kliment Ohridski, and “1110 years” (binary) of computer science and information technologies in Bitola. Indeed, the Faculty of Information and Communication Technologies was founded by virtue of law in December, 2013, and by founding such a higher education unit, the University “St. Kliment Ohridski” – Bitola promotes a faculty completely focused on educating information professionals.

It is gratifying to note that the agenda of this year’s conference covers a wide range of very interesting topics relating to Information Systems, Communications and Computer Networks, Data and System Security, Embedded Systems and Robotics, Software Engineering and Applications, Electronic Commerce, Internet Marketing, Business Intelligence, and ICT Practice and Experience, with 50 papers by 113 authors from 12 different countries.

Right after the opening remarks, Prof. Vladimir Dimitrov from the Faculty of Mathematics and Informatics at the University of Sofia, Bulgaria, as well as Prof. Željko Stojanov from the Technical Faculty "Mihajlo Pupin" in Zrenjanin, Serbia, will give their keynote speeches toward formalization of software security issues and inductive approaches in software process assessment. Prof. Dimitrov is one of the key initiators of the Bulgarian segment of the European Grid and a member of the editorial board of IEEE IT Professional and Transactions on Cloud Computing. Similarly, Prof. Stojanov has participated in a handful of research and industrial projects and is a member of IEEE and the Association for Computing Machinery (ACM).

Nevertheless, no matter how much we can do by ourselves on the national or regional level, whether it be research or application, it is never enough. In a spirit of true cooperation, we in this region of the world, must join in an action-oriented effort to attack and solve the problems encompassing the economic, social, institutional and physical elements of development, in a wider sense!

Are Macedonia and Western Balkans moving towards their maturity as outsourcing destinations? That's why we've dedicated a whole day to outsourcing opportunities that exist in Macedonia and Western Balkans – what can we do to boost up outsourcing, how can we become outsourcing experts, overcome cultural differences, and use all that in our everyday work? Independent consultants, Mr. Richard Avery, Ms. Carola Copland and Ms. Nina Ugrinoska will share their mind-coaching techniques, their experience in nearly all areas of the strategic outsourcing lifecycle, and their real life stories and solutions provided.

Last but not least, we should have in mind that all these economic, social, institutional and physical elements of development are under the auspices of the Ministry of Information Society and Administration. Therefore, at the very beginning, after the welcoming note of our Vice-rector, Prof. Svetlana Nikoloska, I invite the Minister of Information Society and Administration of the Republic of Macedonia, Mrs. Marta Arsovska Tomovska, who was a featured speaker at the 22nd "Smart Government and Smart Cities" conference held in Dubai in May, 2016.

In concluding, as a Conference Chairman, I wish you every success in your deliberations and a very pleasant stay in the beautiful city of Bitola."

Conference Chairman,

Prof. Dr. Pece Mitrevski

Dean of the Faculty of Information and Communication Technologies – Bitola

CONTENT

Invited Speakers

Regular Papers

International Conference on Applied Internet and Information Technologies, 2016 DOI:10.20544/AIIT2016.31

Gesture Control of a Mobile Robot using Kinect Sensor

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Abstract. This paper describes a methodology for gesture control of a custom developed mobile robot, using body gestures and Microsoft Kinect sensor. The Microsoft Kinect sensor's ability is to track joint positions has been used in order to develop software application gestures recognition and their mapping into control commands. The proposed methodology has been experimentally evaluated. The results of the experimental evaluation, presented in the paper, showed that the proposed methodology is accurate and reliable and it could be used for mobile robot control in practical applications.

Keywords: Kinect sensor, gesture recognition, mobile robot, control, human-robot interaction.

1. Introduction

With the development of technology, robots are gradually entering our life. The applications are ranging from rehabilitation [1, 2], assisted living [3], education [4], housework assistance [5], to warfare applications [6]. Various applications require specific control strategies and controllers. Development of a myriad of low-cost sensing devices, even nowadays, makes remote control of robotics devices a topic of interest among researchers. In particular, gesture control of robotic devices with different complexity and degrees-of-freedom is still considered as a challenging task [7].

In this context, recently developed depth sensors, like Kinect sensor [8], have provided new opportunities for human-robot interaction. Kinect can recognize different gestures performed by a human operator, thus simplifying the interaction process. In this way, robots can be controlled easily and naturally. The key enabling technology is human body language understanding. The computer must first understand what a user is doing before it can respond [9, 10, 11].

The concept of gesture control to manipulate robots has been used in many research studies. Thanh et al. [12] developed a system in which human user can interact with the robot using body language. They used a semaphore communication method for controlling the iRobot to move up, down, to turn left or right. Waldherr et al. [13] describe a gesture interface for controlling a mobile robot equipped with a manipulator. They have developed an interface which uses a camera to track a person and recognize gestures involving arm motion. Luo et al. [14] use the Kinect sensor as motion capture device to directly control the arms by using the Cartesian impedance control to follow the human motion. Jacob and Wachs [15] have used hand's orientation and hand gestures to interact with a robot which uses the recognized pointing direction to define its goal on a map. Kim and Hong [16] have proposed a system intended to support natural interaction with autonomous robots in public places, such as museums and exhibition centers.

In this paper we have used Kinect sensor for a real-time mobile robot control. The developed application allows us to control the robot with a predefined set of a body gestures. The operator, standing in front of the Kinect, performs a particular gesture which is recognized by the system. The system then sends commands to the microcontroller Arduino Uno, which operates with the robot.

2. System architecture

The proposed system is composed of several components: operator, Microsoft Kinect sensor, mobile robot, computer, and mobile robot. The architecture of the system is shown in Figure 1.

Fig. 1. System architecture

To control the mobile robot user has to make some pre-defined gestures using its body. The Kinect sensor than captures the movement in real time and sends the skeleton joints' data to the computer via USB for processing. Application on the computer processes the information from the Kinect sensor converts them into control commands and sends them to the robot i.e. to the Arduino microcontroller via Bluetooth. Depending on the received command data the mobile robot is moving.

2.1. Microsoft Kinect sensor

Kinect sensor was introduced on the market in 2010 as a line of motion sensing input devices by Microsoft and was intended to be used with Xbox 360 console. It is a peripheral input device composed of several sensors. Namely, it contains a depth sensor, a RGB camera, and four-microphone array. The core component of Kinect is the range camera (originally developed by PrimeSense) which is using an infrared projector and camera and a special microchip to track objects in 3D. So, the sensor provides full-body 3D motion capture, facial recognition, and voice recognition capabilities. The internal structure (sensor components) and the architecture of Kinect for Windows are presented in Figure 2.

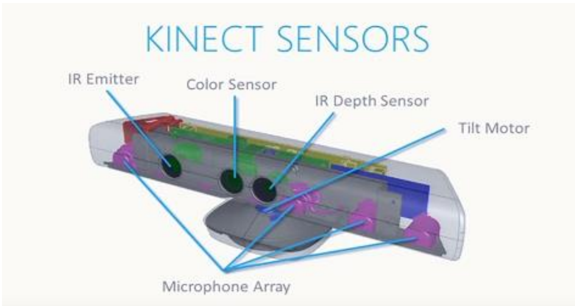

Fig. 2. Kinect Sensor internal structure

Capabilities of image and depth capturing, audio recording as well as its low cost make Kinect very popular input device for various applications. It allows users natural interaction with the computer and control of applications or games solely using their bodies. This is enabled by identification of the position and orientation of 25 individual joints (including thumbs) and their motion tracking. The angular field of view of the Kinect sensor in the horizontal direction is 57° and in the vertical direction is 43°. It is also equipped with an additional motorized pivot which can tilt the sensor up for an additional 27° either up or down. The sensor can maintain tracking through an extended range of about 0.7–6 m. It can track up to 6 human body skeletons in the working area.

2.2. Mobile robot description

Developed mobile robot contains the following components: Bluetooth Module HC-06, Arduino Uno, H-Bridge L293D, DC motors, Jumper Wire and Breadboard. The control algorithm runs on the Arduino Uno. The communication with the computer is established via the HC-06 Bluetooth Module. The L293D is designed to provide bidirectional drive currents of up to 600-MA at voltages from 4.5V to 36V. The connection scheme of the robot is depicted in Figure 3 and the developed robot is presented in Figure 4.

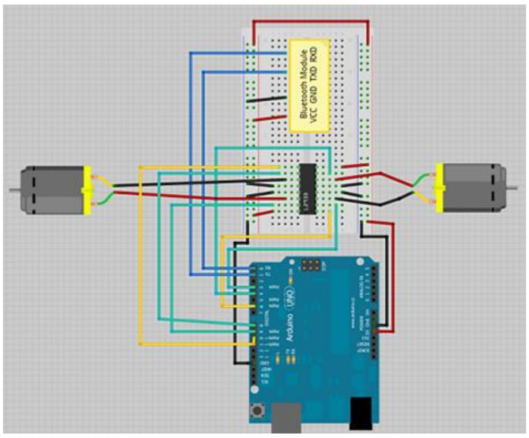

Fig. 3. Connection schema of the mobile robot

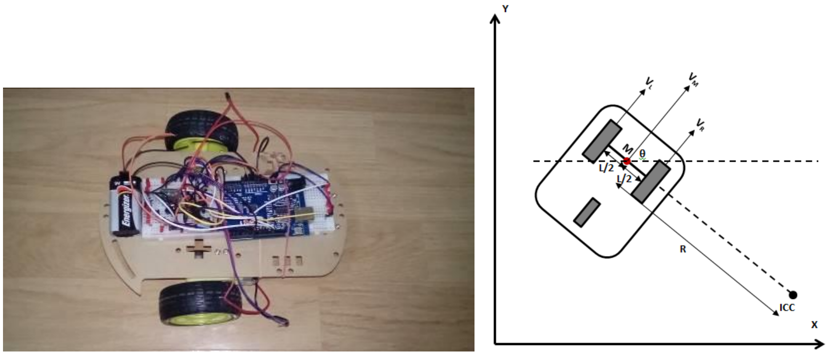

Fig. 4. Developed robot and its model

The develop robot has two powered wheels driven by separate DC motors and one castor wheel used for stability. Robot position in the global reference frame is defined by the position of the mid-point axis (M) and the heading angle i.e. with following vector (*x, y, θ*). Considering the robot geometry (Figure 4) one may conclude that during the motion its left and right wheels are moving around the ICC with the same angular velocity as defined by Eq.1.

$$\omega_M = \frac{V_M}{R} = \frac{V_R}{(R - L/2)} = \frac{V_L}{(R + L/2)} = \frac{V_R - V_L}{L} \tag{1}$$

The instantaneous curvature radius of the trajectory is defined by the Eq.2.

$$R = \frac{V_R + V_L}{V_R - V_L} \cdot \frac{L}{2} \tag{2}$$

The kinematic model of the developed robot can be represented with Eq.3.

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} Vx \\ Vy \\ \omega \end{bmatrix} = \begin{bmatrix} \cos\theta & 0 \\ \sin\theta & 0 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} V_M \\ \omega_M \end{bmatrix} \tag{3}$$

Having in mind that $V_M=(V_R+V_L)/2$ the above equation could be rewritten as:

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} 1/2\cos\theta & 1/2\cos\theta \\ 1/2\sin\theta & 1/2\sin\theta \\ -1/L & 1/L \end{bmatrix} \begin{bmatrix} V_R \\ V_L \end{bmatrix} \tag{4}$$

3. System evaluation

To evaluate the proposed system a dedicated application written in Visual Studio using C# programming language was developed. The interface of the application is shown in Figure 5. Joints that are recognized and tracked are marked with blue circles.

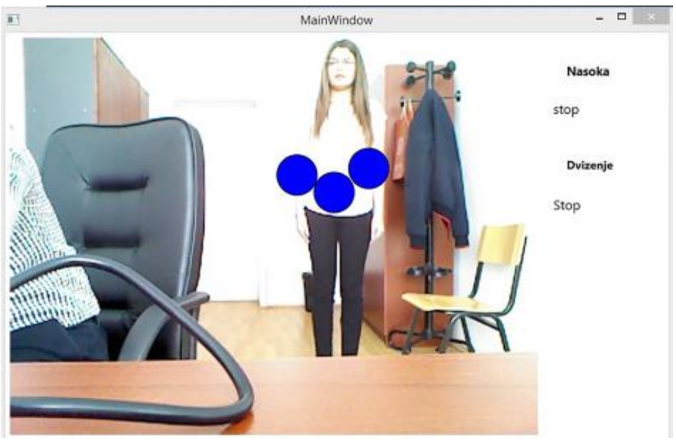

Fig. 5. Screenshots of the developed application

The set of gestures aimed at robot control and their meaning are presented in Table 1.

To stop the robot user needs to move down right and left elbow. If one elbow is up and other is down the robot is moving right or left depending on which elbow is up. To move the car forward or backward the user must place the right and left elbow in front or behind the hip center. The software application than detects the user’s gesture in real-time. The application converts detected movements into control commands. Bluetooth communication is used to sends the commands to the microcontroller on the robot. With detected body movement user controls the motors. Also, the microcontroller returns direction of movement back in the application.

Table 1. Overview of gesture sets.

Command	Action description
Stop	elbow right and elbow left down
Right	elbow right up elbow left down
Left	elbow right down elbow left up
Forward	elbow right and left placed before hip center
Backward	elbow right and left placed behind hip center

The system has been evaluated in the laboratory environment. The aim of the evaluation was to determine the percentage of successfully recognized and executed commands. The robot was controlled by five different users that were initially instructed on how the system works, and each user was given 20 test trials. Afterwards they were asked to perform each command three times in a random order. The results (in %) of successfully recognized and executed commands are presented in the Table 2 bellow.

Table 2. Results of the experimental evaluation.

User No.	Stop		Right		Left		Forward		Backward	
	% Rec	% Exec	% Rec	% Exec	% Rec	% Exec	% Rec	% Exec	% Rec	% Exec
U1	85	94	100	100	100	100	95	100	90	100
U2	90	89	100	100	100	100	85	100	95	100
U3	90	100	100	100	100	100	100	100	100	100
U4	95	100	100	100	100	100	100	100	100	100
U5	95	100	100	100	100	100	100	100	100	100

Moreover, during the tests we have measured execution times for each command (the time from the moment the gesture is performed by the operator till its execution), and we have determined that they vary between 50 and 150ms, which makes this interface applicable even for real-time control.

4. Conclusion

In this paper we present a system that enables human robot interaction using low-cost Microsoft Kinect sensor. The ability of depth perception enables full-human body skeleton tracking and gesture recognition. Recognized gestures afterwards are used to turn the mobile robot left, right or move it forward, backward and to stop it. The evaluation of the proposed system suggests that the proposed human-robot interface is reliable (with high percentage of recognized gestures) and accurate (high percentage of executed actions) and thus it could be used in practice for various applications of mobile robot control. The proposed system could be applied in control of various robotic devices (such as robotic wheelchairs) that are aimed at disabled persons having functional upper limbs. Moreover, the proposed system could be applied for control of industrial or medical processes where the user could not directly interact with the equipment or apparatus. From user perspective, the system could support more than one user because the Kinect sensor and the developed control application have the possibility to track multiple skeletons in the same time.

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