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Design and Development of a Monitoring System based on Smart Device for Service Robot Applications

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Abstract

Smart device has become an affordable main computing resource for robotic ap-plications in accordance with a fast growth of mobile internet environment. Since the computing power of smart device has been increased, smart device based ro-bot system attempts to replace traditional robot applications with laptop-based system. Methodologies for acquisition of remote sensory information and control of various types of robots using smart device have been proposed recently. In this paper, we propose a robot control system using a monitoring program and a communication protocol. The proposed system is a combination of an educa-tional programming oriented robot named EPOR-S. as small service robot plat-form and a smart device. Through a simulation study using image processing, the feasibility of combination of the proposed robot monitoring program and control system was verified.

Keywords: *Robot Control System, Protocol Communication, Monitoring Program, Service Robot, Smart Device*

1. Introduction

Today, the smart device market is rapidly increasing owing to their popularity and their total market size has now moved ahead of personal desktop computers. The rapidly growing market of smart devices means that the applied technology has also advanced. Recently, the computing power of smart devices has improved significantly along with their equipment, such as digital cameras, Bluetooth and WIFI communication modules, touch screens, and various sensors. With the development of mobile computing technology, some attempts have been made to replace cur-rent computing and sensing technologies applied in existing robotics with the computing capabilities and sensors of smart devices [1]. In this paper, we propose a method to replace the robot control currently implemented with laptops with smart devices. First, we developed a monitoring pro-gram that includes several applications for a service robot that can be run on a light weight Windows-based smart device. This controlling and monitoring method was applied to control an educational programming oriented robot named EPOR-S as a small service robot platform through Bluetooth communication using its own communication protocol [2]. Afterwards, we verified the use of the

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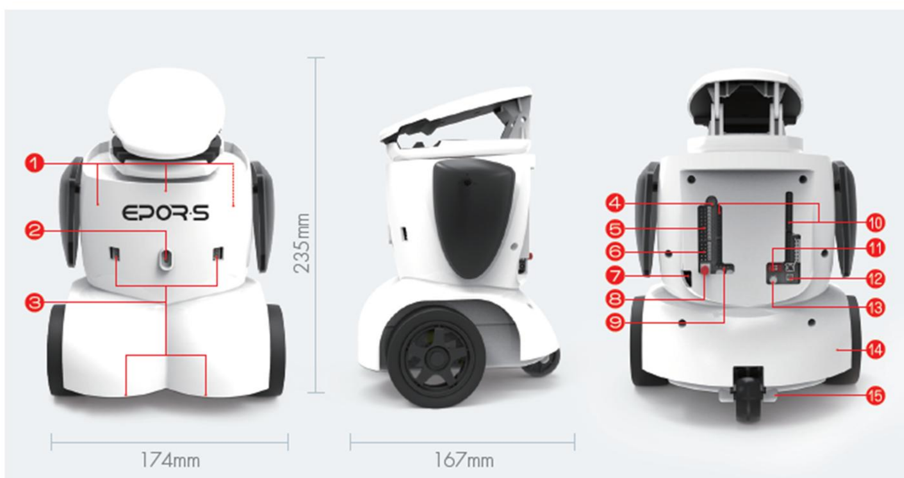
combined service robot platform and mobile device robotic system using simulation experiments to provide light services using images such as object recognition, face tracking, and autonomous navigation through an image processing algorithm embedded in the monitoring program.

2. Proposed Monitoring System for a Service Robot

2.1 Specifications of a Service Robot, EPOR-S

EPOR-S is a small service robot platform for robotic SW application developers developed by XBOT Co. The EPOR-S mainboard follows the Arduino Pin-out open source hardware and has a variety of input/output devices including DC motors, servomotors, and various sensors. In addition, a variety of sensors can be utilized with the built-in sensor connector. Table 1 shows the specifications of the EPOR-S and the built-in input/output devices [3, 4]. Figure 1 shows the appearance and of EPOR-S and its features.



❶ RC Servo Motor X 3
❷ CDS Sensor/RGB LED
❸ Sensor Input X 4
❹ MIC Sensor
❺ Digital Input
❻ Analog Input
❼ DC IN
❽ ON/OFF Switch
❾ I2C Terminal
❿ Arduino IO Port
⓫ DIP 2P Switch
⓬ RGB LED
⓭ CDS Sensor
⓮ DC Motor X 2
⓯ Battery

Figure 1. Appearance and of EPOR-S and its features

Table 1. Specifications of EPOR-S robot

Computing Device Connectivity		Smart device and Raspberry PI
Controller Compatibility		Arduino UNO
Servo Motors for Head / Two Arm	Stall Torque	1.8 kg/cm (4.8V), 2.5 kg/cm (6V)
	Operating Speed	0.1 sec/60degree (4.8V), 0.08 sec/60degree (6V)
DC Motors for Two Wheels	Torque	1.0 kg/cm
	Gear Ration	1:120
	Load Speed	50 RPM/ 10 cm/s (3V), 15cm/s (5V)

Communication Method	USB-UART, Bluetooth v2.1, WIFI (optional)
Weight	810g

2.2 Configuration of Robot Control System

In this paper, we proposed a monitoring program and a dedicated protocol for bi-directional communication between a smart device and a robot for remote sensing and control for robotic applications. The monitoring program communicates between the smart device and the robot based on Bluetooth communication [5]. The configuration of the proposed robot control system is shown in Figure 2. In addition, a robot control algorithm based on image processing was implemented for the performance verification experiments of the proposed service robot system.

Figure 2. Configuration of the proposed robot control system

2.3 Communications Protocol

Communication between the smart device and robot is done via Bluetooth by using the protocol in consideration of efficiency and stability. The dedicated communication protocol was designed to control and monitor the robot and is divided into two parts: robot to smart device and smart device to robot [6].

The communication protocol for controlling the robot in the smart device was HEAD-DATA-TAIL, as shown in Figure 3. The first data of the protocol is treated as Commands notated as CMD, and the CMD number is the type of robot output device to be controlled by the Master. Our proposed protocol adopted a method of controlling the output device by dividing it into seven types. The protocol DATA has a constant length irrespective of the type of output device.

In order to provide services to the users in the system, it is important to acquire the data from sensors attached on the robot in real time, which can be known through the real-time data of the sensor to monitor the status of an environment. The method of receiving the sensor data from the robot at the smart device also adopts the Bluetooth communication method using the protocol description shown in Figure 4.

Start Bytes		CMD	DATA1	DATA2	DATA3	DATA4	DATA5	Tail Byte
'X'	'R'	1Byte	1Byte	1Byte	1Byte	1Byte	1Byte	'S'

CMD Type	DATA 1	DATA 2	DATA 3	DATA 4	DATA 5
MOTOR SPEED	SPEED 1 (Upper Byte)	SPEED 1 (Low Byte)	SPEED 2 (Upper Byte)	SPEED 2 (Low Byte)	-
SERVO ANGLE	HEAD (D8)	ARM(Right) (D9)	ARM(Left) (D10)	-	-
Analog Write	D5	D6	-	-	-
Digital Write	D4	D7	D12	D13	-
RGB LED	LED Num	R	G	B	-
LCD	Grid	'X'	'X'	'X'	'X'
TONE	NOTE (Upper Byte)	NOTE (Low Byte)	Duration	-	-

Figure 3. Description of control protocol and its details according to command type for a service robot

Start Bytes (3Bytes)			Data Size (2Bytes)		ADC Data (A0~A3, A6:CDS)					ADC A7:MIC		D2	D3	D11	Tail Byte
R	X	=	Size (Upper Byte)	Size (Low Byte)	1Byte	"	"	"	"	"	"	"	"	"	0x30

Figure 4. Description of a data sensing protocol for a service robot

2.4 User Interface

The user can control the robot's output device by using the monitor program installed in the smart device and can check the sensor data of various sensors built into the robot. In addition, it is configured to select the robot control algorithm based on the image processing or sensor data installed to provide a simulated service. The user interface has been implemented based on a window programming based graphical interface. Figure 5 shows the screen of the developed user inter-face for robotic service applications [7].

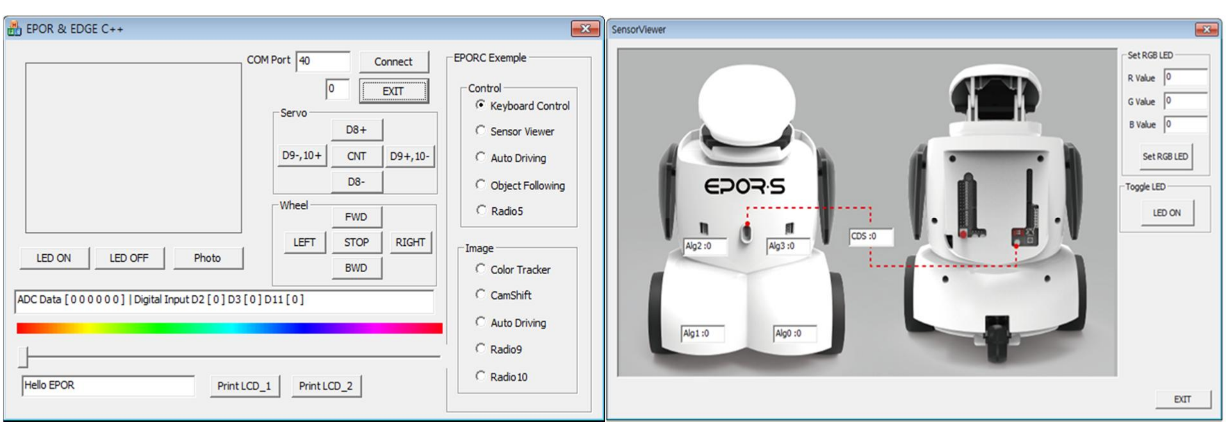


Figure 5. User interface for robotic service applications

3. Experimental Result

3.1 Robot Hardware Configuration for an Experiment

To verify the feasibility of a service robot platform using a smart device as a computer, we implemented a simulated service based on image processing that could be provided by a small service robot platform such as EPOR-S. The robot hardware configuration for the experiments are shown in Figure 6. We installed a smart device based on the Windows 10 operating system equipped with a USB camera in the head cradle of EPOR-S, the specifications of the smart device are shown in Table 2 [8].

Figure 6. Robot hardware configuration for experiment

Table 2. Specifications of smart device for a service robot

Model		Cube iWork8 Air
OS		Windows 10 & Android 5.1
CPU		Intel Cherry Trail Z8300 quad core
RAM		2GB
ROM		32GB
Screen	Type	IPS with Capacitive touch screen
	Resolution	8 inch, 16:10
	Size	1920*1200 Pixel
Camera		2MP each for front/rear camera

3.2 Experiment of a Robotic Application using the Proposed System

In this paper, we conducted a vision based autonomous driving application as an experiment to show the feasibility of the proposed robot system. This robotic application is very effective to show that a service robot is able to drive autonomously based on decision of moving direction according to the angle of the line component acquired using Probabilistic Hough Transformation [9].

This experiment is able to verify the abilities of the proposed service robot sys-tem by applying the robot control and sensing guided by the image processing algorithm of the monitoring program running on the smart device. Figure 7 shows the experimental result, while Figure 8 shows the process of the vision based autonomous driving application.

Figure 7. Experimental result of a vision based autonomous driving

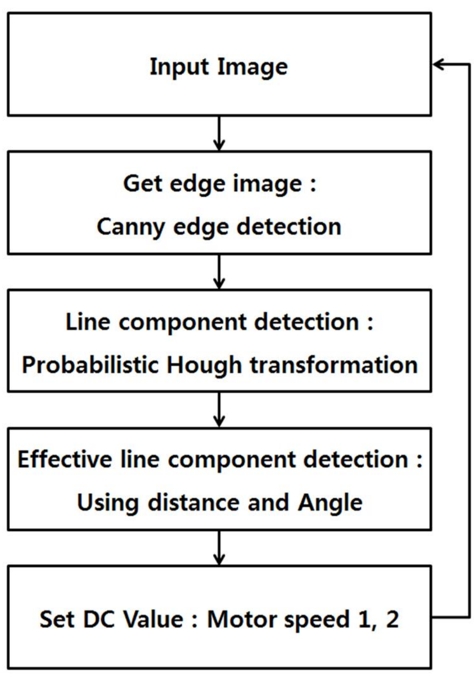


Figure 8. Process of the vision based autonomous driving application

3. Conclusion

In this paper, we propose a monitoring system based on smart device for a service robot applications as a new type of service robot platform which combines a smart device and a service robot. The proposed service robot system is able to show an affordable performance in conducting a vision based autonomous driving successfully.

In order to implement the proposed monitoring system, we also design a dedicated communication protocol between a smart device and a service robot. The monitoring program was implemented on the smart device side and the smart de-vice controlled the robot platform by transmitting the control commands through the Bluetooth wireless connection. In addition, we demonstrated the feasibility of the proposed system by conducting a vision based autonomous driving experiment using real-time image processing running on the smart device.

When considering the rapid advancement of smart devices with various embedded sensors, we expect smart device based robot control schemes are considered to give meaningful contributions to the field in that it is new types of robot applications, successfully integrating and exploiting a traditional PC based mobile control method and the distinct features of a smart device, including mobility in particular. Localization of a service robot using a GPS and acceleration sensor in-formation and HRI using a camera, sensors, audio features of smart device.

References

[1] Wafa, Batayneh., Eyad, AL, Smadi., Abdullah, Al, Zghoul., Ghaith, Alshaggah., “Bluetooth Based Stair Climbing Robot Control Using Cell Phone,” International Mechanical Engineering Congress and Exposition(IMECE)., 13-19, pp. 6, 2015.
DOI: 10.1115/IMECE2015-52066.

[2] Maity, Ayan & Paul, Avijit & Goswami, Priyanka & Bhattacharya, Ankan, “Android Application Based Bluetooth Controlled Robotic Car,. International Journal of Systems Engineering. 1. 43-47, 2017.
DOI: 10.11648/j.ijiis.20170605.12.

[3] EPOR and XBOT homepage, http://www.erpo.org and http://www.xbot.kr

[4] Young Dae, Lee, Jeong Jin Kang, Kee Young Lee, Jun, Lee, Yongho Seo, “The Development of an Educational Robot and Scratch-based Programming,” International Journal of Advanced Smart Convergence., Vol. 5, No. 2, pp. 8-17, 2016.
DOI: 10.7236/IJASC.2016.5.2.8.

[5] Young Joon Kim, Se Jun Park, Yong Ho Seo, “Script based Simple Programming Toolkit for Open Source Hardware,” International Journal of Software Engineering and Its Applications., Vol. 10, No. 2, pp. 1-8, 2016.
DOI: 10.14257/ijseia.2016.10.2.01.

[6] Antoni Grau, Marina Indri, Lucia Lo Bello, Thilo Sauter, "Industrial robotics in factory automation: From the early stage to the Internet of Things", Industrial Electronics Society IECON 2017 - 43rd Annual Conference of the IEEE, pp. 6159-6164, 2017.
DOI: 10.1109/IECON.2017.8217070.

[7] RAO, R. S., et al. “Human robot interaction: application to smart wheelchairs,” Robotics and Automation, 2002. Proceedings. ICRA'02. IEEE International Conference on. IEEE, 2002. pp. 3583-3588, 2002.
DOI: 10.1109/ROBOT.2002.1014265

[8] Utz, H., Sablatnog, S., Enderle, S., & Kraetzschmar, G., “Miro-middleware for mobile robot applications,” IEEE Transactions on Robotics and Automation, 18(4), 493-4979, 2002
DOI: 10.1109/TRA.2002.802930

[9] MATAS, Jiri., GALAMBOS, Charles., KITTLER, Josef., “Robust Detection of Lines Using the Progressive Probabilistic Hough Transform,” Computer Vision and Image Under-standing, 78.1: 119-137 ,2000
DOI: 10.1006/cviu.1999.0831.