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THE DESIGN AND APPLICATION OF WEB-BASED GUIDE ROBOT

ПРОЕКТИРОВАНИЕ И ПРИМЕНЕНИЕ ВЕБ-ГИД РОБОТА

Роботтук заттардын Интернетинин мисалы катары роботтоштурулган негизделген гид робот интернет аркылуу көзөмөлдөнөт жана тармак ичиндеги интернетте гид маалыматын бөлүшөт. Веб-браузерди колдонуп, Интернетке туташкан каалаган түзмөк бул роботту башкарып, берилген маалыматтарды ала алат. Telepresence Робот түрүндөгү гид роботунда колдонуучу интерфейси жана гид маалыматы үчүн веб-баракчаларды жайгаштырган веб-сервер бар. Ошондуктан, роботтон алыс жайгашкан колдонуучу жана роботтун жанындагы жергиликтүү колдонуучулар мобилдик түзмөктөрүн колдонуп, интернет аркылуу гид маалыматына жете алышат. Бул макалада биз вебге негизделген гид роботун кантип иштеп чыгууну жана университеттин кампусуна багыттоочу роботту анын тиркемелеринин бири катары кантип ишке ашырууну сунуштайбыз.

Өзөк сөздөр: *робот-гид, заттардын интернети, микроконтроллер, Bluetooth, программалык камсыздоо, түзмөк, башкаруу.*

Интернет-робот-гид, как пример Интернета роботизированных вещей, управляется через Интернет и обменивается информацией руководства в сети в рамках сети. Используя веб-браузер, любое устройство, подключенное к Интернету, может управлять этим роботом и получать предоставленные данные. Робот-гид в форме робота Telepresence имеет веб-сервер, на котором размещены веб-страницы с пользовательским интерфейсом и направляющей информацией. Таким образом, пользователь, находящийся вдали от робота, и местные пользователи, находящиеся рядом с роботом, могут получить доступ к путеводной информации через Интернет с помощью своих мобильных устройств. В этой статье мы представляем, как разработать веб-робота-гида и реализовать робота-гида в университетском городке в качестве одного из его приложений.

Ключевые слова: *робот-гид, Интернет вещей, микроконтроллер, Bluetooth, программное обеспечение, устройство, управление.*

Web-based guide robot as an example of Internet of Robotic Things is controlled through web and share guide information on web within a network. Using web browser, any device connected to the Internet can control this robot and get the data provided. Robot in the form of Telepresence Bot has a web server hosting webpages for user interface and guide information. Therefore, a users both distant and near the robot can access guide information via web using their mobile devices. In this paper, we present how to design web-based guide robot and implement university campus guide robot as one of its applications.

Key words: *robot guide, Internet of things, microcontroller, Bluetooth, software, device, control.*

Introduction. Internet of Things (IoT) is the concept of connecting any device to the Internet and to other connected devices. Almost all, every area, every device, every sensor, every software can be connected to each other over Internet. The ability to access these devices through a smartphone or through a computer is called IoT. IoT is basically a platform where we connect anything with

electronics, software, and sensors to the internet enabling them to collect and exchange data. IoT platform collects and combines data from multiple devices and platforms and applies analytics to share the data with applications to address industry-specific needs.

Internet of Robotic Things (IoRT) is the concept where intelligent devices can monitor events, fuse sensor data from a variety of sources, use local and distributed intelligence to determine a best course of action, and then act to control or manipulate objects the physical world, and in some cases while physically moving through that world. Namely, IoRT is one of the IoT and the main difference with IoT is that a robot takes real actions in the physical world. Figure 1 represents the scope of Internet of Things and Internet of Robotic Things. [1]

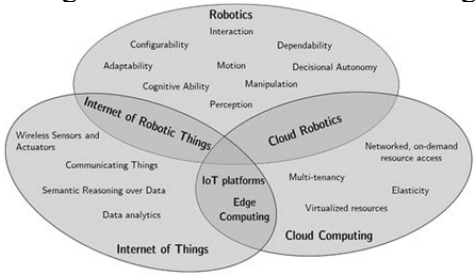

Fig. 1. The scope of Internet of Robotic Things

Guide robot presented in this paper is kind of robotic telepresence and is also known as robot assistant. A robotic telepresence system results from combination of the robotics and the information and communication technologies. This allows users to remotely control a robot and provide useful information with people around the robot. A successful robotic telepresence system must face a number of issues that can be grouped into three main categories: (1) providing accessible and easy-to-use interfaces to facilitate the telepresence experience, (2) integrating robust multimedia features and real-time communications under different network conditions, and (3) considering efficient and adaptable solutions to provide the requested robotic abilities. [2]

Also, guide robot is an example of Internet of Robotic Things. It is controlled through web and share guide information on web within a network. Using web browser, any device connected to the Internet can control this robot and get the data provided. There are several applications of web-based Guide robot like university campus guide, tour guide, airport guide and shop guide.

In this paper, we present how to design web-based guide robot and implement university campus guide robot as one application

I. THE DESIGN OF WEB-BASED GUIDE ROBOT

A. Architecture

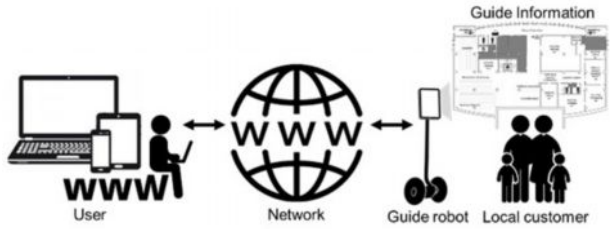

Fig.2. Architecture of Web-based Guide Robot

Figure 2 shows how web-based guide robot works. A user controls the guide robot and offers guide information to local customer in need of assistance through web-based network.

Telepresence Robot-shaped guide robot has a web server hosting webpages for user interface and guide information. Therefore, local customers can access guide information offered by the robot using their mobile devices.

B. Design

This robot consists of two main parts: remote-controlled wheeled robot and web for guide robot.

- Remote-Controlled Wheeled Robot

The robot is a remote-controlled, wheeled device that has wireless connectivity. This robot has

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two wheels connected to stepper motors and has a camera and ultrasonic sensor to detect front obstacle. Using Bluetooth, it is controlled by mobile devices like laptop or smartphone remotely. All parts of the robot are as follows.

- Microcontroller as robot control center
- Sensor to detect the environment around robot
- Actuator which is responsible for moving robot
- Wireless communication between robot and user
- Control algorithm

- Web for Guide robot

There are two kinds of web for Guide robot. One is a web user interface to control robot and the other is a webpage to display guide information. The robot uses a wide touchscreen providing video and audio capabilities and it shows guide information on the screen through web. Web components for guide robot are as following.

- Client-side user interface
- Server-side guide information webpage
- Web-server for hosting user interface and guide webpage

C. Implementation

- Hardware

For making the robot, two types of microcontroller are used and all electronic parts are connected to Arduino and Raspberry Pi respectively.

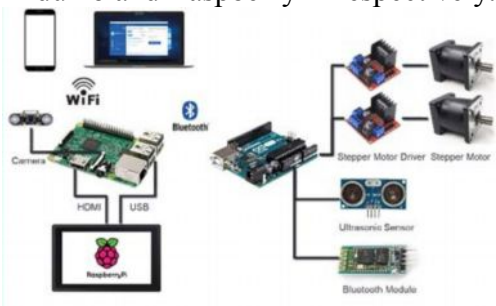

Fig. 3. Web-based Guide robot hardware design diagram

1. Microcontroller

Arduino and Raspberry Pi are a popular choice when developing embedded system like IoT. That's because it enables to develop easily with reasonable price and a large number of applications and examples.

Arduino is an open-source platform used for building electronics projects and consists of physical programmable circuit board and IDE (Integrated Development Environment) with simplified version of C++. Arduino boards are relatively inexpensive compared to other microcontroller platforms and Arduino Software (IDE) is easy-to-use for beginners, yet flexible enough for advanced users.

Raspberry Pi is well-known to several Internet of Things projects because it offers wireless networking like Bluetooth and WiFi and a complete Linux server with a tiny platform at an incredibly low price.

In this paper, Arduino UNO and Raspberry Pi 3B were used.

2. Motor

For controlling the robot precisely, two stepper motor with planetary reduction gear were used. Stepper Motors rotate a precise angle according to the number of pulses of electricity sent to them and it requires a motor driver to energize the phases in a timely sequence to make the motor turn. TB6600 Arduino Stepper Motor Driver is an easy-to-use professional stepper motor driver, which could control a two-phase stepping motor. It is compatible with Arduino and other microcontrollers that can output a 5V digital pulse signal.

3. Range Sensor

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is reflected back to the sensor. A timing chip measures the time interval between transmitting the signal and receiving the echo to calculate the distance to the object.

4. Bluetooth

HC-05 Bluetooth Module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with microcontroller like Arduino. It is responsible for the communication between Raspberry pi and Arduino.

5. Camera

Raspberry Pi Camera is compatible with Raspberry Pi and supports all revisions of the Pi. It has a 5 megapixel OV5647 sensor and the focus distance is adjustable. Especially, it includes Fisheye Lens which offers wider field of view and infrared LED which supports night vision.

6. Touchscreen

10.1 inch Capacitive Touch Screen LCD with 1280x800 hardware resolution has HDMI interface for displaying, USB interface for touch control. It works with Raspberry Pi and supports Raspbian OS without any driver.

- Software

Guide robot software consists of three main parts: Web control for user and Robot control for robot and Main control for interaction between user and robot. The software design diagram is presented in Figure 4.

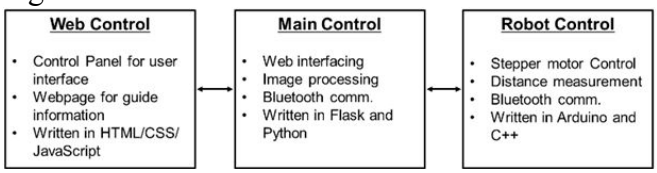

Fig. 4. Web-based Guide robot software design diagram

1. Robot Control

The robot is basically controlled in accordance with commands from user interface through Bluetooth. It can move the robot forward and backwards, turn right and left, and stop. Also, it automatically stops when detecting an obstacle by measuring the distance to any obstacle using ultrasonic sensor. The control algorithm was described in Figure 5.

The software for robot control was implemented in C++ using Arduino IDE.

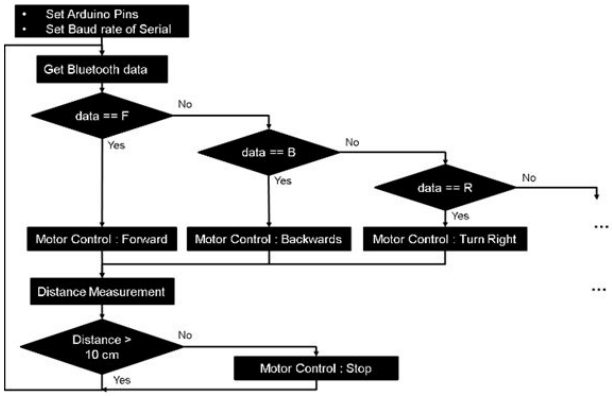

Fig. 5. Guide Robot Control Flow

2. Web Control

Two types of web application are needed for web of guide robot.

One is a control panel for user interface for controlling robot and the other is a webpage for guide information. The user interface and guide webpage can be hosted using web-sever and any mobile devices connected to network can access to the control panel and the webpage.

The user interface including image streaming and the website for guide information were designed by HTML, CSS and JavaScript.
As shown in Figure 6, simple images to control robot were placed on webpage by HTML and a script was described by JavaScript for dynamic behaviors that an event occurs when an image is clicked or a slide is moved. Also, a live video was implemented on webpage by streaming a sequence of independent JPEG pictures called Motion JPEG.

Fig. 6. Web User Interface: Robot Control Panel

3. Main Control

This main control software mainly handles interaction between user and robot. It includes webpage interfacing and image processing as well as Bluetooth communication.
For this, a micro web framework called Flask is used. Flask is suitable for creating web applications running on embedded devices like this robot. Also, using Flask application called Flask- SocketIO, it is possible to access to low latency bi-directional communications between the clients and the server.
This socket is great for providing live information by getting info on the webpage without reloading or waiting for long-polling.
With these Flask relevant tools, it enables not only to host webpage but also to interact between user as client and robot as server. In addition, images streaming is possible through web using Flask.
All main control software was implemented in Python and Flask written in Python. Figure 7 describes software components for main control.

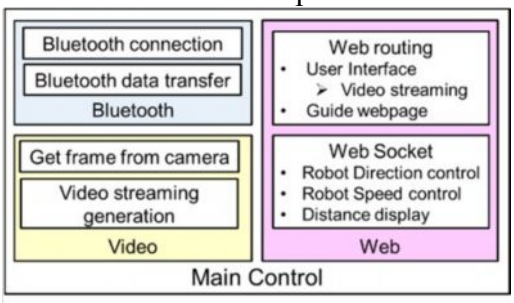

Figure 7. Main Control Software

Firstly, Bluetooth package providing the Bluetooth protocol stack was used. PyBluez module allows Python code to access the Raspberry Pi's Bluetooth resources.
Secondly, getting frame from Raspberry Pi camera and generating video streaming was implemented in a background thread. It captures video frames from the camera when a user connects to the web user interface and this is constantly running while the Flask web-server is running.
Finally, in web program, web routing for user interface including video streaming and webpage for guide information was implemented. Also, web socket was applied for robot direction control and speed control as well as displaying distance between robot and an obstacle. This web socket was used to react instantly when a user sends a command through web.

II. WEB-BASED GUIDE ROBOT APPLICATION

As one of applications of web-based guide robot, a university campus guide robot was implemented. This robot provides information about Kyrgyz State University of Construction, Transportation and Architecture (KSUCTA).

Fig. 8. KSUCTA University Guide Robot

This robot is controlled by robot control panel as user interface and provides university homepage through web as moving information center. So, with laptop and mobile devices, users can control robot and can access to information. It is possible to control remotely while the video is streaming on web user interface and automatically stop when detecting obstacles in front of the robot.

Depending on guide information, many types of guide robot like airport guide robot, café guide robot and shop guide robot are possible. For example, in case of shop guide robot, a shop owner can move the robot to specific area remotely and the robot moving around the area can show and explain information about products to customers.

III. CONCLUSION

In this paper, a web-based guide robot presented has been designed and implemented. It was able to be controlled remotely and get guide information provided by the robot via web. Once web server in robot is activated, the remote user is able to move the robot forward, backwards and to turn it left or right. A video stream enables the user to navigate remotely. The robot can stop at a safe distance from an object and it doesn't allow moving any further in that direction until the obstacle is removed. Turning left and right or moving backward operations are also available in order to avoid the object.

Regarding the robot control, only one user who connects the robot firstly can control this robot since Bluetooth has the characteristic of one to one communication. With this skill, the robot control authority by other users can be restricted except the robot administrator.

Thanks to web development with Flask framework, we saved a lot of time and effort to build web application and environment for the robot. Especially, video streaming using Flask was also very helpful.

In the near future, we will develop other kinds of web-based guide robot and in order to interact with user more closely, intuitive user interface and webpage will be added. Also, a database to store specific information for providing customized information will be applied optionally.

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