Design and Navigation Prospective for Wireless Power Transmission Robot

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Design and Navigation Prospective for Wireless Power Transmission Robot

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***Abstract*— In this paper a novel system is introduced as combination of state of the art in the field of wireless power transmission and mobile robotics. A mobile robot is equipped with wireless charger and navigates in the environment of various battery nodes in order to charge the network in an efficient way. The presented research in this paper illustrates design and development of real functional system with the aim to change the traditional way of carrying the battery to charger into navigating the charger to batteries. Even though some theoretical research on this field was available however the working prototype has been not developed yet hence we focused on the practical application and brought the concept into practice. We initiated the research by reviewing the existing wireless power transmission technologies and later on equipped mobile robots with QI standard compatible WPT. The complete prototype architecture from both the hardware and software aspects is presented in this paper. We believe such architecture can be a useful testbed for bringing such technology from theory to practice.**

***Keywords*—Wireless power transmission robot, Mobile robot, Autonomous Navigation, Robot charging, QI standard.**

I. Introduction

Battery charging with wireless power transfer is a novel approach. However, the concept of wireless power transfer even for charging batteries is not a new idea. It has been invented by researchers but not widely implemented yet. In the field of wireless power transmission the distance between transmitter and receiver, which is going to be large in the focus of recent research, can make the dream come true in different uses in human life [1]. Meanwhile from the energy efficient point of view, if the transmitter and receiver coils are in close proximity to each other many applications are feasible in recent time [3-5]. In this work we have equipped the universal mobile charger with robotic platform by adding some sensors and designing wheels for the robot movement. Furthermore, mobile robots are becoming one of the most well-known applications of robotics. These robots can be categorized into five main groups based on their characteristics that are land-based wheeled, land-based tracked, land-based legged, air-based, and water-based robots. Land-based wheeled robots typically require the least investment while providing significant exposure to robotics. These robots are the most popular mobile robots among beginners and the robotic community due to their exposure to greater knowledge, cost factor, and their simplicity [6-9].

Fig. 1: Recent applications of wireless power charging system in our daily life

The structure of this paper is organized as follows. After introduction, system architecture shown in Section II. The robot design and future appearances of wireless power transmission robot are described explicitly in Section III, while user experiment in Section IV and experiment result in Section V. Finally, conclusions and future work are presented in Section VI.

II. System Architecture

Wireless Power Transmission robot architecture is described in to two parts. Robot hardware design is presented in the first part where as software architecture is presented in the second part.

A. *Robot Hardware Design*

Robot hardware design consists of its three major parts namely sensors, servo motor and wheels. Below are the descriptions of those major portions. Figure 5 shows the full overview of the WPT robot hardware design. The hardware structure of the WPT robot is illustrated in Figure 6 where the wireless charging source is equipped with a mobile robotic system to facilitate the interaction.

1) ***Wireless Charger and Receiver*:** In our experiment we use solo qi wireless charger with USB charger as wireless power source [10-12]. Product feature and technical specification of the wireless charger as follows.

Product features: Qi™ Compatible, Charge up to 2 devices simultaneously (Wireless + USB), Charging Indicator Light, Additional USB charging port, AC Wall Charger included.
Technical Specifications:
Power Input AC Adapter: AC 100-240V, DC18V/1.65A, 3.5 DC, USB output: 5V/2.1A, 10W, Charging for iPad and other smart phone, Wireless output: DC6V-9V/Sinusoidal voltage, 5W, Charging frequency : 110K-132 KHZ, Standby power : ＜0.3W, Wireless distance : 5~8mm, Coil Alignment Guided Positioning with tactile feedback (Magnetic Attraction), Wireless efficiency : 70 max, Ripple and Noise : ＜50mV, Dimensions : (L) 98mm(W)98mm(H)12mm, Products weight : 150g. In figure 2 it shows the top view, front view, back view of the wireless charger and when the receiver is in touch with wireless charger.

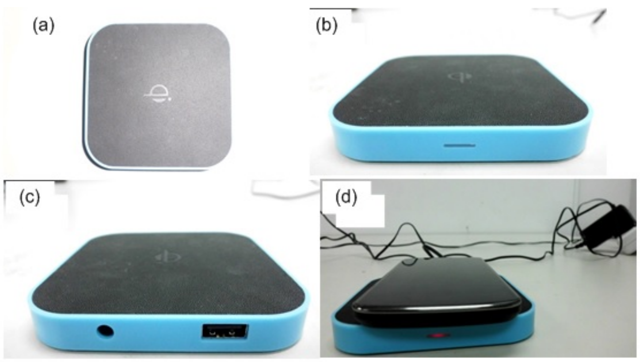

Fig. 2:(a) top view of wireless charger. (b) Front view. (c) Back view. (d) Charger in touch with receiver.

2) ***Universal Receiver:*** Universal receiver is required for the user mobile device that is not capable for wireless charging. In the figure 4 it's shown the user mobile device description.

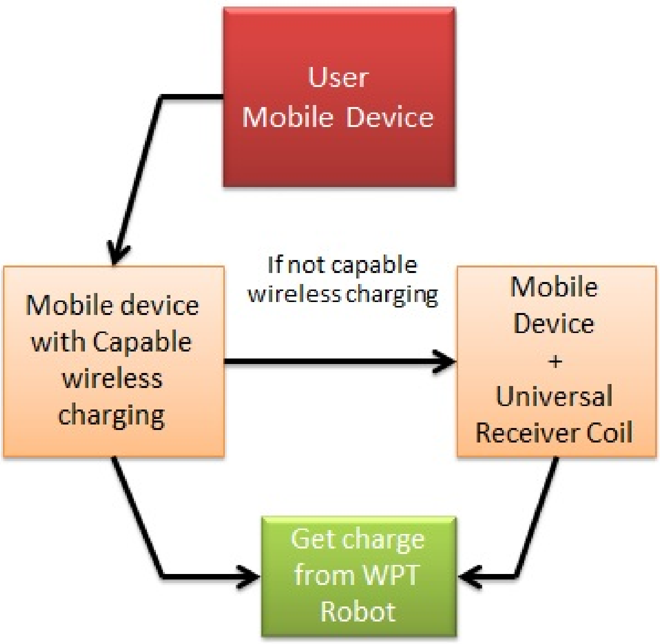

Fig. 4:User mobile device description.

As a wireless charging node which is experimented with two mobile batteries LG(capable built in wireless charging, battery model-Non removal Li-po 2100 mAh) and HTC(battery that is not capable wireless charging connected with the universal receiver coil, specification of the universal receiver coil-Dimension:70*50*1.1mm, net weight 2.5g, Input power:3.5W,Output:DC 5V/650mA (Avg), Charging current: DC 5V/650mA (Avg), Charging time: 0.5 hrs, Reaction temperature: -10to40 S451, working heat up range: S804, 20 S451(ambient temperature S804, 25 S451), working ambient humidity: S804; 80, working life: charge and distance more than 4000 times). In figure 3 shows the front and back side of the receiver coil and how it attached with the HTC mobile (which is not capable for wireless charging) for experiment.

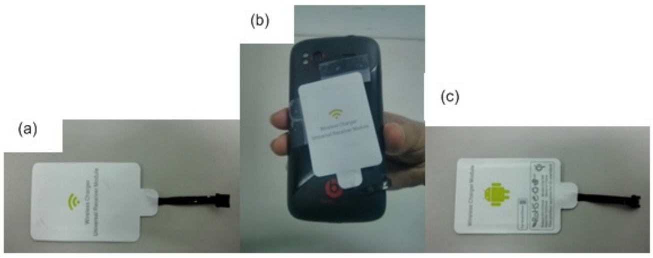

Fig. 3:Universal receiver coil (a) front side. (b) Receiver coil attach with HTC mobile. (c) Back side

Sensors: The four kind of sensor we can use in our system is Ultrasonic sensor, touch sensor, light sensor and sound sensor with different functionalities.

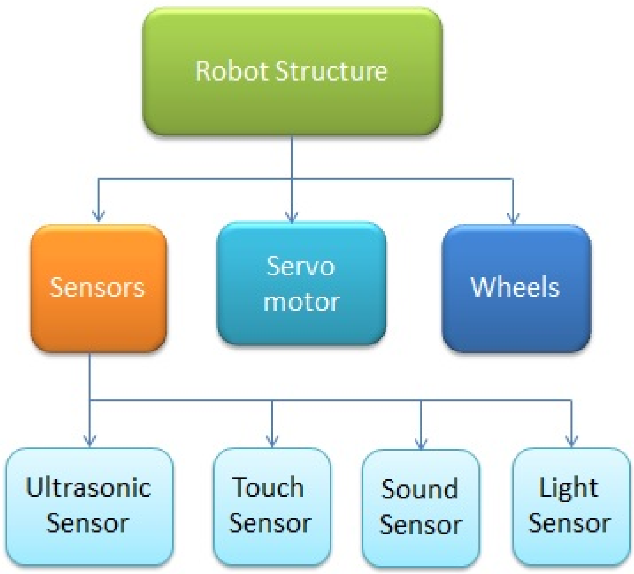

Fig. 5: Full Robot hardware construction system.

Ultrasonic Sensor: Ultrasonic Sensor blocks are used to measure the distance from an obstacle or to detect an obstacle without contact. Ultrasonic Sensor blocks consist of two blocks. Ultrasonic Sensor Interface block is an interface block to the outside of a NXT controller model. Ultrasonic Sensor

Read block is used to read Ultrasonic Sensor data. In simulation, these blocks are just place holders; however, they will be used to implement an appropriate device API in the generated code.

Touch Sensor: Touch Sensor blocks are used to detect contact with an obstacle. If the Touch Sensor had contact with an obstacle, the sensor returns 1. The Touch Sensor consists of two blocks. Touch Sensor Interface block is an interface block to the outside of a NXT controller model. Touch Sensor Read block is used to read the Touch Sensor data. In simulation, these blocks are just place holders; however, they will be used to implement an appropriate device API in the generated code.

Light Sensor: Light Sensor blocks are used to measure brightness. Greater value means darker (or lower reflection). Light Sensor consists of two blocks. Light Sensor Interface block is an interface block to the outside of a NXT controller model. Light Sensor Read block is used to read Light Sensor data. In simulation, these blocks are just place holders; however, they will be used to implement an appropriate device API in the generated code.

Sound Sensor: Sound Sensor blocks are used to measure the sound pressure. Smaller value means louder sound. Sound Sensor consists of two blocks. Sound Sensor Interface block is an interface block to the outside of a NXT controller model. Sound Sensor Read block is used to read Sound Sensor data. In simulation, these blocks are just place holders; however, they will be used to implement an appropriate device API in the generated code.

Servo Motors: Servo Motor blocks are used to control a Servo Motor. Servo Motor consists of two blocks. Servo Motor Interface block is an interface block to the outside of a NXT controller model. Servo Motor Write block is used to set Servo Motor control data. In simulation, these blocks are just place holders; however, they will be used to implement an appropriate device API in the generated code.

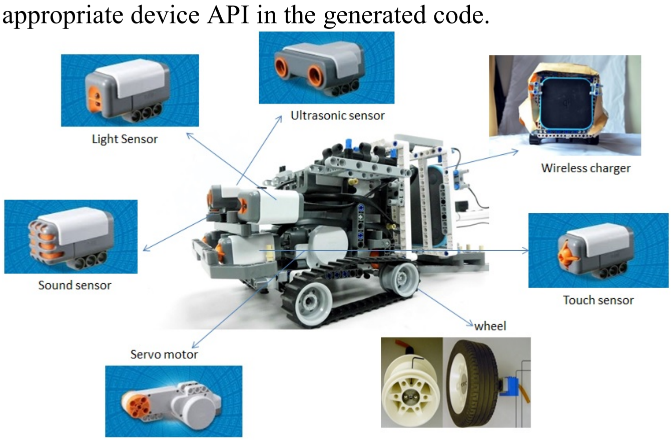

Fig. 6: Full overview of the WPT Robot hardware design.

B. *Software Architecture*

The overall software structure is presented in Figure 7. Data from ultrasonic, touch, light and sound sensors are transmitted to the processor unit. The State Flow module handles state transitions of the robot. Finally the Control unit includes a PID controller for navigation of two motors which are connected to wheel.

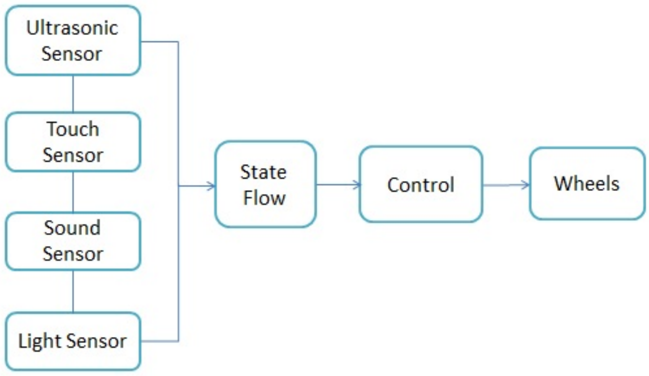

Fig. 7: Overall software architecture of the robot.

III. ROBOT DESIGN AND ARCHITECTURE

In the design of the robot, we took into account to make use of a very intuitive and convenient; resulting in our robot design in a planner way. According to the system structure design, the platform is figured as follows which mainly consists of robot moving body part and wireless charger holding carrier.

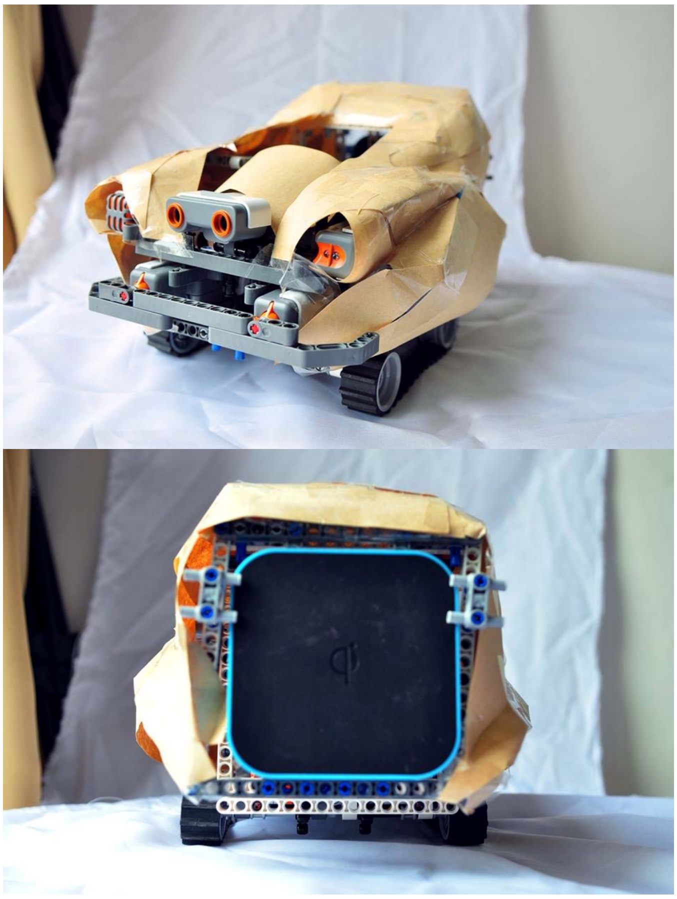

Fig. 8: Appearance of the WPT robot.

our robot is differential wheeled robot, through the relative speed of the two wheels to control the speed and turning angle, where we used to walk on two wheels to control the robot, but a robot to throw into confusion balance we also used two other auxiliary wheel to help robots, when the robot control wheel turning angle one would use negative acceleration, while others give a positive acceleration, the robot will reflect the proper rotation, doing so can reduce the wear rate of the wheels and machinery. Respectively provided on both sides of the machine sensors and touch sensors sound, which allows convenient user's voice received mobile robot and robot control. We use the software aspects of LEGO MINDSTORMS NXT Support from Simulink MATLAB with the STAT FLOW to control the robot's actions. Robot shell design we used paper to cover the whole robot.

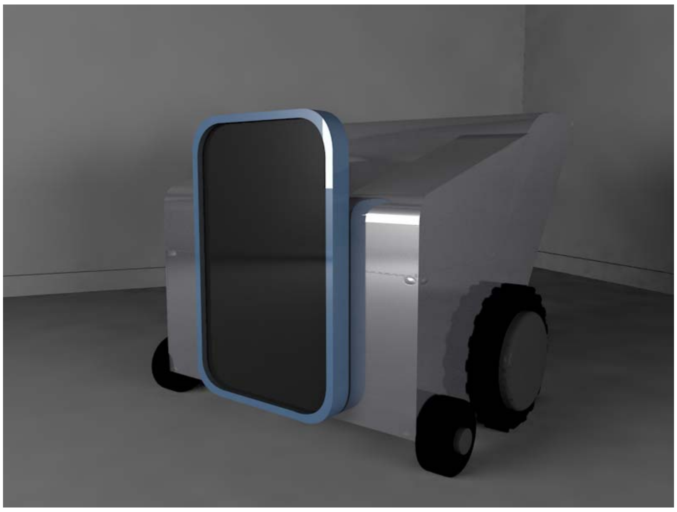

Fig. 9: Appearance the WPT robot in near future.

We are aiming to improve the mechanical system from the design point of view. In above figure it is shown the design of our most recent 3D view of wireless power transmission robot.

IV. User Experiment

As varies with the charging node functionalities it defines the importance of charging distance in our experiment.

A. Robot in Touch with Receiver

In robot navigation user tests For HTC mobile user the charger need to be touch with the receiver. When the wireless charging robot come to the receiver mobile and touch with the receiver it can take charge. From the figure 10 it can figure out that while the battery is in the charging mode it shows the signal to the user that it is charging.

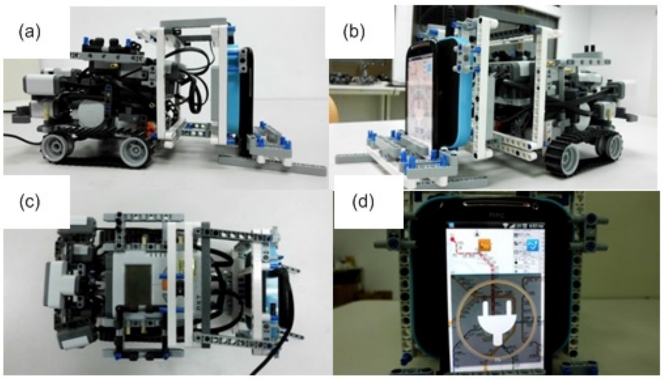

Fig. 10: When the wireless charging robot is touch with receiver (a,b) Side view. (c) Top view. (d) Back view.

B. Robot Distance 5mm with Receiver

While the wireless charging robot come closer with the receiver (mostly 7mm) for LG mobile then the mobile started to take charge and shows the signal to the user. From figure 11 it shows the charging distance that is 5mm in this experiment.

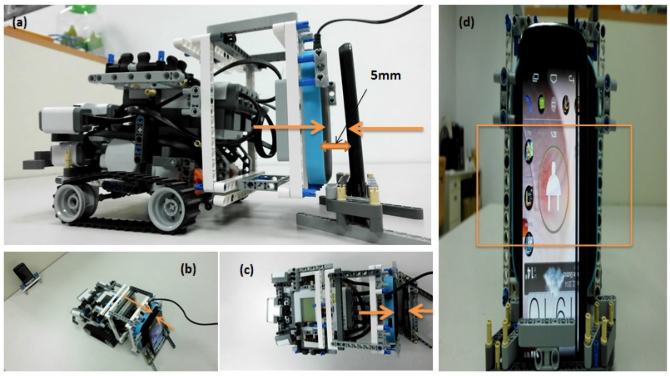

Fig. 11: Wireless charging robot when it is 5mm distance with receiver (a) Side view. (b) Corner view. (c) Top view. (d) shows charging.

V. Experiment Result

Experimental full environment is consists with wireless charging robot and the user mobile devices. In our experiment WPT robot continuously moves between two receivers within a certain time. While one receiver takes charge for certain time another mobile receiver wait for the robot. In figure 12 as we can see from the scametic diagram of WPT robot environment there are 5 user mobile device nodes where the WPT robot will move continuously one by one between them. However in figure 13 that from experimental view there is 2 mobile devices in two corner of the table and the WPT robot moves between these two mobile devices in a certain period of time decided by the user.

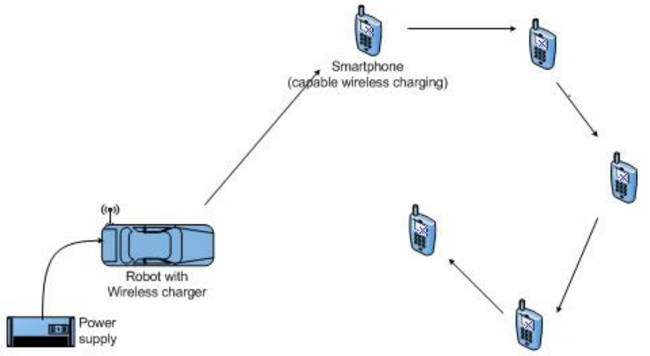

Fig. 12: Schematic Diagram of WPT robot environment.

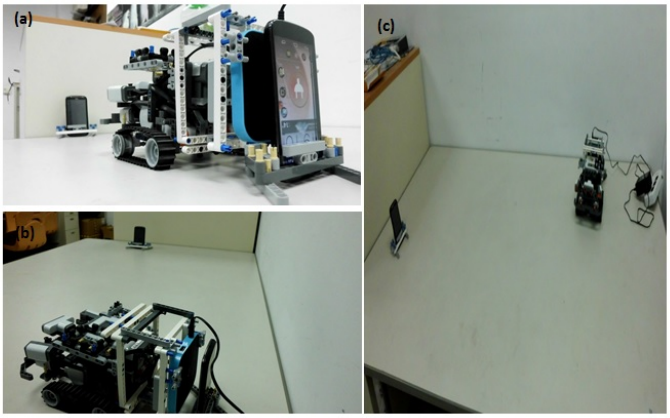

Fig. 13: Full environment of the experiment.

In the state flow module, we let the robot translate back and forth between two user. Based on our experiments we adjusted the timing. The default value for changes navigation between two user is 11 seconds. Users can commend the robot via voice or more directly via touch sensor. Ultrasonic sensor is used to find the receiver. While it comes in front of the mobile receiver it turn stop and starts to charge. We explain the way of handling the robot for the user before experiment. In many cases users also like to use the smart phone interface which can simply interrupt the robot movement using the touch sensor.

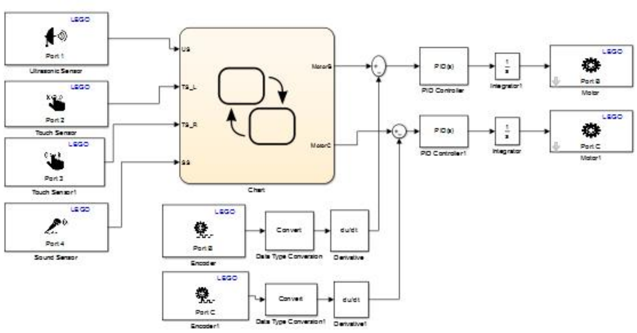
Fig. 14: Simulation in Matlab.

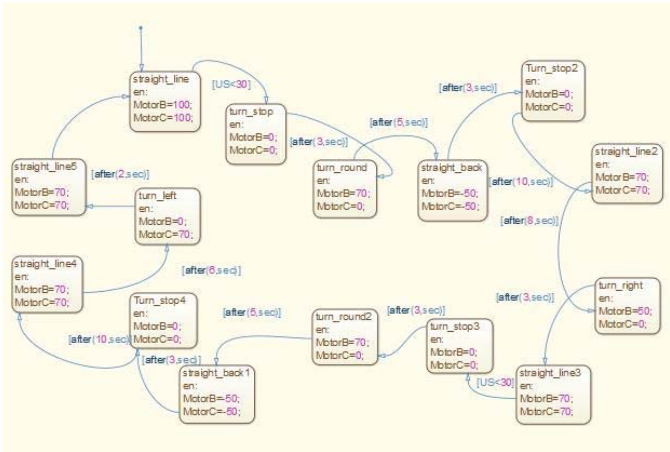

Fig. 15: Programming with state flow.

In figure 16 an instant of robot performance is illustrated. In this experiment the robot is placed in the research lab. While during the research time if researchers are busy then this robot can help them to get charge for their mobile devices.

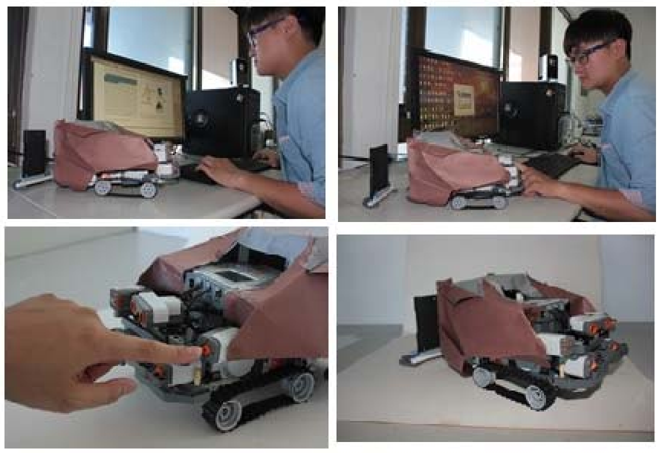
Fig. 16: Robot user involvement experiment in the Research Lab.

It can move among the researchers for charging purpose. As we can see in the figure while the researcher was busy the robot helps to get charge. As long as researchers press the touch sensor the WPT robot move itself near to standing mobile device placed by user.

VI. CONCLUSIONS AND FUTURE WORK

In this paper we have presented a robotic system which is used for the purpose of wireless charging between multiple users where it is possible to use various modes of interaction with multi-modal functionality in practice of daily life. This proposed system where the user involved with different interactions is mostly designed for indoor use whereas outdoor work functionality will be our future work. Furthermore, our most recent designed wireless power transmission robot has shown as well as one scenario is presented for the purpose of future use. In future we aim to further develop this robot with more functionality such as adaptive behaviour and also plan to perform formal user studies to improve the design and behavior of the robot.

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