MULTI-PURPOSE MOBILE UTILITY SERVICE ROBOT

Angelo D. de Villa,
Jake M. Laguador,
Joel Nikko L. Meñez,
Jeah V. Montenegro

ABSTRACT

This hardware and software development research aimed to create a prototype robot to be used as a moving surveillance to monitor the performance of people on the workplace or it can be used to handle chemicals more safely in harmful environments instead of bringing it with industrial personnel. This product is combination of mechanical, electronics and electrical processes to build and automate the robot. The prototype is made up of imported Bluetooth module, Gripper attachment, Tank Threads, Quad-Track Input (QTI) Sensors, Ping Sensor and Servo Motors, IP Camera, IR Sensors, Electronic Components, Battery Packs and Aluminum Hardware Structure. This design project is an instrument that would contribute to the growth and development of a certain community, industry or organization if the function and purpose it serves will be utilized well.

Keywords: Robotics technology, Service Robot, hardware, software, Servo Motors

Introduction

Robots are widely used in such industries as automobile manufacture to perform simple repetitive tasks and in industries where work must be performed in environments hazardous to humans [1]. Industrial robots on the one hand and technological innovations in the private sector are of major importance [2]. Mobile robot localization and object pose estimation in a working environment have been central research activities in mobile robotics [3]. Service robot will become an important part of everyday lives that accomplishes a specific task given by the user [4].

The "Multipurpose Mobile Utility Service Robot", was a developed prototype to navigate as a line follower, a fully automated path finder or be remote-controlled. This design project is beneficial to the managers and supervisors of manufacturing industries to achieve full automation with distant moving surveillance to monitor the performance of their people on the workplace. Industrial personnel working in harmful environments will have a means of handling chemicals more safely by being distant on the hazard while controlling and performing their duties. The scientists can use the design for scientific explorations of unexplored terrain and areas with extreme conditions to collect some specimens and capture videos necessary to explain certain phenomena. The design project can also provide an extra helping hand to households with disabilities to get things on and off of their areas. This will serve as their assistant to pick up things they need even without leaving their position.

This is a developmental research using Robotics Technology which aims to make life easier. With the advancement of both hardware and software, robots are also being developed to satisfy the ever-expanding needs of humans. This study was a combination of building and programming a robot which is the integration of mechanical, electronics, and electrical processes to solve complex problems. The computer interfacing was programmed using Visual Basic 2010 Express which is a powerful Graphical User Interface (GUI) based programming platform that is suited to create user-friendly application.

The objective of developing a prototype was obtained considering the achievability and functionality of the design. Majority of the peripherals were operated by servo motors using

Pulse Width Modulation making the programming possible for the proponents. The prototype was made with an imported Bluetooth module, Gripper attachment, Tank Threads, Quad-Track Input_(QTI) Sensors, Ping Sensor and Servo Motors while other necessary parts were bought locally like the Internet Protocol (IP) Camera, Infrared (IR) Sensors, Electronic Components, Battery Packs and Aluminum Hardware Structure.

System Design

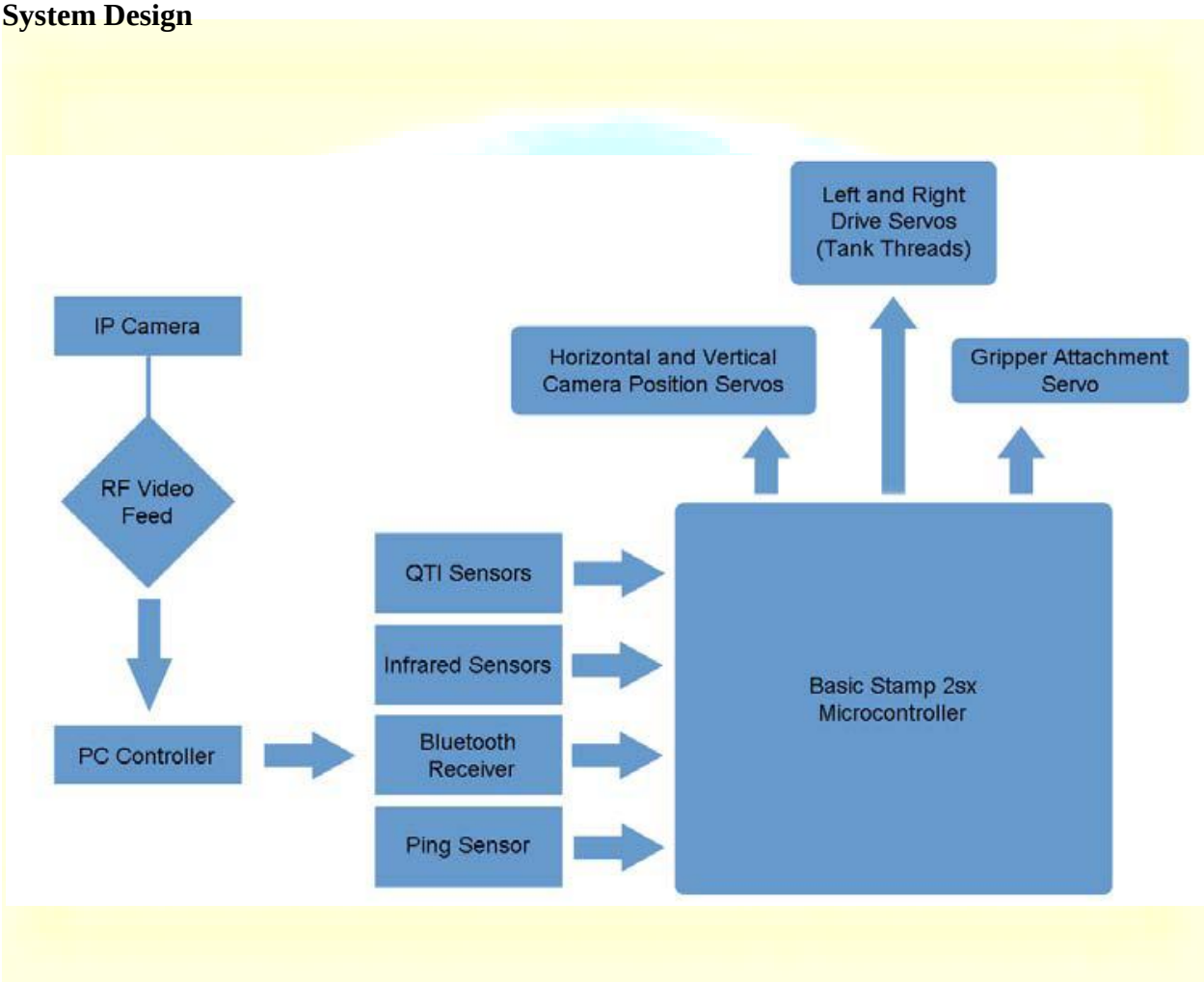

Fig. 1. Multipurpose Mobile Utility Service Robot Block Diagram

Fig. 1 shows the Block diagram which illustrates the interconnection of functional units in the prototype. The PC Controller gets Radio Frequency (RF) Video feeds from the IP Camera while also sending information to the Bluetooth Module of the robot during operation. The Basic Stamp 2sx Microcontroller accepts information from the Bluetooth Module, Ping Sensor, IR Pair

Sensors and QTI Sensors. It also sends information to the Camera servos, Drive servos and Gripper.

Software and Hardware Development

The hardware design is according to the design function on how the robot should work. The designers considered the microcontroller which served as the brain of the robot itself. The designers were to choose from the three microcontrollers that are capable of doing the desired outputs, the V3X Robotics Module, the Parallax Basic Stamp Module, and the Lego NXT Mindstorms Controller. The designers opt to factor out the Lego NXT Mindstorms due to the cost and design simplicity and V3X Robotics Module since it uses a fixed program platform thus, unable to fully customize. Lego Mindstorms is a robotics platform where the robot structure is built with LEGOs [5].

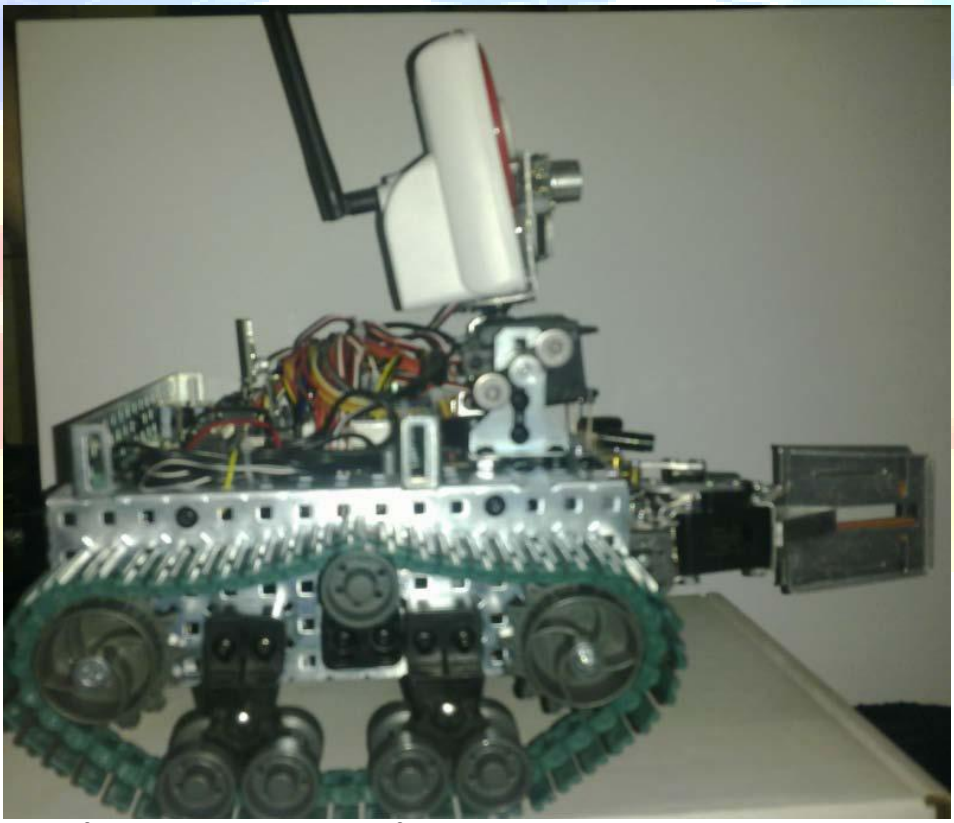

Fig. 2 Side View of the Prototype Design of Multi-Purpose Mobile Utility Service Robot

The Basic Stamp Module is a physical Microcontroller Unit (MCU), which unlike the other two, can be programmed at will. The BASIC Stamp 2 serves as the brains inside of electronics projects and applications that require a programmable microcontroller [6]. The designers considered the input and output of the robot and its parts. Since the chosen microcontroller uses Pulse Width Modulation (PWM), the needed peripherals should agree with it for control. A good combination of Parallax and V3X Robotics items were considered and the compatibility made the programming more difficult. The proponents still managed to tune things up by replacing the Basic Stamp 2 with its variant Basic Stamp 2sx to satisfy the extra processing speed and program space needed.

Since V3X Robotics and Parallax are both USA-based industries, local resellers in the Philippines tend to sell it for prices way too much than expected. This led the designers to directly import their materials to the respective companies to lessen the cost of the project.

The independent IP Camera is placed near the Ping))) Sensor to move with it when the driving servo moves. It is “independent” because it is used mainly as a monitor and it will not affect the overall operation of the robot. Parallax's PING))) ultrasonic sensor provides a very low-cost and easy method of distance measurement and it is perfect for any number of applications that require to perform measurements between moving or stationary objects [7].

The appropriate programming language was also selected for the ease of use for the users. The robot is encoded using PBASIC language which stands for Parallax BASIC, a variant of the BASIC language [8] that is easy to use. It is also considered due to the fact that the Basic Stamp 2sx has a built in PBASIC interpreter that helps lessen the program compilation. The prototype is designed with the proponent’s own “Character-Controlled” Bluetooth communication protocol.

The “Character-Controlled” Bluetooth communication protocol transmits an 8-character, no parity signal with one stop bit. It uses 9600 baud rate and the data contains one alphanumeric character which is then encoded and decoded to ASCII upon transmission. Each character is bound to a specific command which executes when the said character is received.

The computer interfacing is programmed using Visual Basic 2010 Express which is is a free development tool, able to aid in designing and programming simple or complex applications [9]. It is a powerful Graphical User Interface (GUI) based programming platform that is suited to create user-friendly application. The application is programmed to communicate with the robot using the same "Character-Controlled" Bluetooth communication protocol. Visual Basic does not have a native way of controlling Bluetooth peripherals. Using Bluetooth-over-Serial communication protocol it is then, able to use Bluetooth connectivity. It also uses ActiveX Plug-in to communicate with the IP Camera.

Results and Discussion

Different aspects involved in the robotic system design were considered which include the feasibility of the design, the availability and cost of materials, conditions using peripheral devices like Gripper attachment, Bluetooth Module, Tank Threads, QTI Sensors, Ping Sensor, and Servo Motors and the effectiveness of operation. Servos are extremely useful in robotics because of its motors are small and have built in control circuitry, and are extremely powerful for their size [10].

The prototype is designed to navigate in three modes, namely: line follower, path finder, and be remote controlled. It has two main functions: pick-and-place and surveillance. In line follower navigation, it uses the close-proximity infrared detection to detect and command the servo motors where to go by sending the appropriate pulse signals.

The path finder navigation makes use of its infrared pairs and the Ping sensor. The Ping sensor measures distance using sonar; an ultrasonic pulse is transmitted from the unit and distance-to-target is determined by measuring the time required for the echo return [7]. Output from the Ping sensor is a variable-width pulse that corresponds to the distance to the target. It can detect and navigate through obstacles and objects up to 3 meters away and evades objects in a 5 inch radius from the ping sensor.

The remote controlled navigation makes use of the robot's Bluetooth connectivity to send and receive to a controller PC. The controller PC also acts as a monitor through IP Cam visual

feeds. It can effectively communicate with its controller up to 30 meters unobstructed and is halved when obstructed. The gripper attachment of the pick-and-place function can lift 5 cm. wide objects up to 100 grams.

This design does not seek to include the actual acceptable size of a typical mobile robot due to limited availability and cost of large scale industrial component. The line follower navigation is limited in following a continuous black line since the QTI sensors can only detect whiteness and darkness of the track. Since the QTI sensors are located beneath the Robot itself, it cannot be used in uneven terrain thus removing will make it function as path finder.

The design's path finder navigation mode is limited to 3 meters object detection from the prototype. Small objects and too low objects may also be undetectable due to the Ping sensor's sonar limitations. The designers limited the design to operate using Bluetooth connectivity which leads to the 30-meter communication range. The IP Cam also operates on the same range and transmits signals using the frequency of 2.4 GHz. Future studies may upgrade the connectivity using Wi-Fi or similar signals to improve communication range but must use a higher quality IP Cam to permit the operations in wider range. Due to size and available components, the pick-and-place function is limited to lift 5 cm. wide objects up to 100 grams.

The prototype is made considering the achievability and functionality of the design. Majority of the peripherals were operated by servo motors using Pulse Width Modulation making the programming possible for the proponents. Signal strength distance of the Bluetooth module varies depending on the obstacle it runs into. The other devices like the QTI Sensors, Gripper Attachment, Ping Sensor, IP Camera and Servo Motors function well as long as supplied by enough voltage.

During the designing process, the functional parts, principle of operation, and capabilities and limitation of each functioning unit of the system were analyzed. The overall design operated at approximately 4 – 6 Volts DC at 140 +/-50mA using PWM. With the help of the rubber holder, the object is safe and secured. Gripper performance may vary according to battery and servo performance.

The QTI sensors were used as line follower function as long as black lines are detected in its path. The IP Camera Ping sensor can see obstacle about 45 degrees upward and 45 degrees downward from the initial position and also 180 degrees left and right. The IP Camera operated at approximately 5V. The servo motors are controlled using PWM and run in approximately 4-6 volts DC.

Conclusion and Recommendation

It can function as a pick-and-place robot using any of its three modes of navigation; use it for industrial surveillance and security purposes. It can also be used in scientific research to explore and study extreme environments using path finder mode and to do repetitive tasks regularly for household utilities. Robots are designed to do specific task. This makes it costly to get robots for every problem encountered. It is economical nowadays to have a single device that do a handful of things. This led the proponents to the idea of developing a multipurpose robotics design project

The prototype performs task as what the operator dictates it to do with the use of controller. By means of series of experiments, precision in movement was polished. Since the controller of the device is programmed using Visual Basic 2010 Express program; the user can easily operate it without any assistance. Basic controls are self explanatory.

The construction was basic, the block diagram showed the proper interconnection of each part. Some of the parts are enclosed with aluminum metal for protection purposes. The prototype met the desired functionality with efficiency and accuracy. With the use of the Line Following Device, the prototype can function in automatic manner by means of following black lines as path. With the help of the ping sensor as the path finding device and the infrared pair sensor, the device can automatically reroute to avoid obstacle on its path.

Since it is equipped with an IP Camera, it can enable the user to see the entire path. With the use of servo motors, the camera can be controlled 180 degrees left to right and 45 degrees upward and 45 degrees downward from the initial position.

Multi-Purpose Mobile Utility Service Robot is recommended to replace some of man's works, minimize accidents, and for precise output. Future designers can use lighter metal chassis to increase the movement speed of the design. They can design the camera and the Ping sensor a wider range than 180 degrees. Enhance the transmitter and receiver module to provide further control range and control efficiency. Use arrow keys as an alternative basic movement key for the Robot is also recommended.

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