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GPS Controlled Autonomous Walking Robot

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Abstract

The Global Positioning System (GPS) is normally attached to modern cars. It is used to indicate the driver by voice signal to understand the current location and the directions to reach the target location. In this research the GPS is mounted on a walking robot in order to guide the robot along a specified path. Autonomous walking robot is soon to become a very useful system for transporting materiasl from one place to another. They can go even when the path is unstructured. This can be used within a city/town or within a restricted place such as hospital, campuses and industrial work places. When the GPS is used in the walking robot, the signal that is available in GPS unit has to be converted to relevant servo signal to drive the legs of robot. Hence there is an effort of signal processing and conversion to servo signal. The GPS guided walking robot has to have a set of sensors and to have a good level of intelligence in order to take suitable decisions when encountered with obstacles, stationary or otherwise. The GPS has its own accuracy of identified location and this can vary between 1 to 5 meters. The GPS controlled robot reaching a target location with an acceptable accuracy is a standing problem. In this paper, a GPS guided walking robot is designed using an economical Garmin eTrex Vista GPS. The problems of obstacle avoidance and accuracy in localization are addressed and methods are proposed for solving such problems.

Keywords

GPS, BASIC Stamp, Robot localization, obstacle avoidance.

1. Introduction

This paper describes an instrumentation and control of a walking robot that is able to reach a specified destination by using inputs from the Global Positioning System (GPS) unit. The walking robot uses the current position from the GPS as well as a destination point already entered into the GPS unit to continuously compute the angle of turn to reach the desired destination point.

The Basic Stamp 2 module processor is the core element of the system. The user will enter the target location into the GPS through the GPS keypad. The GPS receiver inputs the GPS position information such as the current coordinate, target coordinate, distance and bearing to BASIC Stamp 2 processor for computation. The Basic Stamp 2 uses an algorithm to compute the distance of the target from the current location. BASIC Stamp 2, then, serially outputs this information to a servo controller driver board to control the walking direction of the robot.

This research is divided into six sections that give attention to the BASIC Stamps 2 functioning. The function block diagram can be seen in Figure 1. The Servo Controller Driver board will drive all 12 units servo motor simultaneously and continuously at 180 degrees of rotation. The processor used on the Servo Controller Driver board requires a supply of 5 VDC while the servo motor requires a separate supply voltage between 4 to 7.5 VDC for operation. BASIC Stamp programming will be written on the external PC before downloaded through RS232 serial communication port into BASIC stamp micro controller. PC can be disconnected once the program is completely downloaded or left connected to the micro controller to display the real time data on the monitor.

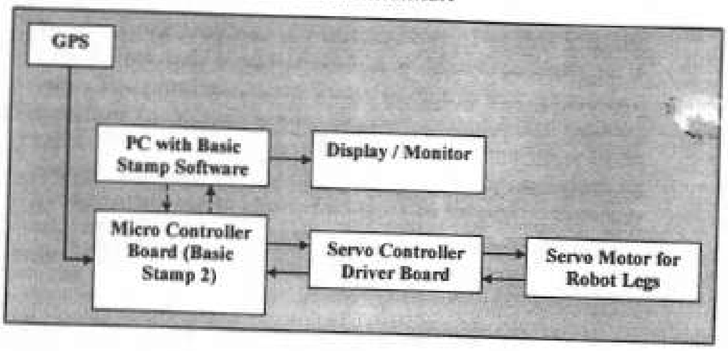

Figure 1 – Block Diagram

The Global Positioning System (GPS) is a location system based on a constellation of about 24 satellites orbiting the earth at altitudes of approximately 11,000 miles. GPS was developed by the United States Department of Defense (DOD), for its tremendous application as a military locating utility. GPS satellites are orbited high enough to avoid the problems associated with land based systems, yet can provide accurate positioning in 24 hours a day, anywhere in the world. Uncorrected positions determined from GPS satellite signals produce accuracies in the range of 50 to 100 meters. When using a technique called differential correction, users can get positional accuracy to within 5 meters or less [1]. The Garmin eTrex Vista GPS (Figure 2)

[2] sends out its data on a simple comma delimited code scheme as shown in Table 1.

Table 1 – GPS Output Data

$GPRMB - Recommended Minimum Navigation Information

$GPRMB, A, 0.66, L, 003, 004, 4917.24, N, 12309.57, W,
1 2 3 4 5 6 7 8 9

001.3, 052.5, 000.5, V * 0B
10 11 12 13 14

#	Data	Comment
1	A	Data status A = OK, V = warning
2	0.66	Cross-track error (nautical miles, 9.9max.)
3	L	Steer Left to correct (or R = right)
4	003	Last waypoint
5	004	Next waypoint
6	4917.24	Destination waypoint latitude 49 deg. 17.24 min.
7	N	North/South.
8	12309.57	Destination waypoint longitude 123 deg. 09.57 min.
9	W	East/West
10	001.3	Range to destination, nautical miles.
11	052.5	True bearing to destination.
12	000.5	Velocity towards destination, knots.
13	V	Arrival alarm A = arrived, V = not arrived.
14	*0B	Mandatory checksum

Figure 2 – Garmin eTrex Vista GPS

2. Software

The microcontroller chosen to implement the software portion of our research is the Basic Stamp 2 [3]. Each BASIC Stamp module contains a BASIC Interpreter chip, internal memory (RAM and EEPROM), a 5 VDC voltage regulator, a number of general-purpose I/O pins (TTL-level, 0-5 VDC), and a set of built-in command for math and I/O pin operations. BASIC Stamp modules (Figure 3) are capable of running a few thousand instructions per second and can be programmed with a simplified, but customized form of the BASIC programming language, called PBASIC. We chose this module because it has 16 I/O pins and two serial communication pins; a facility of USB serial communication port is also available in the module which is sufficient enough for this research requirements. Furthermore, it is relatively easy to program and establish communication between GPS and microcontroller.

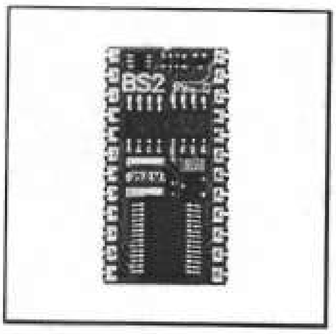

Figure 3 – Garmin eTrex Vista GPS

The biggest challenge that arose in software was determining the angle that the walking robot needed to turn in order to head towards the destination. When the walking robot first starts moving, the information on which direction it is facing, and therefore how much to turn. There are two solutions proposed for this problem. The first is to use three points and the law of cosines to determine the angle to turn. The problem we ran into with this is that we weren't sure how to determine the direction in which the walking robot was initially going. We therefore came up with an alternate solution by using electronic compass which is already available in this GPS [5]. The electronic compass not only gives the angle data but also indicate the directional data for computing its heading.

3. Obstacles Avoidance

We decided to use the ultrasonic sensor (Figure 4) for developing algorithms for obstacle avoidance. The reason for choosing this type of sensor is that:-

- It has a variable detection range of 2cm – 300cm [3-5], which can be changed through the BASIC Stamp programming.
- The accuracies will not be affected by any type of common external radiations. The other sensor type such as Infrared Sensor are affected by external radiation. With this ultrasonic sensor, robot can work day and night easily.
- This is sensor is relatively economical compared to others.
- The obstacles near to the path can also be detected by ultrasonic sensors. However, the infrared sensor may

not detect any such obstacles because Infrared sensor is a directional type sensor.

In addition, we incorporated a one-rotational degree of freedom to the sensor, up to ± 90o, to improve the sensor detection ability. This is possible by using a 180o rotation servo motor driving the sensor. However, the angle of rotation is programmable within the BASIC stamp software.

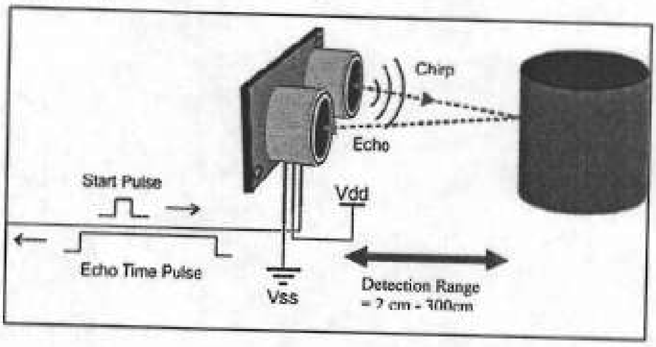

Figure 4 – Ultrasonic Sensor

4. The Robot Controller

The GPS receiver inputs the position information to micro controller for computation (Figure 5). Micro controller, then, serially outputs this information to a servo controller to drive the direction of walking robot. The programming of the microcontroller allows the ultrasonic sensors to interrupt the system when an obstacle is detected. The program will turn the walking robot in the appropriate direction and move forward for a short amount of time. Then the interrupt routine ends and the main portion of the routine takes over (Figure 6).

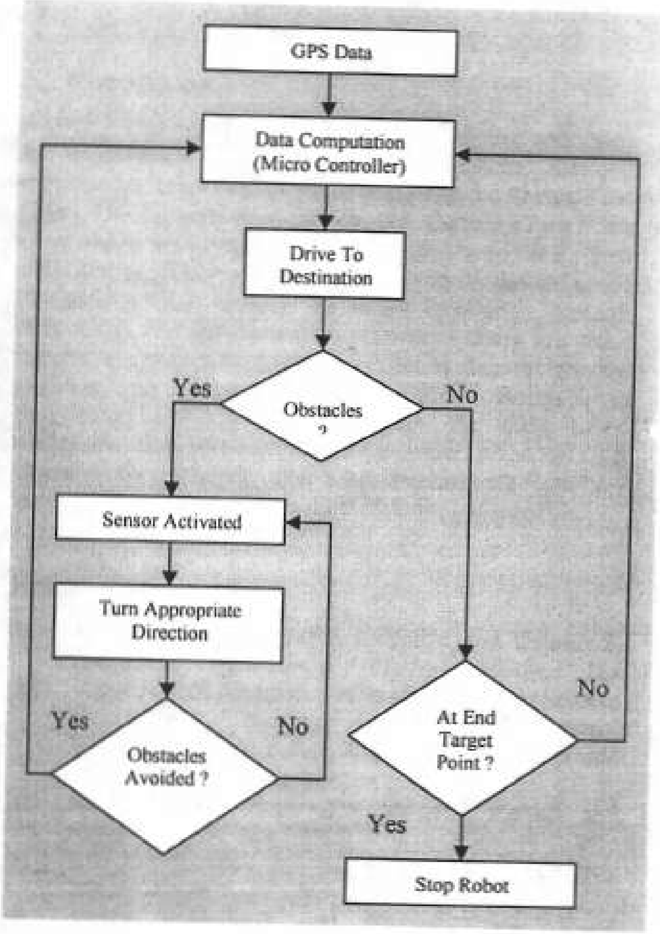

Figure 5 - Software Flowchart For Controller.

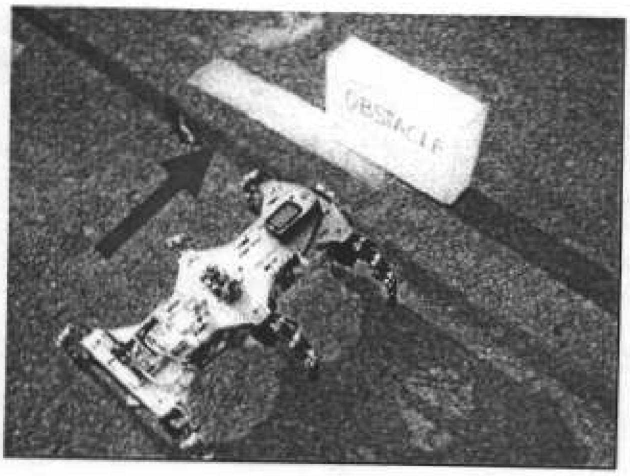

Figure 6.1 – Robot Detect Obstacle.

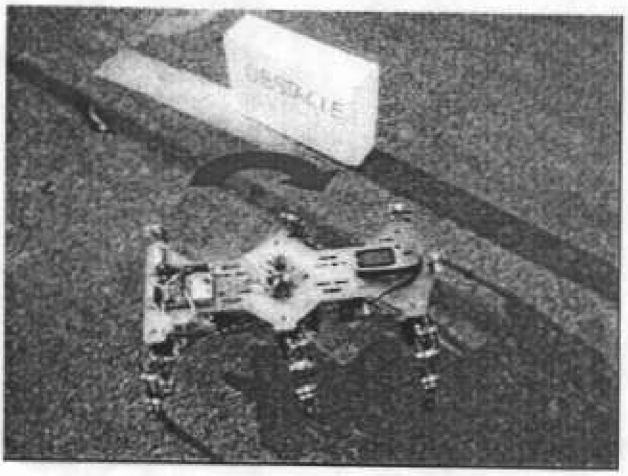

Figure 6.2 – Robot Turn Appropriate Direction.

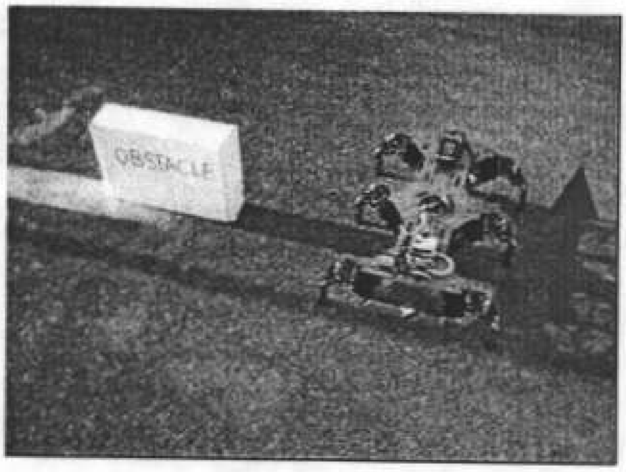

Figure 6.3 – Robot Move Forward Direction.

Figure 6.4 – Robot Move To The Target Direction.

5. Conclusion

A GPS guided walking robot has been developed and tested for its collision free navigation. The BASIC Stamp-2 software has been very useful in designing the navigational tasks. The compass inherent with the Garmin eTrex Vista is an added advantage in the economical type GPS Two rotational ultrasonic sensors are employed for detouring the obstacles without loosing the target location. Through localization has been possible. However, there are some inevitable error in localization. This is due to inherent positional in accuracies of the GPS. Research is progressing towards switching from the GPS based navigation to local sensor based navigation when the GPS is near to the obstacles. This needs a careful study on how the target is identified and a dead reckoning is possible.

References

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