Design of a low cost human following porter robot at airports

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Abstract - **The human following robots is one of the popularly discussed and researched technological areas. Several methodologies were put forward to create such a robotic creature that will respond in accordance with the human action and become a very good companion for the human beings. The aim of this paper is to design and develop a low cost autonomous porter robot for airports, that will become a helping aid for the passengers in many respects. Infrared and ultrasonic technologies play a key role in this work. The idea was experimentally verified with the help of a prototype in which all the proposed technologies are experimentally implemented, and the desired outcome was obtained successfully.**

Index Terms—Ultrasonic sensor, Infrared sensor, human following, obstacle detection, AVR ATmega32

I. INTRODUCTION

HUMAN following robots are an actively researched and developed area due to its scope and applications in daily life. There are several such systems were proposed using IR sensors, laser range finders, charge coupled devices, voice recognition systems, PIR sensors, camera and so on. The human following devices usually have a target tracking system, an obstacle sensing system and a robot control system. Here the system utilizes ultrasonic sensor for target tracking and IR sensor for obstacle tracking.

This is a passenger friendly porter robot which will carry the luggage, performs the luggage checking operation and accompanies the passenger at the air port. The proposed system is developed for replacing the man power requirements by automatic systems. This robot will reduce the time delay and human efforts in luggage management. Luggage management includes metal detection, weight measurement and dimension checking. A hand held device containing necessary manual controls is provided with each robot in order to incorporate a passenger control option for the robot. The passenger can communicate with the robot through the device. For this purpose radio frequency transponders can be used. The robot control sections can be implemented on microcontrollers. A prototype was made and tested and successfully proved its functionality.

This paper deals with the basic principles behind the robot and the various stages of development and testing of the prototype. The first three sections explain the target detection, obstacle detection and robotic control sections respectively. The section four will give the detailed specifications and design of the prototype. And the last section will discuss about the performance and test results of the prototype. The future advancements that can be implemented to the system are also mentioned in that section.

II. THE PROPOSED SYSTEM DESIGN

A. Target Detection

The ultrasonic sensor module is the key element in target detection. The ultrasonic module consisting of a transmitter and receiver sections will detect the human presence. The robot will move forward, right or left in accordance with the detected human presence. The basic principle behind the operation is that the ultrasonic transmitter emitted an ultrasonic wave in one direction, and started timing when it launched. Ultrasonic spread in the air, and would return immediately when it encountered obstacles on the way. At last, the ultrasonic receiver would stop timing when it received the reflected wave. As Ultrasonic spread velocity is 340m / s in the air, based on the timer record t, we can calculate the distance (s) between the obstacle and transmitter, namely:

$$s = 340t / 2 \qquad \text{---1}$$

which is so- called time difference distance measurement principle The principle of ultrasonic distance measurement used the already-known air spreading velocity, measuring the time from launch to reflection when it encountered obstacle, and then calculate the distance between the transmitter and the obstacle according to the time and the velocity. Thus, the principle of ultrasonic distance measurement is the same with radar.

Distance Measurement formula is expressed as:

L = C X T ---2

In the formula, L is the measured distance, and C is the ultrasonic spreading velocity in air, also, T represents time (T is half the time value from transmitting to receiving).

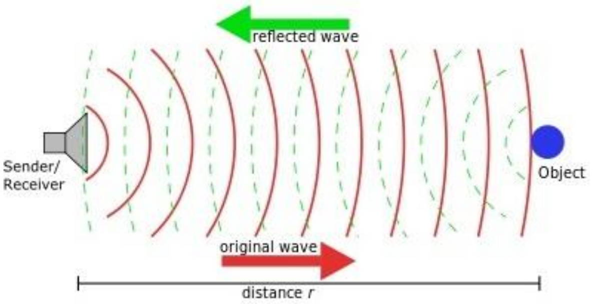

Fig 1. Ultrasonic wave propagation

B. Obstacle Detection

The obstacle detection is done on the robot by providing an infra red eye to it. The infra red eye is the ir transceiver circuit through which the robot detects the obstacles and controls itself either by changing direction for stationary obstacles or by stopping itself, waiting for the obstacle to move away. The transceiver design must be carried out by considering several aspects. The basic optoelectronic components required are the LED at the transmitter and the photo detector at the receiver. IrDA specification requires that the optical channel operate in the near-infrared spectrum from 850 nm to 900 nm. The sensitivity of the photo detector is a function of the wavelength of the incident light. To maximize efficiency, the LED should be chosen so that its peak emission wavelength lies near the peak sensitivity of the photodiode.. Photodiodes (PD) are usually operated under a receive-bias voltage, and can be modeled by the circuit shown in Figure 4. The main photocurrent i_S is generated through the creation of electron-hole pairs when photons from the incident light penetrate the diode. There is a linear relationship between the photocurrent, i_S, and the irradiance, E_e which is a measure of the intensity of the incident light and is given in W/m2. The photocurrent is calculated by:

is=Seff(l)Ee ---3

where S_{eff} is the effective sensitivity of the diode in units of A*m2/W. The sensitivity is a function of the wavelength, and takes into account the spectral sensitivity of the diode as well as the effect of the device's lens. As an example, the Temic BPV22NF is rated to provide 85 nA of photocurrent per 1 uW/cm^2 irradiance. In practice, it appears that the sensitivity is, to some extent, a function of the frequency of the signal. Thus, when comparing photodiodes, the designer should test both the static (dc) and dynamic (ac) performance of the devices.

The current source, i_n , models the inherent noise of the photodiode, principally the shot noise generated by the DG leakage current and the photocurrent generated by ambient light. The noise is white in spectrum and has a spectral density of:

N(f) = 2qIs A^2/Hz ---4

where q = 1.69 x 10^{-19} C , and I_s is the dc component of i_s. The root-mean-square (rms) value of i_n can be calculated by taking the square root of the product of the spectral density I_s, and the bandwidth of the received signal.

The remaining two elements of the model, R_s and C_d represent the series resistance of the diode and the diode capacitance. The series resistance is a fixed value; for the Temic 8PV22NH; for instance, R_S = 400 .

Since the diode is operating under reverse bias conditions, the capacitance C_d is dominated by the depletion capacitance across the PN junction. As a result, C_d is greatly dependent on the applied reverse bias voltage for the BPV22NF photodiode. This characteristic is particularly significant when designing low-voltage receivers, as a low supply voltage severely limits the maximum reverse bias that can be applied to the diode. This ultimately impacts the frequency response of the receiver, and so the designer must ensure that sufficient steps are taken to achieve the required performance. For instance, one can potentially use a voltage multiplier circuit to bias the diode over and above the supply voltage. However, extreme care is needed to ensure that the added circuitry does not in itself introduce problems, such as injecting noise to the receiver.

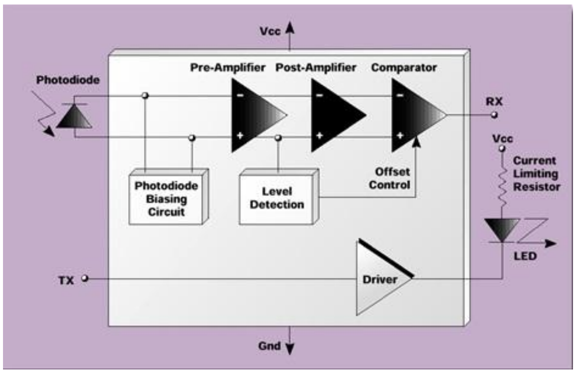

Fig. 2. Block diagram of IR Transceiver

C. Robotic Control Circuitry

The control circuitry can be made around a microcontroller that can handle ultrasonic sensors, IR sensors, motors metal detector pressure sensors etc at the same time. Usually an 8 bit higher end controller will be sufficient for the purpose. The control circuitry includes robot section and the hand held module each requires separate controllers. RF communication is established between the robot and the hand device by using rf transceiver modules on both sides. Specific code number assignment will help to identify between the robot and its corresponding hand device. Block diagram of the proposed system is as given below.

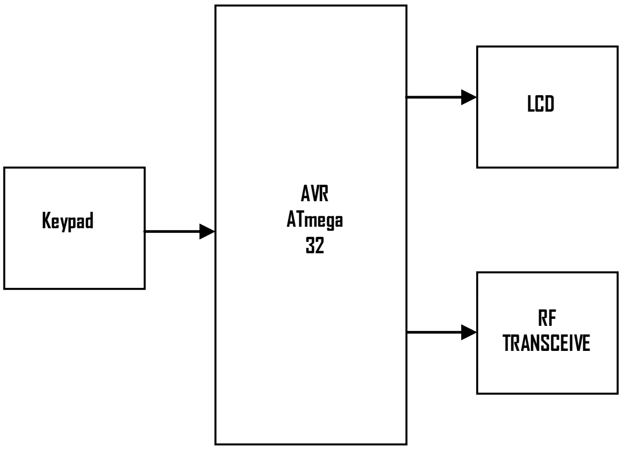

Fig. 3. Block diagram of Hand Device

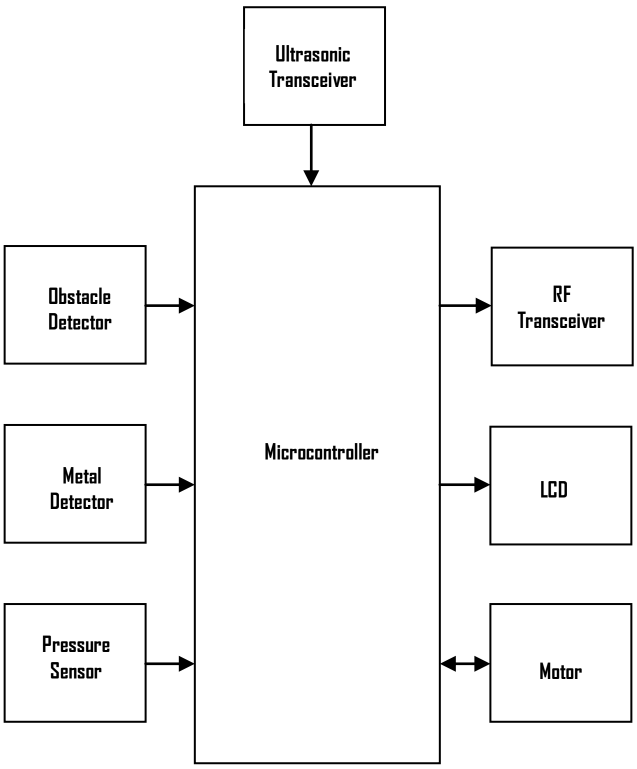

Fig. 4. Block diagram of Robot

The hand device incorporates an RF transceiver section for communicating with the robot. A keypad is provided for the user to input information and required messages are shown on the LCD module. The robot moves on motors that are interfaced to the microcontroller. The target detection component which is an ultrasonic sensor will provide necessary control signals for driving the motor. Obstacle detection can be done through the IR transceiver section. The robot will move only if the passenger clears the metal detection and weight measurement tests.

III. PROTOTYPE DESIGN

The Table 1 shows the components used in the prototype.

TABLE I PROTOTYPE COMPONENTS

Microcontroller	AVR ATmega32
Target Detector	Ultrasonic Transceiver
Obstacle Detector	IR Transceiver
Weight Measurement	Load cell Pressure Sensor
Communication Media	RF Transceiver module

Fig. 5. The Demo Robot

The prototype is made on AVR ATmega32 microcontroller. The prototype strictly follows the proposed system ideas. an avr atmega32 microcontroller. It is the high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller combines 32KB of programmable flash memory, 2KB SRAM, 1KB EEPROM, an 8-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts. By executing instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

Fig. 6. Demo Hand Device

Two ultrasonic sensor modules containing both transmitter and receiver are used for target detection. This helps in the distance measurement function. They can be placed at the front of the robot as two ultrasonic eyes. The variation in left eye will cause the robot to turn left and it moves right by the variation in right eye. The IR transceiver module is doing the role of obstacle detection. A load cell pressure sensor is used for weight measurement. RF transceiver modules are interfaced with both robot section and hand device for establishing effective communication between them. Proper programming of AVR ATmega32 is required for the robot and hand device. This is done by using Atmel AVR Studio 5.0.

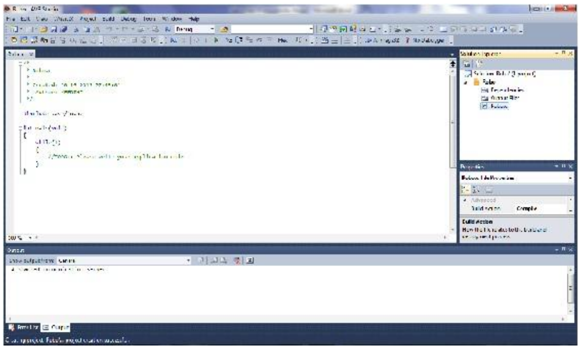

Fig. 5. Atmel AVR Studio Environment

IV. PROTOTYPE PERFORMANCE

The prototype realized all most all the properties of the proposed system. It has a target detection capability of around 1 meter and obstacle sensing power of around 30cm.The ultrasonic sensor uses a frequency of 40kHz for its operation. It gets activated only if the weight of the luggage does not exceed 5Kg and the metal detection results negative. The communication to the robot becomes very smooth through hand device by using RF modules.

V. CONCLUSION

Intelligent aerodrome cart finds very useful applications in present day life. There are several chances for future enhancements and it can be successfully implemented at several places to reduce man power requirements, and to reduce time delay. By reshaping the robot into various other forms with appropriate sensor module interfacings, it can be used in many different industrial and commercial applications such as transportation of materials in laboratory, industries, hospitals etc.

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