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iROBO: Robot Which Can See the World

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***Abstract*—This paper describes the development of a capture and image processing system for a moving mechanism so that it becomes capable of identifying still signboards, human gestures and texts. This research presents a preliminary approach to perform any type of image processing task in MATLAB and then interfacing it with serial port to the microcontroller. The PIC 16F877A has been used for controlling the robot motion. Even though this attempt is aimed at gesture following, the research opens up possibilities for many other algorithms related to signal and image processing that can be implemented using the same low cost hardware.**

***Index Terms*– Robot, MATLAB, Algorithms and Image Processing**

I. INTRODUCTION

AUTOMATION is the need of the hour in 21st century and onwards. It is actually the control of different processes with the least interference of human beings by utilizing control systems. Two chief application areas based on image processing: human interface and machine perception [1]. The latter uses two major fields of robotics and image processing, giving rise to what is commonly known as computer vision [2].

One common factor that lies with most of the image processing tasks is the memory requirement and the delay associated with real-time applications [3]. As it is an undergraduate project so the memory requirement is fulfilled using a mini laptop. It also gives high processing so that images can be processed in acceptable time. For image interpretation template matching is used to match small portions of an image to the stored images. Matching can either be feature based or template based [4].

Our project is about the automation of a vehicle using three different image processing algorithms.

We have automated our robot in three fields:

- Sign Detection
- Gesture Recognition
- Textual Interpretation

In the sign-based mode the robot detects the signs in real time and then using the algorithm interprets and, hence, follows them accordingly. In case of gesture-based mode, it takes instructions in the form of human gestures in real-time and applies image processing on it. Text-based mode takes characters as input, on which processing is carried out.

II. HARDWARE IMPLEMENTATION

The project's hardware includes image acquisition device, microcontroller to control DC motor driven circuitry and two laptops; one inside the robot and one is for monitoring [5]. In the next section all the hardware components are being discussed in detail.

A) Mechanical Structure

Robot structure is more of a vehicle like form having 3 wheels. Front two wheels are the controlled wheels while a single free wheel is used at the rear. The structure is given a presentable look as shown in Fig. 1.

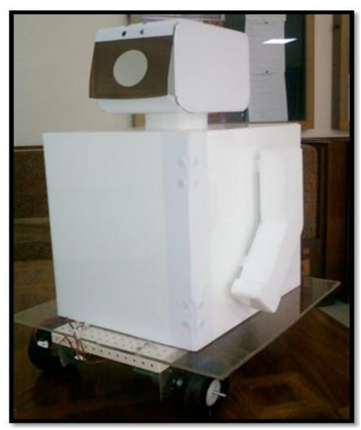

Fig. 1: iROBO, Final Look

B) Image Acquisition Device

The image is acquired through a simple webcam interfaced with PC via USB cable. The camera specs are [4]:

- Still Image Capture Resolution: Up to 16 Mega pixels
- Frame Rate: 30fps at VGA Mode
- Lens: F=2.4, f=3.5mm
- Computer Port: Standard USB 2.0 Port

The important considerations for camera selection include the bits per pixel and the frame rate. As the resolution and bits per pixel increase, the memory requirement also increases and the processor can get overloaded and slow the process. As we are focused only on still images so a lower frame rate is also acceptable compared to the normal rate of 30 frames per second [4].

C) Aspire D270 Laptop

The laptop required is to have less weight and small size and processing to support image processing. The used laptop has following specifications:

- Processor: Intel Atom D2600, 1.6GHz, 1MB L2 Cache
- Screen: 10.1 inch, 1024 x 600 pixel resolution
- RAM: 2GB DDR3
- Hard Disk: 320GB
- Weight: 1.4 kg

D) Electronics Circuitry

L298 is used in motor driver circuit. It is a dual full bridge driver that has a wide operating voltage range and has two built in H-bridge circuits and thus can control two DC motors as shown in Fig. 2. For our requirement these two bridges are used in parallel for a single motor PWM (Pulse Width Modulation) control to handle the current requirement according to the load [6].

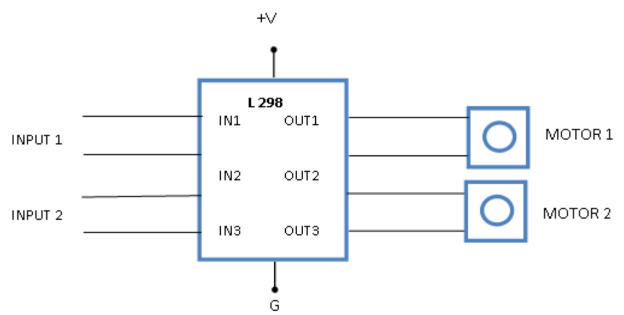

Fig. 2: L298 Basic Connections

E) Microcontroller

The microcontroller chip that has been selected is PIC16F877A. It has been used for motors' speed and direction control and as an interface between PC and mechanical structure through serial communication. It has two PWM modes so two motors can be controlled easily. Microcontroller specs under consideration are [6]:

- FLASH Program Memory 8K
- Data Memory 368 bytes
- Timer0, Timer1 and Timer2
- Two Capture, Compare, PWM modules
- PWM maximum resolution is of 10 bits
- USART (Universal Synchronous Asynchronous Receiver Transmitter) with 9 bit address detection

III. SOFTWARE IMPLEMENTATION

The strategy is being programmed at the embedded system. However through the integrated structure it is already possible to capture and process the image with success. The program is able to detect, interpret and respond to the stored database in order to define the desired action for the robot.

A) MATLAB

MATLAB is very renowned software which is used by engineers extensively for solving the scientific and engineering problems. We can use MATLAB models to access the data in real time and based on that we can take several decisions which again can be seen on the output devices which are interfaced with the computer in real time.

B) MPLAB 8.36

The hardware programming is handled by MPLAB. MPLAB allows source level debugging with the, MPLAB Real IC In-Circuit Debugger and MPLAB SIM Simulator.

C) Sign Detection

Signs used in our project are to be according to the standards. The data base of used signs is shown in Fig. 3.

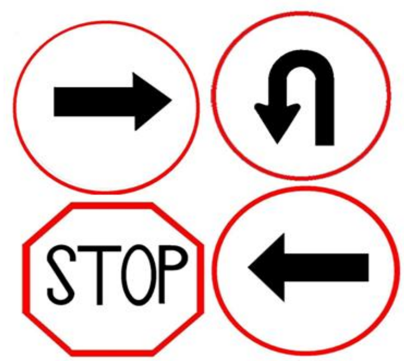

Fig. 3: Signs Database

The layout of signs is same; each sign contains red boundary on a white background, with the sign in black color in the center of the red circular boundary in case of right arrow, left arrow and u-turn and octagonal in case of stop sign (Fig. 3).

The standards say that the diameter of the roundel should be kept 600 mm (23.6"). This size, however suitable for large ranges and height of the detecting objects above the ground. In our case the size is limited because of the height of our robot, which is 560 mm (22"). Therefore, we used the diameter of 200 mm (8"), that is, one third of original [7].

D) Hand Gesture Recognition

In gesture based interfaces the location, orientation and posture of human hand is used as the interactive method. These interfaces are very attractive for the user because they are un-tethered and very flexible, no gloves needed to be worn and can be deployed anywhere [8].

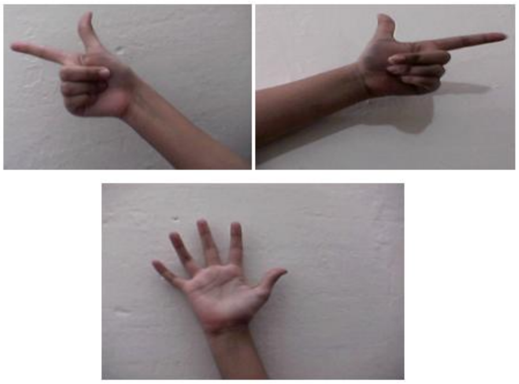

Fig. 4: Hang Gestures Database

E) Character Recognition

As an extension of the project we have implemented character recognition and gesture recognition. For this purpose a database has been built and stored signs can be detected and interpreted to move the robot in the desired direction.

L R

S U

Fig. 5: Characters Database

IV. SYSTEM BLOCK DIAGRAM

A simple webcam is used to capture the view. Captured frame will be processed by a processing device, in this case a laptop, the software will detect the input image sign, interpret it through image processing and take the decision. This decision is then sent to the microcontroller though serial interface and microcontroller will then drive the motors to move the structure according to the detected sign. The block diagram of the system is shown in Fig. 7.

V. CONCLUSION

The objective of this research project was to develop low cost moving mechanism as a base for testing embedded vision and image processing algorithms. This attempt can be extended to 3D vision applications to give more mobility and better performance. Furthermore, the project can be extended using DSP boards for processing images and detecting moving targets [9].

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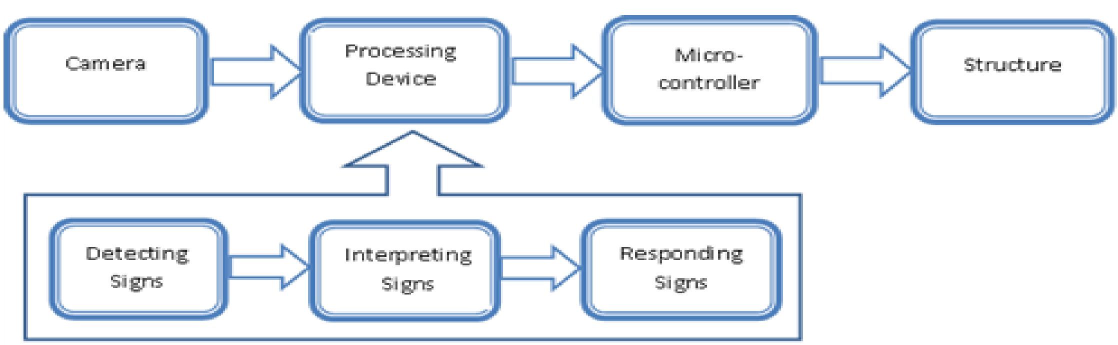

Fig. 6: System Block Diagram