ResearchGate

See discussions, stats, and author profiles for this publication at: https://www.researchgate.net/publication/260250156

Implementation Of Vision Based Object Tracking Robot

Conference Paper · May 2012

DOI: 10.1109/ICIEV.2012.6317485

CITATIONS
8

READS
3,829

3 authors, including:

Abdullah Nahid
Macquarie University
122 PUBLICATIONS **2,175** CITATIONS

SEE PROFILE

Abdullah Al Mamun
Daffodil International University
18 PUBLICATIONS **148** CITATIONS

SEE PROFILE

All content following this page was uploaded by Abdullah Nahid on 20 February 2014.

The user has requested enhancement of the downloaded file.

Implementation Of Vision Based Object Tracking Robot

Kazi Mahmud Hasan, Abdullah-Al-Nahid, Abdullah Al Mamun

Electronics and Communication Engineering Discipline
Khulna University
Khulna, 9208, Bangladesh
{shuvro_eceku07, nahidku,ronee_ece04 }@yahoo.com

***Abstract* - This paper introduces a vision based object tracking robot which is driven by wheels and controlled by a computer along with software. The objective of this project is to design a robot which is automatically controlled by computer to track and follow a colored object. Emphasis is given on precision vision based robotic applications. Image acquisition by the robot is achieved by using a PC-based webcam, then it is send to image processing software for further processing. The overall paper describes a visual sensor system used in the field of robotics for identification and tracking of the object.**

Index Terms* – *Webcam, filter, binary image, robotic vision, steering.

I. INTRODUCTION

The word robot was introduced to the public by the Czech interwar writer Karel Čapek in his play R.U.R (Rossum's Universal Robots), published in 1920. The play begins in a factory that creates artificial people (robots) which is somewhat like modern androids. Robots are electric machines having ability to perform tasks or actions on given electronic programming. As mechanical ways of performing various tasks have been discovered and the development of mechanics and complex mechanisms still going on in full swing, the necessity of human labor has been reduced tremendously. Initially machinery was mainly used for repetitive functions. Automation is desperately needed to handle task of our day to day life [1]. So with the development of science and technology more complex machines have been developed.

Object detection is a fundamental basis of artificial intelligence and robotic vision system [2]. Object detection methods are used in various fields like science, engineering, medical applications. It is necessary for surveillance applications, guidance of autonomous vehicles, smart tracking of moving objects etc. This paper deals with only object detection in robotics. A camera is used for image acquisition and MATLAB is used to process it. The camera works as the eye of the robot. In order to develop a stable and useful vision based robot proper study and accurate model regarding image processing are very much necessary [3][4]. The entire paper is mainly divided into three parts which includes image processing, algorithm regarding object tracking and steering mechanism of the robot.

Designing mechanical model and writing program for robots are difficult as the scale and applications of robots continue to grow. This paper describes our attempt towards designing simple and effective algorithms which is equivalent to existing huge and far more complex algorithms. Most of the robots made previously are expensive and complex but this robot is very much cost effective, lightweight and straightforward than existing robots like iBOT.

II. BLOCK DIAGRAM

The overall process consists of acquiring image using a webcam, then processing it using MATLAB. Based on the processing, control signals are generated automatically which is fed to the robot driving motors so that the motors can perform necessary movements to follow any particular object. A block diagram is given below to highlight the entire process.

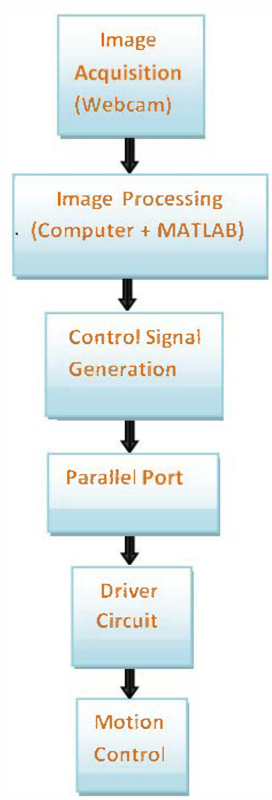

Fig. 1 Block diagram of entire system.

III. Image Processing

1) Image Acquisition: The control of the robot is a dynamic process where images are taken continuously using camera; processing them, find the required information like position and orientation of an object and finally generate control signals to perform required movement. Image acquisition is the first step in vision based robotic system. The Image Acquisition toolbox of MATLAB provides support in this regard. To start working in real time environment a functional USB webcam is connected to the PC.

In order to take images by the webcam, first video input object has to be created and video stream has to be viewed.

Then a video stream is available and still images are captured from it.

Images in MATLAB are 3D matrixes. The matrixes are

(1) I(:,:,1)
(2) I(:,:,2)
(3) I(:,:,3)

Where 'I' is the captured image.

2) Detecting Color Region: The next step in tracking the object is to detect and isolate the color of the object. RGB image comprises of three basic colors red, green and blue. First these three colors are separated from the original image (3D) matrix and three different matrixes are formed.Suppose the matrixes are:

(1) R= RGB(:,:,1) [Red color component matrix]
(2) G= RGB(:,:,2) [Green color component matrix]
(3) B= RGB(:,:,3) [Blue color component matrix]

Now the corresponding intensities of red, green and blue color components are calculated, which are very much necessary for object region detection.

Let the minimum value of red, green and blue color component be 'r1', 'g1' and 'b1'. The maximum values are 'r2', 'g2' and 'b2' respectively. Let the expected object is 'X'. So 'X' can be found by simple logical equation as stated below:

X=(R>=r1&R<=r2)&(G>=g1&G<=g2)&(B>=b1&B<=b2)

Here 'X' is a binary image containing '1's and '0's. Where '1' means presence of color (white) and '0' means absence of color (black).The opposite is also true if 'X' is complemented. For this robot simple form is used. In the following figure below let red color be the object and next it is detected (white region) containing noise.

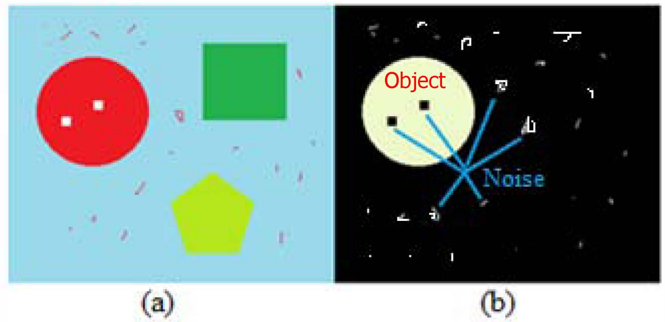

Fig. 2 (a) Original RGB image
(b) Image after applying logical conditions containing expected region and noise

2) Filtering The Binary Image Containing Detected Object (Noise Remove): The binary image obtained above has quite a lot of noise (unexpected color component scattered throughout the image). For high performance robotic vision any unexpected object must be completely removed. There are several functions available in MATLAB to remove noise in an Image. The most commonly used filtering functions for binary image are imerode(), imdialate(), imclose(), imopen() and imfill() [5][6][7][8]. For this robot three basic functions are used.

The function imclose() performs morphological closing operation. It fills the gaps between two objects and smoothens the edges. The degree and type of smoothening and joining depend on the structuring element, Structuring element is the basic shape which is used to perform the operation. The structuring element can be a disk, a diamond, a line, etc.

The resultant image after morphological closing operation is given below.

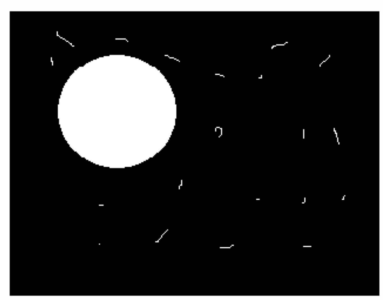

Fig. 3 Image after applying morphological closing operation.

It is seen that this filtering operation fills the holes within object. This filtering operation can also be done by the function imfill().

The filtered image still contains noise. Many scattered color components may be found throughout the image plane. To remove the scattered color components the function imopen() can be used.

The final output of the filtering process is a noiseless image containing only the expected object region as follows.

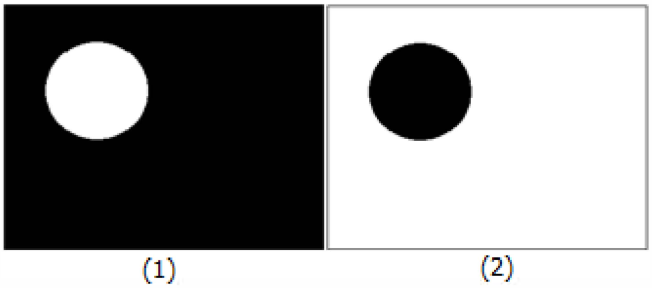

Fig. 4 (1) Image after applying morphological opening operation
(2) Complemented form of filtered image.

3) Multiple Object Handling: In real time situation it may happen that the robot tracked more than one similar color object. So it is difficult to choose which object the robot should follow. The technique used by this robot is to follow any particular object and reject others. But which objects should it reject? For multiple objects, this robot will selectively keep the largest object and reject objects smaller than the largest, even if the object has only one pixel less than the largest one.

Suppose 5(3) is the filtered binary image. After applying multiple object handling technique the resultant image is 5(4) containing only the largest region 'C'.

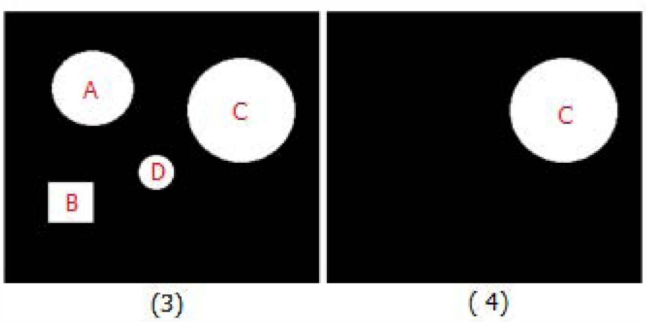

Fig. 5 (3) Multiple object detection
(4) Only the largest object is selected others are rejected.

4) Center Calculation: Finding the appropriate center coordinate (Pixel Coordinate System) is very important for this robot. If the center point is not properly calculated the robot will malfunction and it will not be able to track and follow the object. MATLAB provides built-in function to calculate center point of any region.

Alternate way of calculating the center coordinates is to apply simple geometry of finding center of gravity (CG) which is faster process than using built-in MATLAB function. That's why this process is used for computing center coordinate of the object.

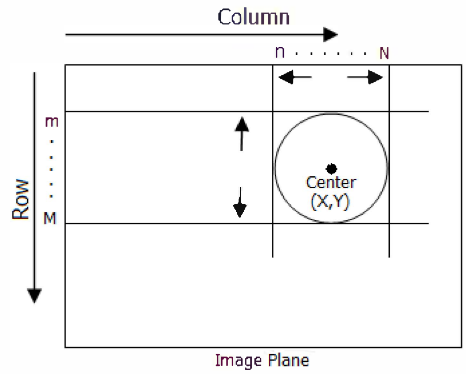

Fig. 6 Geometric calculation for center coordinates.

The equations of center coordinates are

$$X = \frac{Sum\ of\ column\ Numbers\ having\ \text{'1'}}{Total\ Number\ of\ columns\ having\ \text{'1'}}$$

$$So,\ X = \frac{\sum_n^N Xn}{N-n+1}$$

$$Y = \frac{Sum\ of\ row\ Numbers\ having\ \text{'1'}}{Total\ Number\ of\ rows\ having\ \text{'1'}}$$

$$So,\ Y = \frac{\sum_m^M Ym}{M-m+1}$$

A program was written to implement those equations for finding center coordinates. Those equations provide center coordinate which is nearly hundred percent accurate and several times faster than any other process.

IV. ALGORITHM

The robot takes images of its surroundings repeatedly and tracks the expected object and generates controlling signals based on the position of the object on the image plane [9].

Based on camera principles the image plane is divided into five segments for five different commands. The location of the object keeps on changing as the position of the camera changes. This principle leads to develop five different commands. The commands are forward, backward, left, right and stop. The following figure shows the image plane with corresponding segments along with a tracked object. The algorithm ensures guaranteed tracking of the object if the object is found anywhere on the image plane.

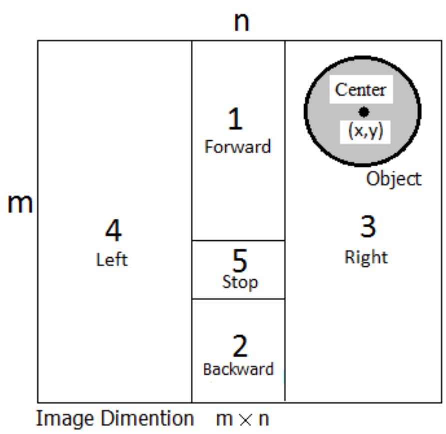

Fig.7 Different segments of image plane.

The algorithm is developed using MATLAB to follow the object. First the image is taken and object region is detected. Then the center coordinate it calculated and conditions are applied to find the corresponding image segment. If the center of the object is in segment 1 then the robot goes forward. The robot goes backward for segment 2. It turns right for segment 3 and left for segment 4 and if the center is in segment 5 the robot stops moving. The overall controlling process is given in the block diagram below.

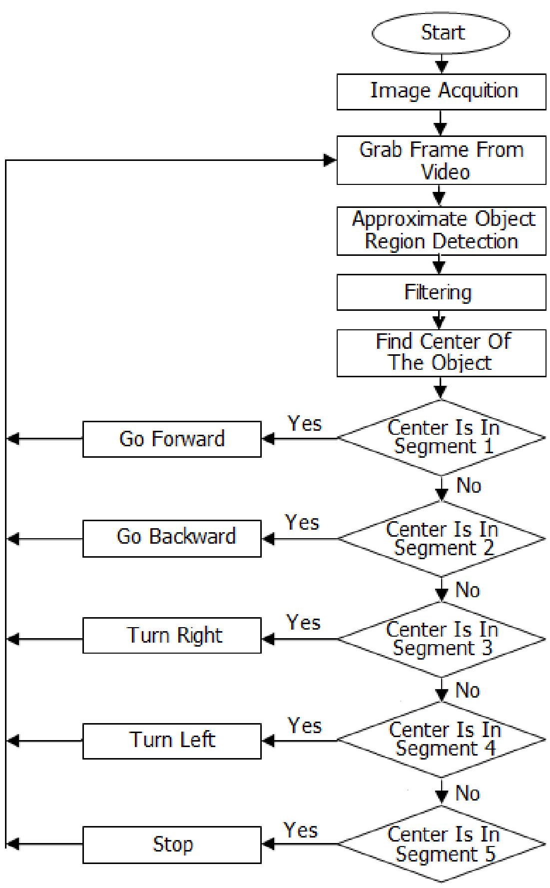

Fig. 8 Algorithm for object tracking.

Two motors are used to drive the robot. The processing unit generates control signals which is then send to the parallel port's data pins and finally fed to the driver circuits of the motors. The process is given in Fig.9.

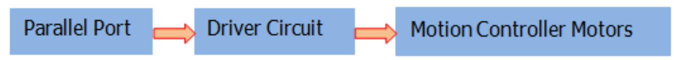

Fig. 9 Computer and hardware interfacing.

Two driving motors moves simultaneously to follow the object. The movement is controlled automatically by the computer. The movements of the robot based on the image processing are listed in the table below.

No.	Status	Command	Left Wheel	Right wheel
(1)	Center in segment 1	Forward	Forward	Forward
(2)	Center in segment 2	Backward	Backward	Backward
(3)	Center in segment 3	Right	Forward	Backward
(4)	Center in segment 4	Left	Backward	Forward
(5)	Center in segment 5	Stop	Stop	Stop

Table. 1 Movements of the robot.

IV. Motor Driver and Steering

1) Motor Driver Circuit: A detailed driver circuit is shown in the following figure. In this circuit the primary elements are 6V relays. Relays are electromechanical switches that can switch between two circuits. Here when voltage is applied, say to input 'S', it's concerning relay will switch from ground to Vcc which applies voltage to the left DC motor and finds ground through other relays. So the use of the relay based driver circuit gives a very low resistance path to the motors.

Relays help provide much greater current to the motors than semiconductor driver circuits. This circuit provides built in dynamic motor breaking ability which gives extra strength to the steering mechanism. Diodes are used to protect the transistors from damaging due to reverse magnetic field. The driver circuit showed better performance than traditional H-bridge motor drivers like L293 or L298.

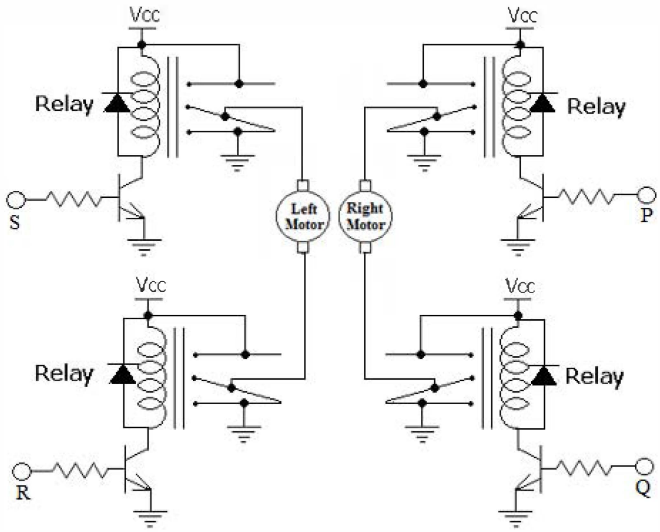

Fig. 10 Driver circuit of the robot.

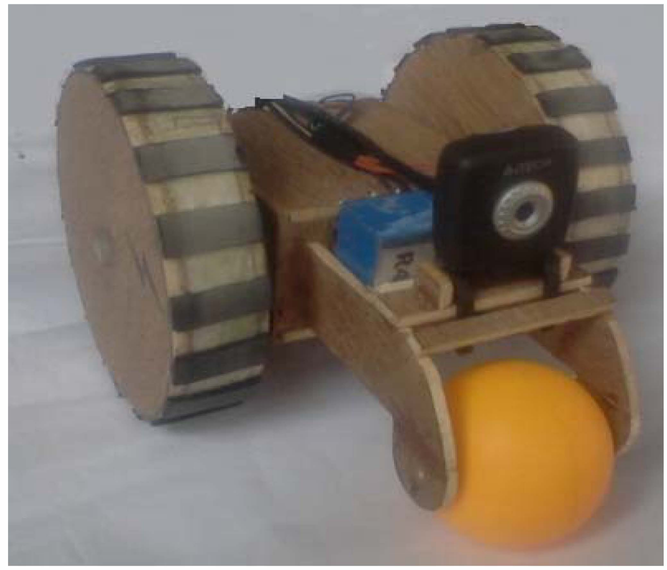

Fig. 12 Actual photo of the robot.

2) Driving And Steering Mechanism:

Two DC geared motors are connected, one to each of the two drive wheels at the right and at the left of the robot's base. Those two motors are responsible of driving the robot backward and forward as well as steering in any required direction. A free running wheel is set in front of the robot.

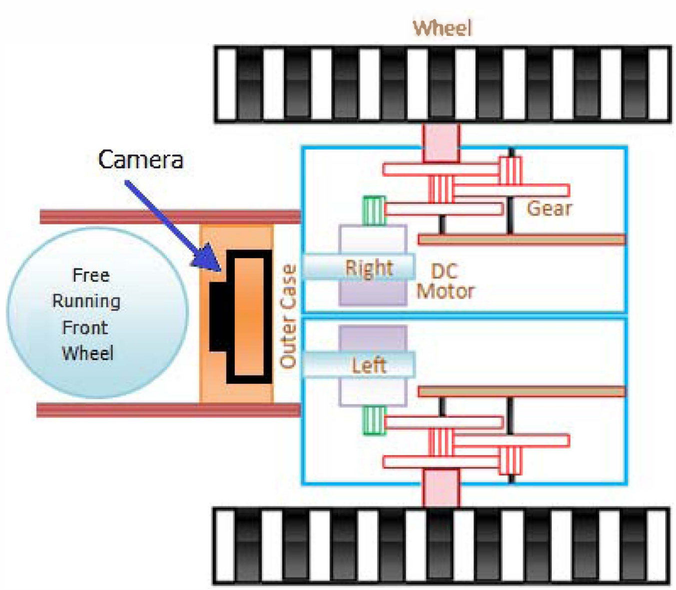

Fig. 11 Internal arrangement.

V. CONCLUSION

The concept of the robot presented here in this paper makes the use of webcam for acquiring images and instructions from computer to perform physical movement. Among the important features of this robot is that any of its physical movements can effectively be controlled within millimetre accuracy through the use of software. Controlling process has been made much more accurate at the cost of programming complexities. The robot is far more cheaper than any other existing equivalent vision based robot. The programming in software made it possible to provide adequate signals with minimum time delay which enabled the robot to manoeuvres fluently. Further modification of this robot includes giving it additional sensors like sonar and infrared [10]. More powerful program will be written using fuzzy logic and neural networks [11][12].

REFERENCES

[1] Professor S. G. Tzafestas, Robotics Springer, Intelligent Systems, Control, and Automation: Science And Engineering Volume 43.

[2]Vincze,M.; Ayromlou, M. & Kubinger, W (1999). An integrating framework for robust real-time 3D object tracking, Proceedings of the First International Conference on Computer Vision Systems,pp. 135-150, January 1999, LasPalmas, Spain.

[3]Buker U. et alii (2001), Vision-based control of an autonomous disassembly station, Robotics and Autonomous Systems, Vol.35,pp179–189robots. Neural Networks 11, 1461–1478 (1998)

[4] J. Kramer and M. Scheutz, “Development environments for autonomous mobile robots: A survey,” Autonomous Robots, vol. 22.

[5] Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, ‘Digital Image Processing Using MATLAB’.

[6] An Introduction to Digital Image Processing with MatlabAlasdair McAndrew School of Computer Science and Mathematics Victoria University of Technology.

[7] Ankur Agrawal ,IIT Kanpur, 'Elementary Introduction to Image Processing Based Robots'.
[8] Tim Morris , 'Computer vision and image processing', Basingstoke : Palgrave Macmillan, 2004.
[9] James Bruce, Tucker Balch, Manuela Veloso, 'Fast and Inexpensive Color Image Segmentation for Interactive Robots.
[10] M.J.Chantler, 'Detection and tracking of returns in sector-scan sonar image sequences'.
[11]Floreano, D., Mondada, F.: Evolutionary neurocontrollers for autonomous mobile robots. Neural Networks 11 (1998) 1461-1478
[12]Hagras, H., Pounds-cornish, A., Colley, M., Callaghan, V., Clarke, G.: Evolving Spiking Neural Network Controllers for Autonomous Robots. Proceedings of the 2004 IEEE International Conference on Robotics and Automation (2004) 4620—4626.

View publication stats