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Dynamic Ball Tracking and Hitting Robot Using Vision System

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ABSTRACT: A ball tracking and hitting robot is designed by using the stereo vision system and Cartesian robot setup. The setup is done to identify a moving ball in space and then hit it by using the Cartesian robot. The vision system is used to identify the object and track its projected path from the initial frame rates of the vision and then find the destination of the ball trajectory. For the ball trajectory a suitable algorithm is developed based on the image frames and the spatial geometric location. The captured images are processed and analyzed for the destination location. The destination geometry detail is calculated and the signals are given for the servo motor which drives the robot to the desired location.

LINTRODUCTION

Many applications require tracking of 3D objects in space or in surface moving with a velocity. The object has to be tracked and some application has to be done with input from the object. This project is aimed at tracking of a ball and hit it using the robotic assembly that can move in a specified work volume area. Visual Servoing is the technique used to capture the ball in 3D and 2D space. Ball tracking can be done through algorithm. For implementing the concept the video frames of the ball has to be captured. By using the first few frames, the velocity and trajectory at which the ball travels can be determined. The sensor system must provide estimates of the object trajectory as early as possible. High accuracy must be obtained, so that the best possible hitting position can be computed and signals can be sent to the actuator for a faster response time. Inverse kinematics is used for the robot control. Two cameras are used to track the ball one from the side and other from the top which is the input for the digital image analysis. After analyzing the images, the control algorithm sends the directions for the motor which does the robot operations. The robot can be used for entertainment purpose. But the technique behind the project can be used in industrial needs.[1]

First the hardware selection is made for the project, a guide rail is used for the X axis movement. By using the Proximity switch, X axis movement can be controlled and limited to its ends. Then by using the Quadrature Encoder HEDS 9100 step increment can be achieved.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

X axis can be traversed for 52cm. The encoder has 500CPR (counts per revolution), so a resolution of approximately 1mm can be achieved for the setup. The encoder is used to control the DC Motor which is used for the linear movement of the X axis of the Cartesian robot. A pull type solenoid is placed over the X axis which is used for the ball hitting operation.[2]

II.NEED FOR THE PAPER

The computer vision technique is cheaper compared to special image processing processors. The image analysis technique is effective in identifying the ball in the 3D as well as 2D space which is moving with a velocity. Here the robot works based on the image sequence. Overall it must have a faster response time. If this is achievable then this concept can be implemented in industrial applications where more precise control movement is required.[3]

III.OBJECTIVE OF THE PAPER

Many applications require tracking of 3D objects in space or in surface moving with a velocity. These objects have to be tracked and some application is done with input from the object. This project is aimed at tracking of a ball and hitting it using the robotic assembly that can move in a specified work area. This technique can be used in industrial applications, automobiles and in hawk-eye prediction of ball trajectory in cricket and tennis.[4]

IV.OUTLINE

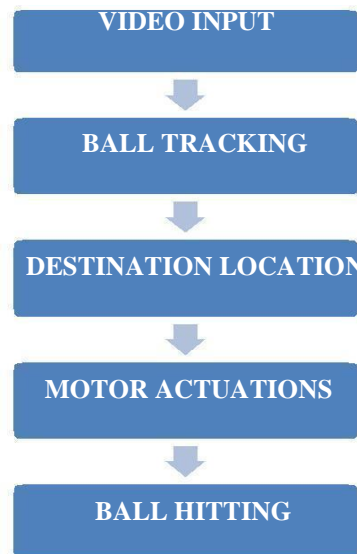


Figure 1.1 Outline of the Paper

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

The outline of the project is depicted in the Figure1.1. The first few frames of the video input are used for the analysis part. By using the images from the video input the ball tracking is done through the RLS algorithm which has been discussed later. By implementing this algorithm the destination location can be predicted and the controller sends the desired signal for the actuators which direct the solenoid to move to the predicted location and hit the ball.[5]

V.HARDWARE SETUP AND TESTING

The robot used is the single axis Cartesian robot with X coordinate. The motor interfacing is used to control the movement of the robot axis. The required linear position can be achieved through the movement and it can be stopped accurately using the encoder (positioning) and the end limits can be controlled by the proximity limit switches. The encoder used has a CPR of 500 which can be used for the precise movement.[6]

By using the encoder the X-axis can be moved with a resolution of 1mm per count. The fabrication of the Cartesian robot . The hardware setup works to hit the ball, for this the ball has to be tracked and inputs have to be given to the hardware.

VI.BALL TRACKING

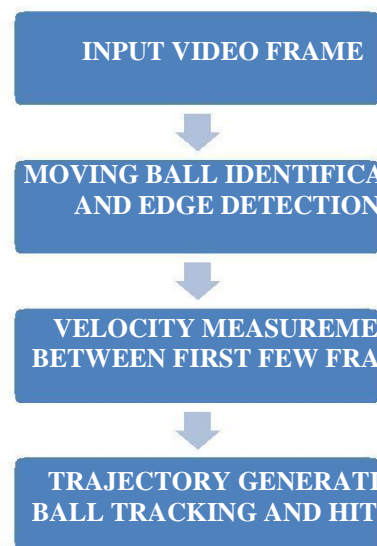


Figure 1.2 Ball Tracking Method

The above Figure 1.2 is the flow control for the ball tracking algorithm. For building ball tracking algorithm the input video frame has to be fed to the system where image analysis is done. If a moving object enters the camera work area the image sequence has to be recorded frame by frame. [7]The object outline, colour and dimension have to be identified to confirm it a

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 7, July 2015

ball or not. Using the data from the video input the edge can be detected. Next parameter to be identified is the velocity of the ball, this can be done through the first few frames of the ball image. The time between the frames have to be measured, for the first three to five frames and with corresponding to time and distance travelled. The velocity of the ball can be determined. The flow control for the ball tracking algorithm is implemented, where the trajectory generation, ball tracking and capture is done through Recursive Least Square (RLS) algorithm. The target trajectory estimate is discussed in section 8 of this paper.[8][13]

VII.VISUAL SERVOING

3D visual tracking and catching of a flying object can be done using the visual servoing technique. There are two basic approaches to visual servo control: Position-Based Visual Servoing (PBVS), where computer techniques are used to reconstruct a representation of the 3D workspace of the robot, and actuator commands are computed with respect to the 3D workspace and Image- Based Visual Servoing (IBVS), where an error signal measured directly in the image is mapped to actuator commands.

In most of the research done in robotic catching using PBVS, the trajectory of the object is predicted with data obtained with a stereo vision system and the catching is achieved using a combination of light weight robots with fast grasping actuators. A major difference exists between motion and structure estimation from binocular image sequences and that from monocular image sequences. With binocular image sequences, once the baseline is calibrated, the 3-D position of the object with reference with the cameras can be obtained.[9][12]

VIII.TARGET TRAJECTORY ESTIMATE

Taking 3D points to a 2D plane is the objective of projective geometry. The approach to determine motion consists of two steps: 1) Extract, match and determine the location of corresponding features, 2) Determine motion parameters from the feature correspondences.

8.1 RLS Algorithm

The Recursive least squares (RLS) adaptive filter is an algorithm which recursively finds the filter coefficients that minimize a weighted linear least squares cost function relating to the input signals. This is in contrast to other algorithms such as the least mean squares (LMS) that aim to reduce the mean square error. In the derivation of the RLS, the input signals are considered deterministic, while for the LMS and similar algorithm they are considered stochastic. Compared to most of its competitors, the RLS exhibits extremely fast convergence. However, this benefit comes at the cost of high computational complexity.[10][11]

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Vol. 4, Issue 7, July 2015

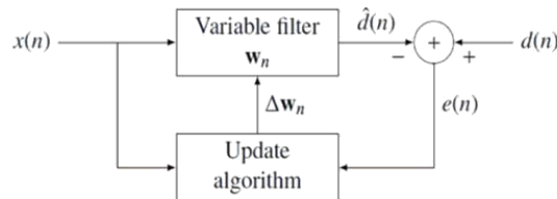


Figure 1.3 RLS adaptive filter

- selecting the filter coefficients
- w_n updating the filter as new data arrives
- $e(n)$ error signal
- $d(n)$ desired signal

IX.SOME APPLICATION

- Table tennis playing robot.
- hawk-eye prediction of ball trajectory in cricket and tennis.
- Used as a safety feature in automobiles Lane departure system and Vision system

X.CONCLUSION

This project implementation of a ball catching task using Cartesian robot has been carried out. The robot can catch an object flying in three-dimensional space using Recursive Least Squares (RLS) algorithm to extract and predict the position of the object from one feature correspondence from only vision system. A complete literature survey has been carried out for the dynamic tracking of ball. The object trajectory path can be obtained successfully even under high noise images. The recursive estimation technique has numerous advantages over other methods currently in use. First, using only one feature point, the issue of feature point's correspondence is simplified. Another advantage is the recursive nature of the computations makes it suitable for real-time applications. Current research is directed towards the study of different control approaches to increase the catching range of the manipulator under noisy images.

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Vol. 4, Issue 7, July 2015

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