Robotic Arm-The Ball Catcher

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Abstract- Catching a thrown ball with a hand is not easy neither for humans nor for robots. It demands for a tight interplay of skills in mechanics, control, planning and visual sensing to reach the necessary precision in space and time. Because of this, ball catching has been used for almost 20 years now as a challenging benchmark system to develop and test robotics key technologies. Here we propose a high speed and intelligent robotic arm set up which will capable enough to catch the short range thrown ball in specified environment. The main technique used is a stereo vision system to tracks the ball and predicts the balls trajectory then the point and time required to reach at destination point, and in which orientation the robot should intercept the ball on its trajectory, is determined. Once robots calculate the desired parameters it will try to catch the ball. Expected outcome of the proposed system is to catch the ball by calculating the coming ball path using computer vision techniques and move the robotic arm in order to catch the ball.

Keywords- robotic arm ,trajectory, desired parameters, computer vision techniques.

I. INTRODUCTION

Robots can be autonomous or semi-autonomous. Many of the today’s robots are inspired by nature. They are also contributing in the field of bio-inspired robotics. Robots replace humans in the assistance of performing some repetitive and dangerous tasks which humans prefer not to do, or are unable to do due to some limitations. Recent years have witnessed a significant change in robotics research. The research emphasis appears to shift from the development of robots for structured industrial environments to the development of autonomous and cooperative mobile robots operating in unstructured and natural environments, such as homes or planet surfaces.

The autonomous robot performing the number of challenging task such as cleaning of hazardous material, surveillance, rescue operation, battle field etc. In the industries, ports and agriculture have the necessary loading capabilities, so that they widely used the wheeled mobile robot. Using wheeled mobile robot is the effective way to promote the factory automation.[1] In recent years, the development of robotic movement has grown rapidly and the visual techniques have also been applied widely. From the simple image processing techniques to complicated image recognition skills, the latest technology is to imitate the stereo vision of human eyes and to track or operate on fast moving objects. Catching a fast moving object can be used to describe work across many subfields of robotics, sensing, processing, actuation, and systems design. The reaction time allowed to the entire robot system: sensors, processor and actuators is very short. The sensor system must provide estimates of the object trajectory as early as possible, so that the robot may begin moving to approximately the correct place as early as possible. High accuracy must be obtained, so that the best possible catching position can be computed and maximum reaction time is available. Smart sensing, object tracking, motion prediction, on-line trajectory planning and motion coordination are capabilities required in a robotic system to catch a thrown ball. To successfully catch a flying ball, a tight interplay of fast perception, a good catching strategy, body control and dexterity is needed to achieve the necessary precision in space and time.

In all the works the general setup is in principle is the same: a stereo vision system tracks the ball and predicts the balls trajectory, then the point and time, where and in which orientation the robot should intercept the ball on its trajectory, is determined. Next, the robot configuration to reach the catch point is computed and finally a path is generated, which brings the robot from its start configuration to the desired catch configuration. To catch an object with a robot arm, the system generates the motion of the arm based on the object’s position information. Following are three approaches for catching objects:

(a) To calibrate the relations of the robot arm and cameras.
(b) To track the current object position by vision system
(c) To move the robot arm to the position at particular time which is predicted using current position and velocity of the object.[2]
II. LITERATURE REVIEW

Most previous the majority of experimental setups reported in literature on link-flexible robot arms operate in the horizontal plane only. For these systems gravitational effects are neglected. Recent works are driven by challenges experienced in terrestrial applications, where the nonlinear gravitational influence has to be considered. Over the years the robotic systems used as well as the perception and planning methods got more and more complex.

U. Frese proposes a system for catching a flying ball with a robot arm using components that are operated through computer for visual tracking. For observation of ball baseline stereo camera is used, author made use of the motion of the object as a segmentation parameter, for computing the difference between the actual image and some reference image and detecting its shape in the threshold result. This approach proved to be very robust, as it only required the background to be static and the object to appear different from the background without assuming any specific appearance.[3]

Jörn Malzahn proposes a control architecture, which enables a multi-link-flexible robot arm under gravitational influence to catch multiple balls sequentially thrown by a human. A net at the end-effector is utilized to intercept the balls when they pass the vertically oriented robot plane of motion. The ball trajectories generated by the human thrower are irreproducible. There are no selected operating points, but the trajectory may pass through the robot workspace at any point[4]. The algorithm used to track the ball and to predict its trajectory is taken from [3]. However, the stereo-camera system used by the authors is replaced by a single Kinect RGB-D sensor in this contribution.

Georg Batz, proposes a special approach to accomplish the task: the non-prehensile catching. Depending on the velocity of tracked ball, two catching methods are proposed: In first method catching of the ball during the initial contact. In Second method, catching the ball during the subsequent contact. In both approaches, the ball trajectory is determined by a recursive least squares algorithm.[5]

Jwu-Sheng Hu proposes a robotic ball catcher with embedded visual servo processor. Servo processor is having the powerful parallel computing capability, which is used to track and navigate a flying ball. Author uses the recursive least square algorithm for trajectory prediction.[2]

III. PROPOSED RESEARCH METHODOLOGY

The main technique used is a stereo vision system to tracks the ball and predicts the balls trajectory then the point and time required to reach at destination point, and in which orientation the robot should intercept the ball on its trajectory, is determined. Once robots calculate the desired parameters it will try to catch the ball. Using the servo motor controlled robotic arm. Proposed system is designed to catch the ball by calculating the coming ball path using computer vision techniques and move the robotic arm in order to catch the ball. Figure 1.0 describe the experimental setup of the system where using the web camera fixed at particular angle will give clear view of image. It is also stated that how ball will move in trajectory which will be used to calculate the last consideration point for catching the ball.

![Fig 1: Experimental Setup](image)

The image provided by a calibrated camera mounted in an eye-in-hand configuration is continuously elaborated in order to identify and extract the position of the ball, i.e. the centroid, in the normalized image plane. The whole image is elaborated until the ball is detected, then a dynamic windowing technique, which is based on a first order prediction algorithm of the ball motion in the image plane, is employed after the first detection, so as to reduce the computational requirement of the image elaboration process. Moreover, by adopting the Region of Interest (RoI) camera acquisition modality, which is available on most of the current USB cameras, the camera frame rate can be significantly speeded up (e.g. easily more than 100 Hz).

An equalized color-based clustering is adopted in the image processing, and it makes use of the Hue, Lightness, and Saturation Color Space so as to limit as much as possible the problems related to the variations of the environmental lightness along the ball path. In details, a binarization process is performed through an equalized test, which is based on a histogram of the H-channel and centered around the known ball color, together with a min/max S-channel threshold. After some post-elaboration process employed to reduce the image noise, all the blobs present in the binarized image are collected and filtered so as to eliminate the background and all the blobs with a very small area. If more than one blob overcomes this filtering process, a neighborhood selection criteria with respect to the predicted ball position is adopted. Finally, the centroid of the selected blob is evaluated as a good approximation of the ball center.

This algorithm can also be executed to find other relevant objects in the environment. For example, a color tuned on the hand of the pitcher is also employed, which allows recognizing up to a fully hand occlusion whether the ball is held in the hand or it has been thrown, avoiding in such a way unnecessary initial movements of the robot.
IV. PROPOSED PLAN OF WORK

Proposed system is mainly divided into following modules. First is video capturing to get the video frames, next is image processing to get the images from frame, and next is to get the pixel information from the image, the detection of color from pixel and at last controlling the hardware.

- **Image acquisition:** Firstly from the video captured image of ball is taken out. The image getting is a digital image. A digital image is produced by several image sensors, which, besides various types of light-sensitive cameras, ultra-sonic cameras, etc. Depending on the type of sensor, the resulting image data is an ordinary 2D image or a 3D image or may be the image sequence.

- **Pre-processing:** Before a computer vision method can be applied to image data in order to extract some specific piece of information, it is usually necessary to process the data in order to assure that it satisfies certain assumptions implied by the method.

- **Feature extraction:** Features of image are extracted from the image data. The mainly extracted feature is color.

- **Detection/segmentation:** At some point in the processing a decision is made about which image points or regions of the image are relevant for further processing.

- **Hardware control module:** In this module the different servo motors are controlled by the servo motor controller which is connected on the USB port of computer so that the motion of robotic arm is controlled.

V. CONCLUSION

Proposed system is to develop a robotic arm operated through computer system in order to catch the balls thrown by the user.

VI. EXPECTED OUTCOME

Expected outcome of the proposed system is to catch the ball by calculating the coming ball path using computer vision techniques and move the robotic arm in order to catch the ball. It is expected by the system to work with accuracy of at least 70%.

VII. REFERENCES


