Goalkeeper Robotic Arm

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Abstract

In this project, a Goal Keeper Robotic Arm using Image Processing techniques was designed and simulated to track a ball with a 1 DoF robotic arm implemented as one Servo Motor. The techniques used in this project are: Image Acquisition, Image Filtration, Color Detection, Contour Detection. Then the ball center is extracted and the angle to be followed by the robotic arm is calculated and sent to the Arduino to actuate the motor, hence block the ball from entering the goal such as the human goalkeepers.

I. Introduction

The field of computer vision is a hotspot of research, with increased interest sparked by the integration of innovative and autonomous automobile and commercial systems that rely heavily on LIDARs, cameras, and image processing. As a result, extensive study into areas connected to the focus of this project has been conducted.

The Goal Keeper Robotic Arm was designed and simulated using Image Processing techniques to track a ball using a 1 DoF robotic arm constructed as a single Servo Motor.

The issue that this project may present is calculating the exact location and speed with which the goalkeeper must move depending on the expected trajectory of the ball calculated from the distance and speed of the ball derived from the acquired images of the ball while being shot.

II. Literature review

In [1], It's discussed that the goalkeeper or any football robot must have the ability to detect balls and acknowledge it from its environment. The location of the ball is crucial to the decision making of the robot.The problem with this detection system is that it will detect all items of the same hue in the image, even if they are not in the field. As a result, the robot processes incorrect data. An elimination operation is performed on the area outside the field in the input image to correct this issue. An object segmentation and detection system is presented in this paper. Calculating the moment of the contour is used to determine the object's position. Following some tests, it was discovered that the system successfully removes some portions outside the field from the image. With an average of 31 frames per second processed, this system simply recognises the ball and robot in the field.

[2] Argued that the 21th century is a platform open enough to implement crossover projects between the cybernetic world and the physical systems. They implemented the goalkeeper system merged with image processing concepts to reach their target.Robotics, as the most promising candidate to theme the next major industrial revolution following the current third (digital) industrial revolution, is poised to play a growing role in society due to its impact on every aspect of life, including medicine and healthcare, building services, manufacturing, food production, logistics, and transportation. The purpose of this project is to construct a robot goalkeeper using embedded control systems. The goalkeeper robot handles the problem of detecting a ball, calculating its position, estimating its trajectory, and predicting a future spot to intercept the ball. The concepts used in image processing is padding as the system used is 8-cell connectivity.In their solution, the goalkeeper shifts left and right along the goal line to prevent the ball from entering the goalpost. The robot goalkeeper is controlled in linear velocity according to the ball speed and direction, and the control strategy is designed based on geometrical laws. In their situation, They are utilising grids, which are nothing more than horizontal and vertical lines that divide the ground into little portions. They order the robot to move based on which grid the ball is in.

In [3], They argued that one of the most crucial responsibilities in MSL is gatekeeping, especially when it comes to defending aerial shots. The goalie approach proposed in this study is based on integrating two picture sources. The goalkeeper adjusts the Kinect sensor's heading angle using the Omni-vision system to capture both depth and RGB images of the ball. The RGB image confirms the recognition's authenticity, while the depth information is employed to discern the ball's spatial position. Once opponents shoot, the suggested system leverages the initial few detected positionsof the ball to anticipate the interception site by the goalkeeper based on the leastsquare method. Experimentation verifies the proposed strategy's correctness and efficacy.

In [4] they mentioned that given the dynamics and speed of a flying object, detection of airborne objects is a challenging challenge to solve. When considering a non-controlled environment, where the predominance of a certain colour cannot be assured, and/or when the vision system is mounted on a moving platform, the problem becomes considerably more challenging. Taking the game of robotic soccer sponsored by the RoboCup Federation as an example, most of the teams competing in the soccer events use an omni directional camera to detect objects in the environment. Because omnidirectional vision systems only detect the ball on the ground, exact information on the ball's position in the air is lost.They describe a unique approach for 3D ball detection in which colour information is used to identify ball candidates and 3D data is used to filter the relevant colour information in this research. The key advantage of their approach is the minimal processing time, being thus appropriate for real-time applications. They give experimental results that demonstrate the suggested algorithm's effectiveness. Furthermore, this strategy was adopted in the most recent official RoboCup Middle Size League competition. In circumstances where the ball was flying towards the goal, the goalkeeper was able to adjust to the right position to defend the goal.Information from the depth camera can be projected to a metric 3D space using the distortion coefficients of the RGB image and the intrinsic parameters of the depth camera. After obtaining a legitimate ball, the next step is to determine the ball's 3D position in relation to the robot, as detailed below. This phase is required in order to determine which direction the goaltender should move in order to defend a goal. This is accomplished by creating a relationship between the RGB and depth image coordinates of the blob's centre.

In [5] they stated that this work offers an image processing-based algorithm for ball detection and tracking by a robot. Misleading detection of numerous objects other than a tennis ball occurs in complex scenarios, resulting in false data and robot imprecision. They tested our method for robot ball recognition using the contour method, the ball's centroid as a distance measure, and the colour intensity level as a detection of the ball itself. The camera's rotation is controlled by a laptop via wireless fidelity for ball recognition and tracking.Using contour matching and a centroid-based strategy, this paper attempts to establish an embedded architectural solution for ball recognition and tracking. They've shown how to recognise a ball using its centroid and mark it as a separate item for robot tracking. Our contour, circle, and colour identification system uses fundamental image processing techniques to assist us find suitable contours for edge refining. Straight segments, solitary objects, and incorrect contours are also discarded by the camera method, resulting in a focused calculation.

In [6] The Target Detection algorithms used to develop an Autonomous UAV are described in this study. This UAV is built for the Ohio Autonomous Aerial Vehicle Competition-2014 (AAVC), in which the Quadcopter must navigate around obstacles in a GPS-less and hazard-filled indoor environment, detect the target while estimating its location, and wirelessly transmit the target's image to the ground station. Image processing methods built in Python are used to detect the target. To assure detection under a variety of lighting, shadow, and distance conditions, the algorithm employs blob and form detection on the Hue, Saturation, and Value (HSV) colour space. The system is then put through its paces in a range of circumstances that account for lighting and shape detection variations. Limited computing processing on board, changing ambient light conditions, and detecting the correct target in the presence of several same-colored targets are all challenges. To boost the method's robustness, they anticipate that there may be several targets of the same hue, but that these objects will be of varying forms. They also assume that no object will be blocking the target's field of vision from the onboard camera at the target's entrance.A Raspberry Pi flying on board a small quad-rotor is used to create, test, and verify an algorithm for autonomous detection of a target in a room. The system detects green coloured circular objects of various sizes well. They have a pretty robust technique using HSV and the shapedetection that They used. They can provide an estimate of the distance between the vehicle and the target using the algorithm, which is then utilised to produce an estimate of the target location.

In [7], In this research, They offer a set of algorithms for identifying an autonomous robot's various trajectories while navigating around obstacles. To do so, They first determine the obstacle orientation before calculating the distance between each pair of obstacles and comparing it to the robot width. These algorithms' outputs are designed to be used by robot route planning to choose the best trajectory. The algorithms are simple and accurate, and they may be used by robots with little processing resources.They provided and discussed an algorithm for identifying object orientation as well as an approach for selecting collision-free pathways in this work. The first approach is a K-Means algorithm with the ability to set the number of clusters automatically. A second algorithm uses the outputs of first one to compare the distances between obstacles and so decide the possible paths (collision-free paths). They examined each of the three possible instances for two obstacles places, as well as how the minimum distance is calculated. If the robot's ultimate aim cannot be seen, the course is chosen using the information available.They provided and discussed an algorithm for determining collision-free pathways as well as a method for recognising object orientation in this work. The first is a K-Means algorithm that can set the number of clusters automatically.

III. List of Components

For the Goal Keeper Assistant Robot the components that were used:

Item	Store	Number	Price
Frame	GUC Workshop	1	100
Arduino UNO	RAM	1	170
Servo Motor (180) 3.2 kg.cm	RAM	1	125
USB Cable	RAM	2	15
Adapter (Different V)	RAM	2	50
Camera	RadioShack	1	200

IV. Configurations

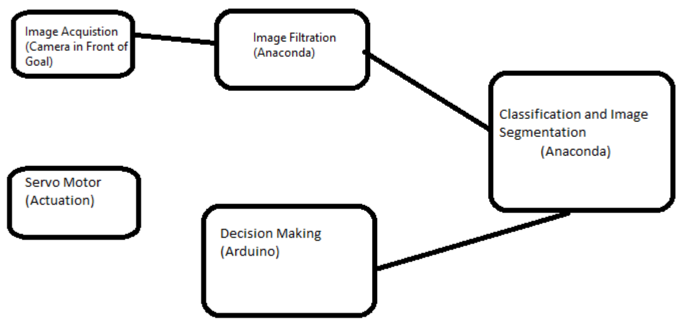

Fig. 1. Flow

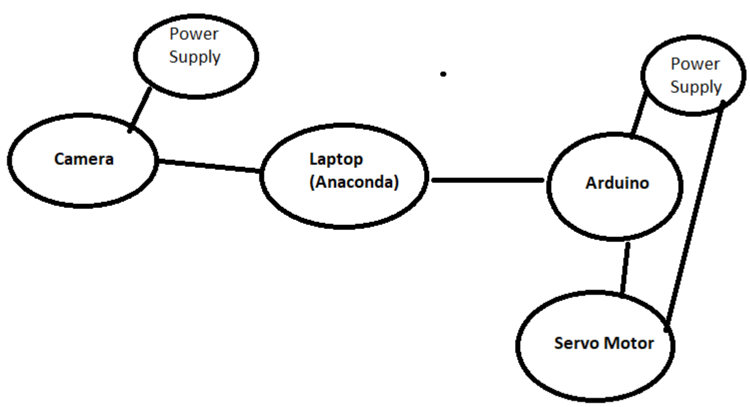

Fig. 2. Electrical

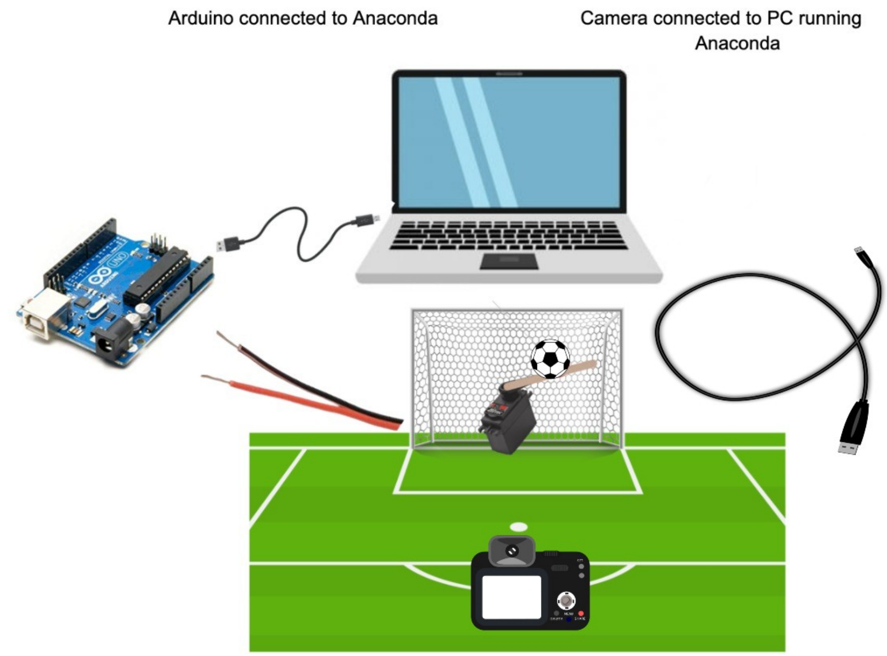

Fig. 3. Hardware

V. METHODOLOGY

A. *Image Acquisition*

First step in the image processing is to get images from the environment of interest through the camera to be later analysed and processed. These images have to meet certain conditions and contain certain elements/regions of interest. In this project the chosen view is the camera to be in front of the goal (Using Camera)

B. *Image Filtration and Morphological Operations*

The images are then filtered and enhanced by various techniques to remove noise and enhance the input image. (Using Anaconda) Hough, Edge detection, Corner detection operations have been used to obtain the object detection accuracy in the picture that we need.

The image in V-B is the original image before any image processing operations have done on it to detect the ball.

The horizontal, vertical and total sobel operations are in the following figures respectively where these sobel operations detect the horizontal and vertical edges 4 ,5 and 6.

Now we apply some of the image processing operations over the image to obtain the borders of the ball.

Fig. 4. Horizontal Sobel

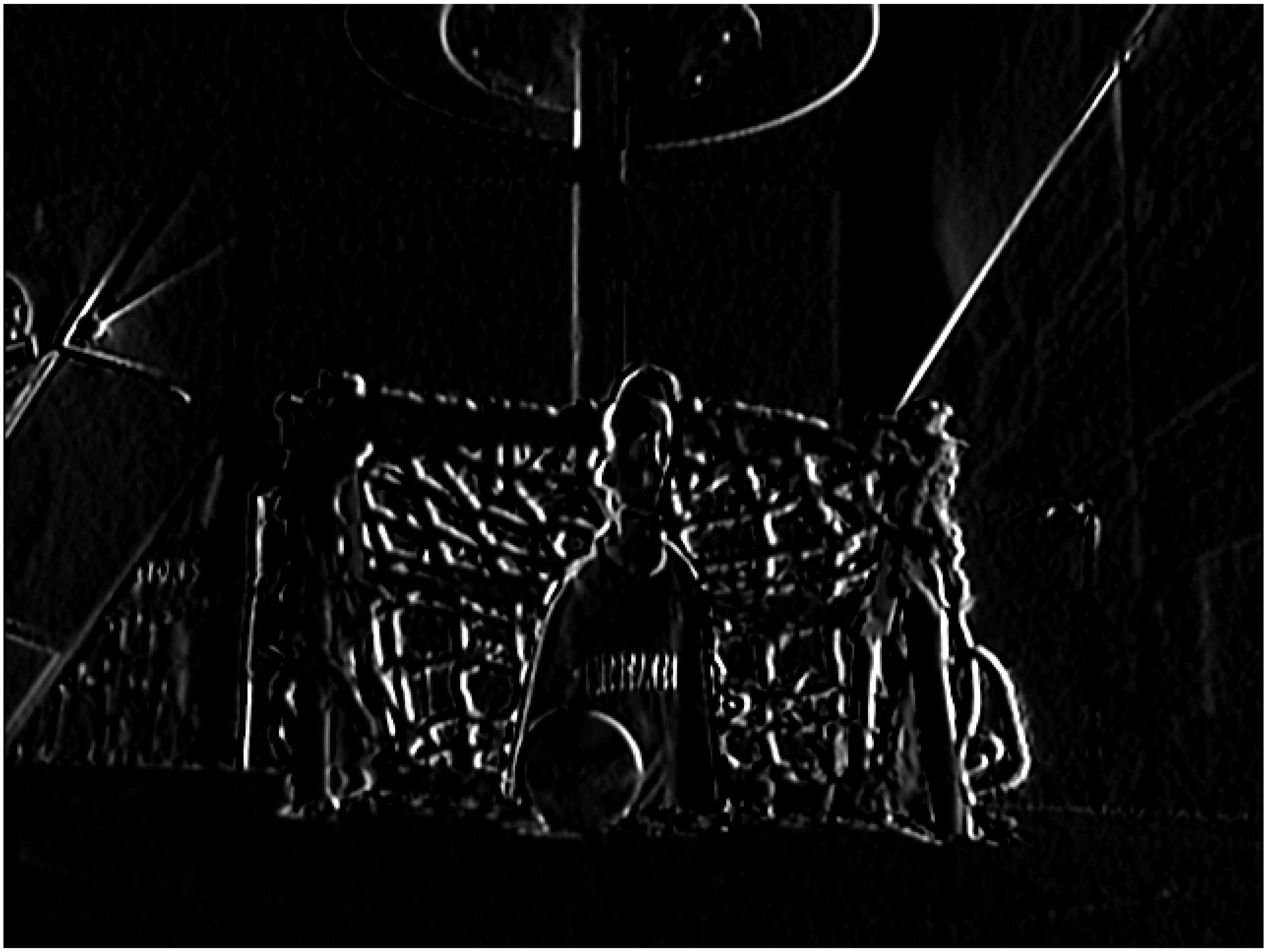

Fig. 5. Vertical Sobel

Fig. 6. Total Sobel

The original image was processed using opening operation (Erosion then dilation methods) in 9 and closing operation (dilation then erosion) in 10 .The erosion of the original image is in 7 and the dilation is in 8.

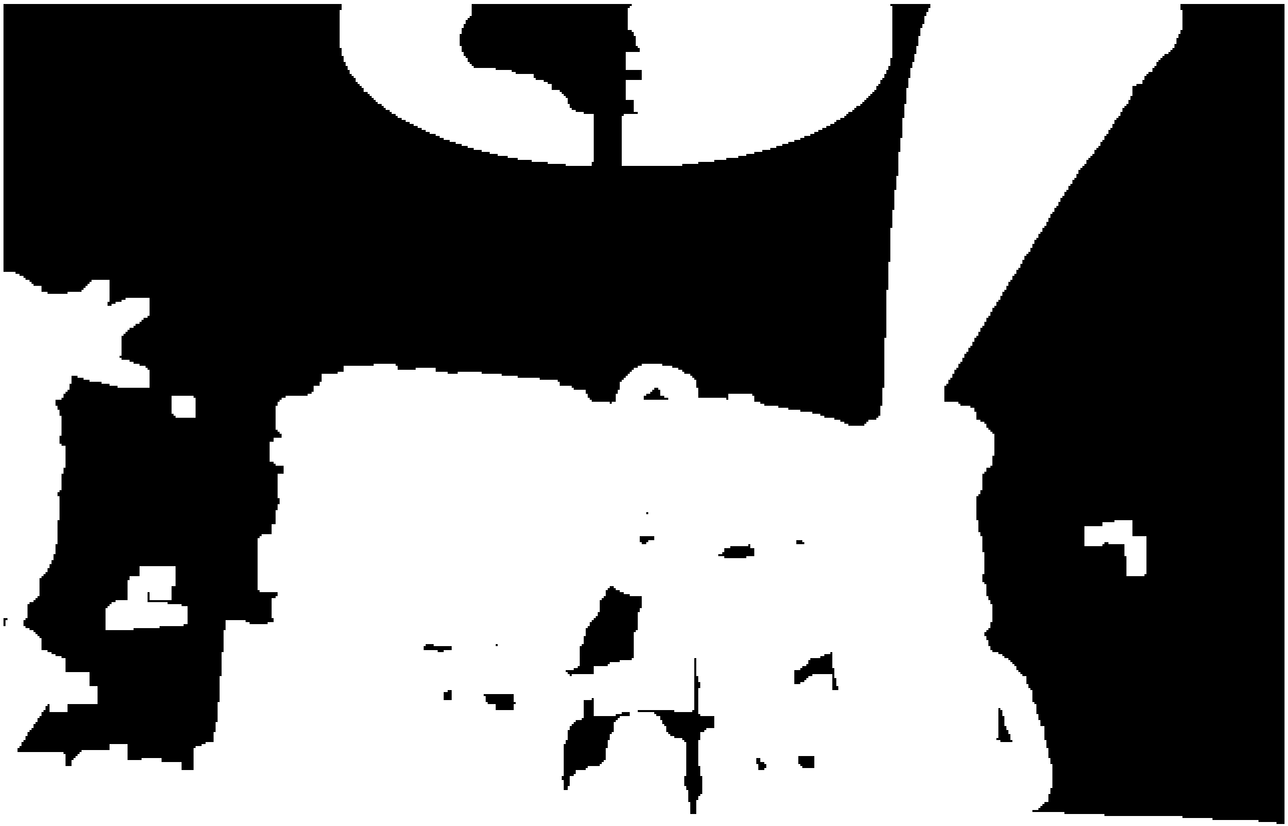

Fig. 7. Dilation

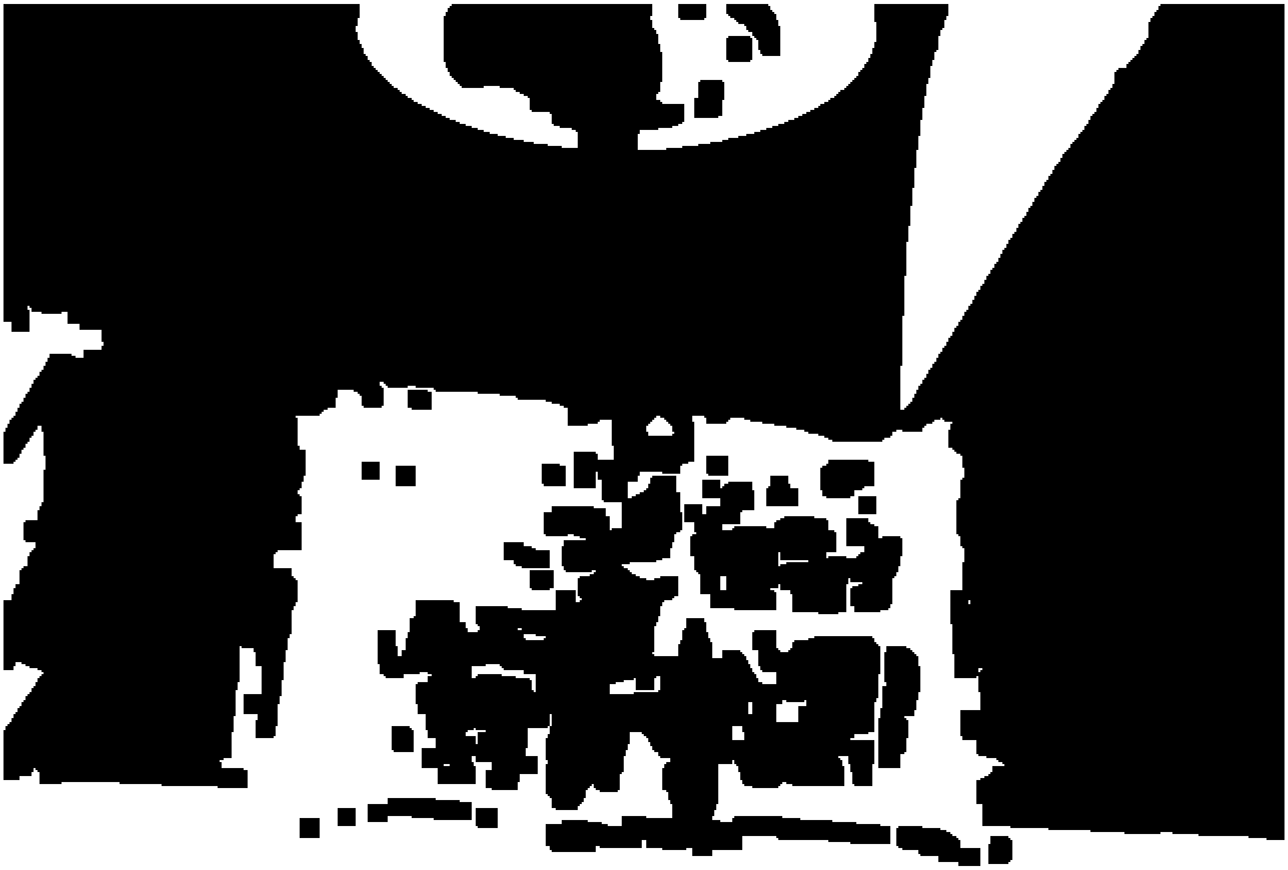

Fig. 8. Erosion

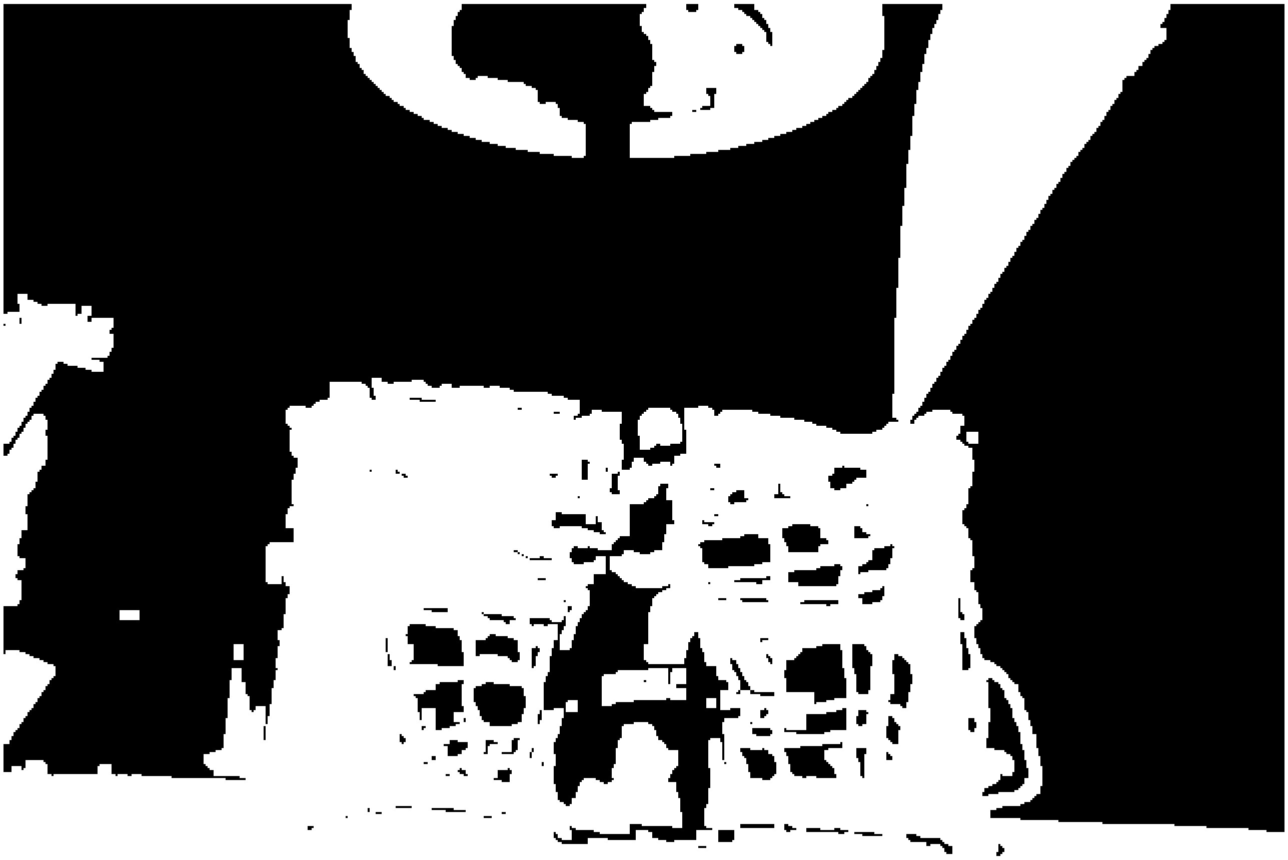

Fig. 9. Opening

Fig. 10. Closing

We also have implemented Harris corner detection and Canny edge detection techniques in 11 and 12 respectively.

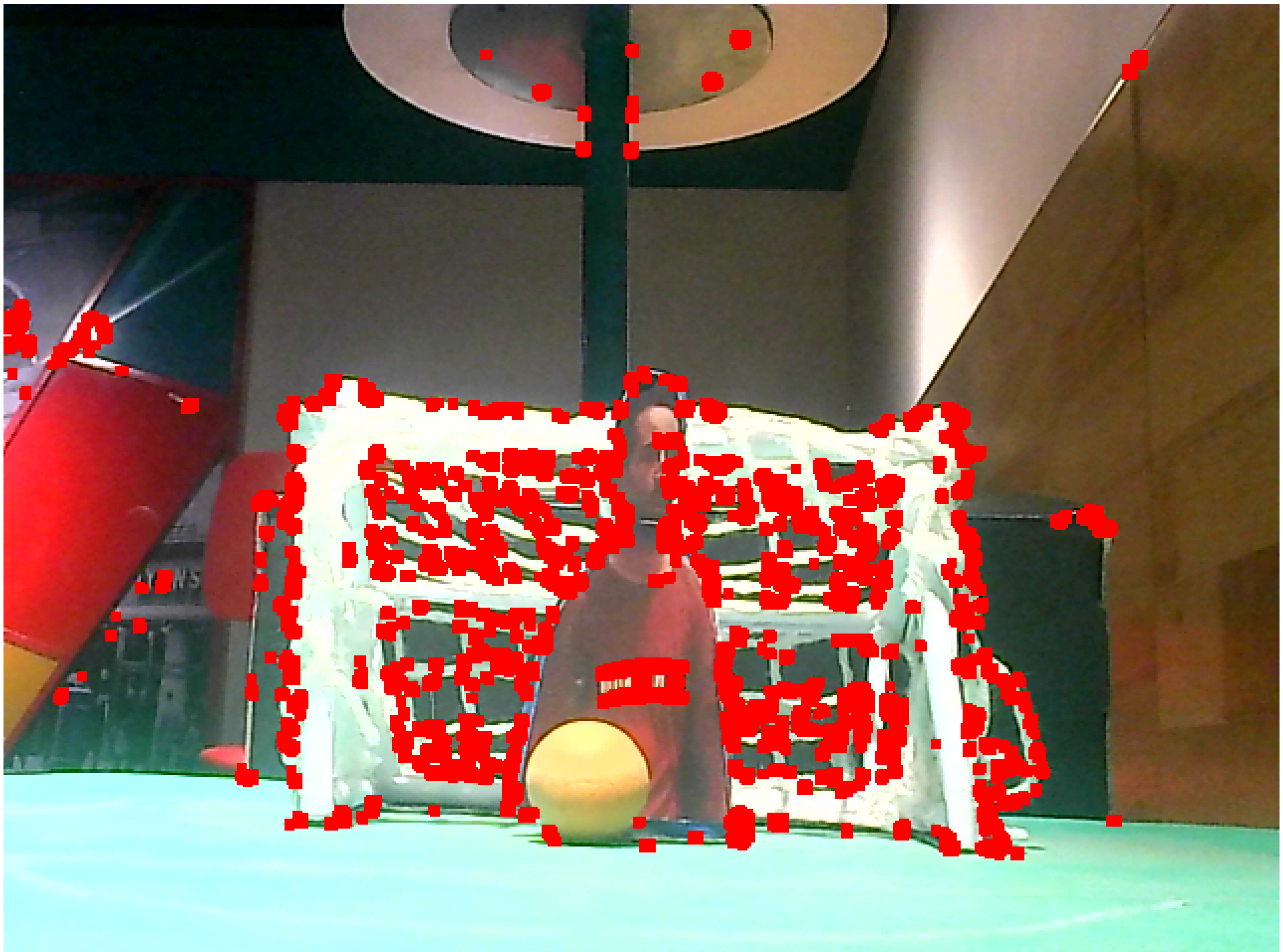

Fig. 11. Harris Corner detection

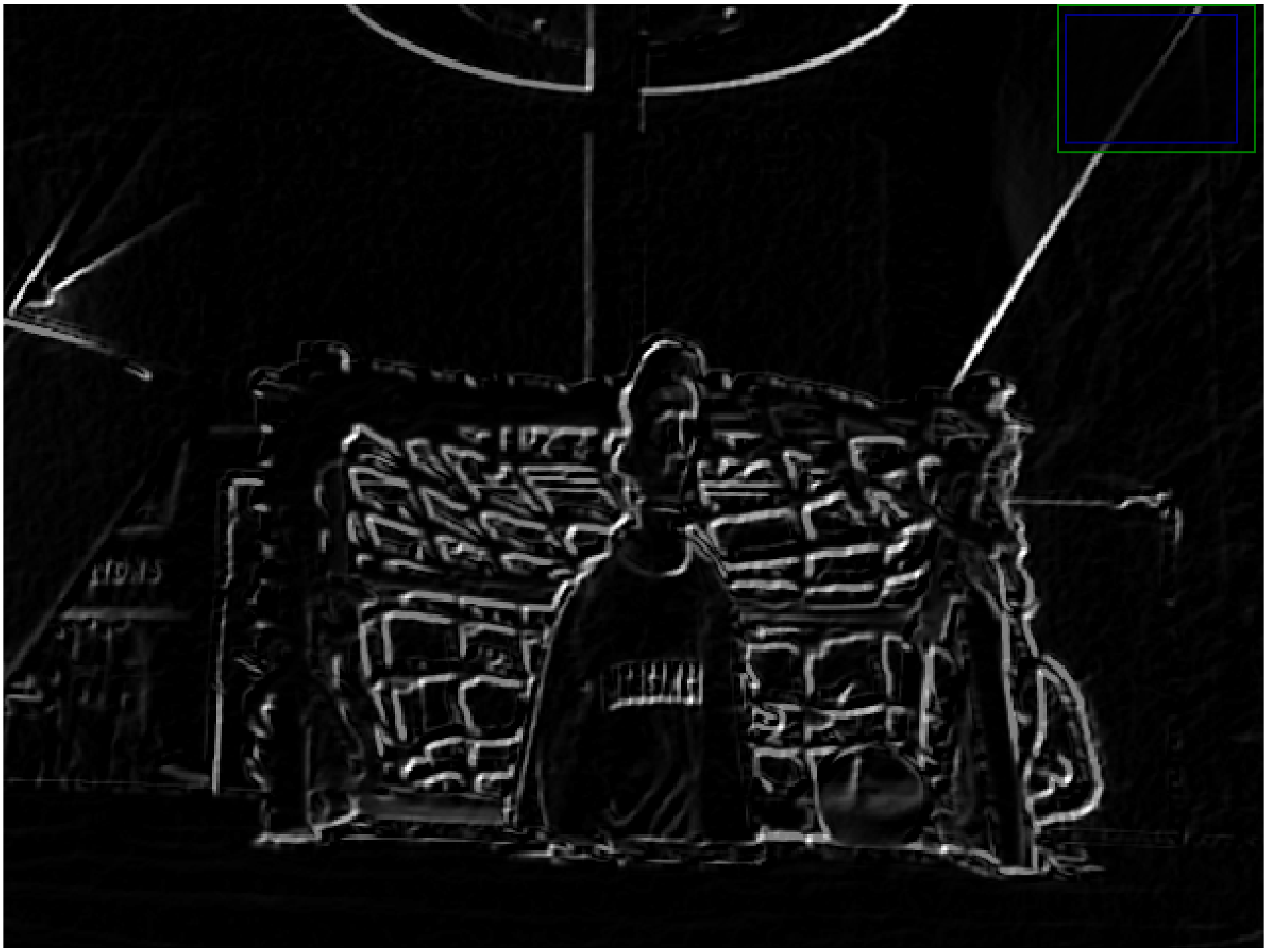

Fig. 12. Canny Edge detection

Canny edge detector and harris corner is applied to the frame to detect the strong edges and corners in the picture and we can see the goal frame edges as well as the goalkeeper dimension.Also, four morpholgical operation are shown such as dilation (in which the white pixels in the frame are bigger and more clear) and erosion (in which the white pixels are minimized) and a combination of erosion then dilation introduces the opening operation and finally a combination of dilation then erosion introduces the closing operation .

VI. Language

The language to be used in the project is Python with the help of Anaconda

VII. Conclusions

In our project, Hough transform was not enough to detect the ball , so we had to add another limitation to our target ball (orange color) we have obtained the hse lower and upper limit for the specific color we used which is pale orange so that the ball could be efficiently detected . Moreover , our first limitation is the circular contour detected by findcontour() function where the center of the ball is detected also and printed , the process of finding contour comes after an opening process (erosion then dilation) to eliminate any unnecessary noise and to filter our image . our second limitation is the color of the ball which occurs in a range of specific lower and upper hsv bounds so by using both limitation the ball center can be efficiently detected. Eventually, Two important values are calculated by subtracting the center of the ball from the center of our image so that X and Y displacements are used to calculate the required angle needed to move the servo so that its center and the ball coincides resulting in a goal-keeping behaviour.

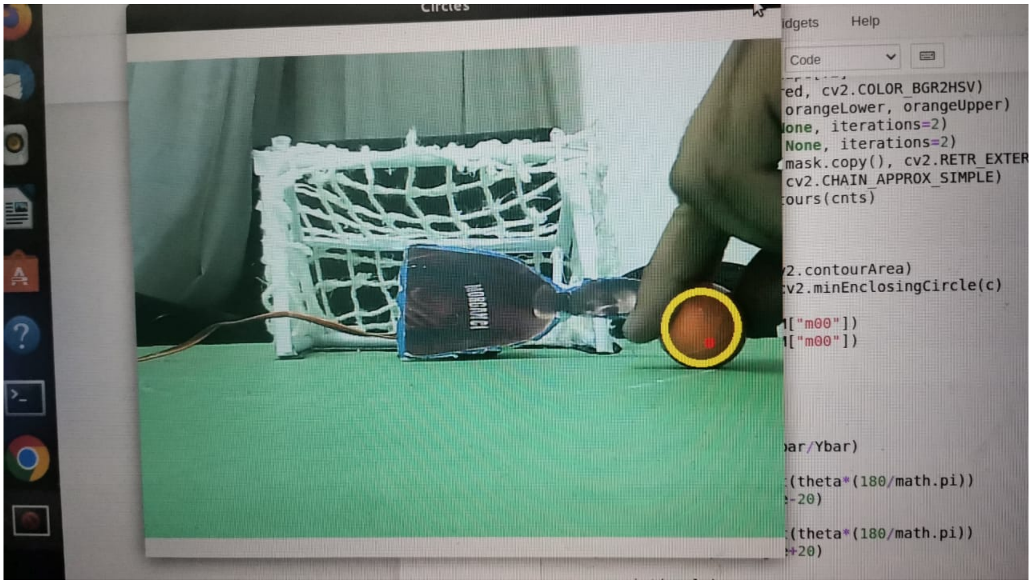

Fig. 13. Final

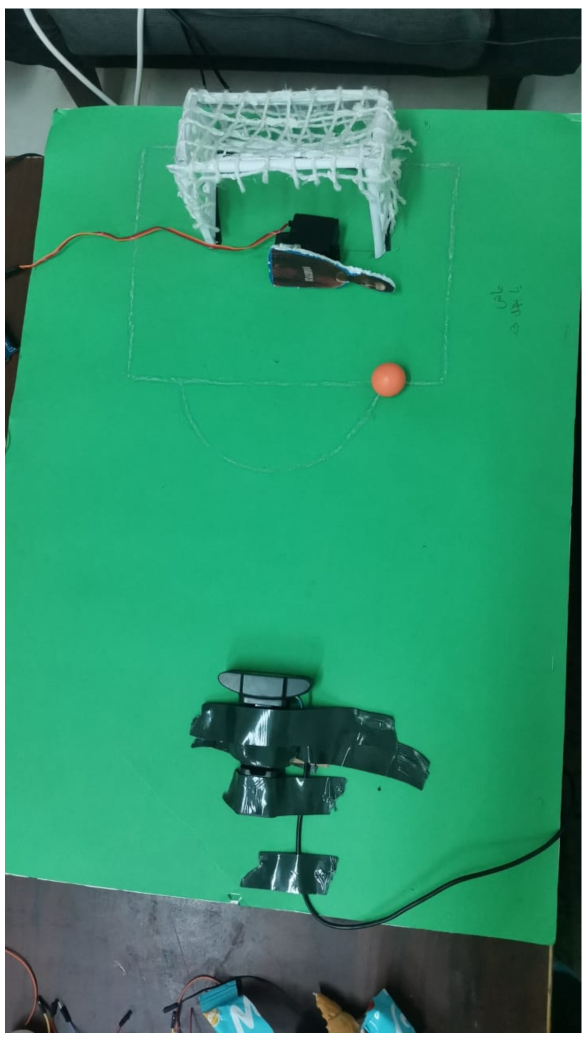

Fig. 14. Final

APPENDIX

ACKNOWLEDGMENT

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