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Development of Autonomous Table Tennis Ball Retrieving Robot

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ABSTRACT

Table tennis is indeed a sport which involves or four people hitting a lightweight ball back and forth across a surface using small wooden rackets. Table tennis players must retrieve played balls off the field's floor, even though numerous balls are used and played during training sessions. As a result, collecting is a time-consuming and exhausting procedure. Pick up hoppers and tubes are some of the equipment and systems used to make the collecting process easier. In this paper, we designed and built an autonomous Table Tennis Ball Retrieving Robot that can collect up to 5 balls at once. An acrylic frame supports the robot, which is guided by four separately controlled wheels. The table tennis balls are sucked into a lightweight basket on top of the robot by a rotating fan. The fan is driven by a brushed motor with a high RPM speed.

Keywords: *Robot, Ball Collector, Table Tennis, Controller*

1. Introduction

Nowadays, Robotics is an inter-professional field of technology that is used in a variety of fields, such as automotive, domestic and sports industries. The use of robotics in the sports industry has recently gained a great deal of interest from the robotics community. Furthermore, computer vision is a fast-growing branch of robotics that has a variety of applications, from surveillance monitoring systems to the automatic collection of 3D models for Interactive Virtual displays. Commercial uses include traffic management, parking entrance control, virtual reality gaming, and facial recognition, to name a few. Sight is also one of the greatest effective primary objectives utilized in genuine robots, including Tesla Autopilot-equipped automobiles, the finest vacuum cleaner models, and assembly robots. Intelligent robotic systems are increasingly being utilized in a variety of applications, including the detection of complicated environmental fluctuations using a sensor, as well as the collection and production of correct motion to achieve a goal. Cameras have become standard sensory equipment in robotics in recent years. They are inexpensive as sensors and can provide robots with a wealth of knowledge about their surroundings. For robots, vision continues to be the most powerful sensing device, just as it is for humans. However, obtaining the necessary information from the image flow is challenging and has drawbacks, such as traditional camera's narrow field of view or situations with inadequate lighting. In robotics, vision is usually used for navigation, object recognition and tracking, 3D visualization, visual focus, self-localization, and other tasks. Cameras can be used to identify and monitor items that are important to the robot's current mission. They will provide the most comprehensive details about the objects in the robot's immediate vicinity as well as their location. Furthermore, active cameras allow you to replay aspects of a previously visited region even though it is out of your immediate viewing range [1]. A comprehensive memory map of the world may be generated to provide access to correct knowledge about the areas of interest that surround the robot [2] Table Tennis is considered as one of the most popular historic competitions that has gained prominence in recent years. Similarly, coaching or practice sessions have improved where input from most table tennis trainees is a difficult job of retrieving & collecting the tennis balls individually during each training session, since table tennis room frequently get congested with balls as played.

However, there are several disadvantages. The drawbacks of current method of collecting the normal table tennis balls not only are very expensive, but also have resulted in waste of time, Inadequate recovery time for tennis players resulting in more energy fatigue and inadequate results of tennis players during training sessions, also that the researchers are only made on normal tennis courts to sweep big courts, not table tennis for smaller room. In Addition, the normal way of ball collection, where the player must bend down to collect the ball act as health hazard for older people as the risk of back injury increases significantly. Therefore, the objective of this study is to model the mechanical subsystem design, to develop the control subsystem and navigation system for the autonomous robot that can sweep around a room to collect the balls.

2. Material and methods

Three types of robots have been selected for further research to aid in the design of the inspection robot, out of the numerous available. The three are listed below, Tennibot Tennis Ball Collector, Inwatec Tennis Ball Collector, and an Intelligent Tennis Ball Collecting Vehicle Using Smart Phone Touch-Based Interface [3][4][5][6].

Tennibot uses computer vision and artificial intelligence to identify and capture tennis balls on the court, it equips state-of-the-art perception and advanced planning algorithms, a scalable operating system that makes a fast prototype test cycle is very important as shown in figure 1 .

Figure 1 Tennibot Robot

The Inwatec crew utilized a Bosch AHM38G lawn mower, dismantled the cylinder, and chopped all of the blades to replace the metal blades (which typically cut the grass) with two blades of flexible fabric (1-2 mm rubber), which they connected using locknuts.

Figure 2 Inwatec tennis ball collector

Using a novel tennis ball collector, Chen and Dai [5] created an intelligent tennis ball gathering vehicle. Four springs link a pair of parallel plastic discs, each of which has a hole drilled in the center from which it may be joined to the axle, to provide a multi-channel tennis ball collector for the robot. Figure 3 shows that the two discs are constructed of robust plastic and are connected by four springs to accommodate the tennis balls. Disks compress tennis balls as they travel towards them. [6]

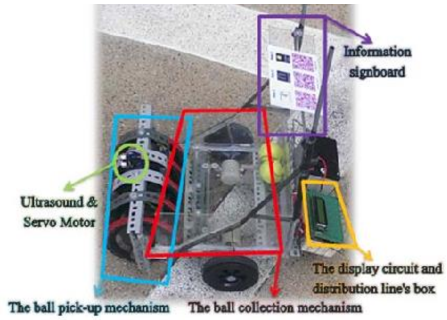

Figure 3 Birdseye view of the Robot

3.Methodology

3.1. Detection System

The Pixy2 is a compact camera that can be used for object identification, line tracking, and basic barcode reading. It can identify seven different objects depending on their form and color (or hue), and each of these objects has its own "signature."

Figure 4 Pixy Cam

The pixy cam has a processor of its own, that does all the detection and give us the information of the location and the size of the object. An image is just a specific number of pixels, and in case of pixy cam we will be getting 320 x 200 pixel [7] Also we can get the width and height of the object, from which we can calculate the object area, center and all other needed information.

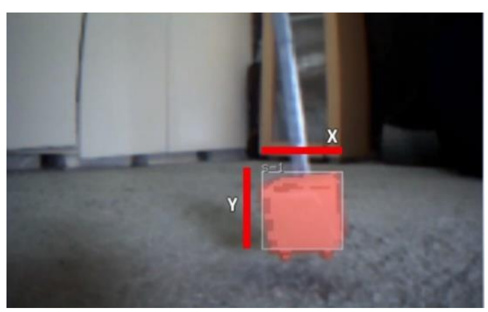

Figure 5 Pixy cam pixel view

In our project we have chosen a 1000 mAh LiPo battery as seen in the figure below which will give us the power that we need at a compact size and a light weight with a supply voltage of 11.1 V

Figure 6 Power Unit

3.2. Navigation system

Our Navigation system consists of 4 Motors and a motor driver, we will be using a 5V brushed motor, in addition to the L298N DC motor driver.

Below is the code for the movement.

```
void moveRobot(int leftSpeed, int rightSpeed)
{
  if (leftSpeed >= 0) {
    digitalWrite(myPins[1], 0);
    digitalWrite(myPins[2], 1);
  }
  else {
    digitalWrite(myPins[1], 1);
    digitalWrite(myPins[2], 0);
  }

  if (rightSpeed >= 0) {
    digitalWrite(myPins[3], 0);
    digitalWrite(myPins[4], 1);
  }
  else {
    digitalWrite(myPins[3], 1);
    digitalWrite(myPins[4], 0);
  }

  analogWrite(myPins[0], abs(leftSpeed));
  analogWrite(myPins[5], abs(rightSpeed));
}
```

Figure 7 Movement Code

3.3 *ROBOT LOCOMOTION*

There are two types of robots: stationary and mobile robots. A stationary robot is one that cannot move or, to put it another way, has a fixed position. So, what exactly is a mobile robot? Mobile robots, according to Lima and Ribeiro [14], are a system that has a lot of versatility in its environment. Mobile robots must also have a device with the following practical characteristics: agility, which means it has complete freedom of movement in relation to its environment, low human monitoring requirements to make it less human-dependent, and perception capacity, which is the ability to sense and respond in any situation. To recap, the mobile robot's main characteristics are its ability to travel through its environment and its ability to navigate itself autonomously. These two traits are the opposites of industrial robots, which are permanently attached to their workstations and depend on difficult codes to complete their repetitive tasks. As the market for mobile robots grows in this age, several different types of mobile robots are being designed and built for various applications. Legged and wheeled robots, on the other hand, are the most popular and commonly produced by researchers [8][9][10]. Wheeled robots, also known as Wheeled Mobile Robots (WMR), are mobile robots that drive through an area by pushing themselves with driven wheels (usually with motors). WMR is widely used by researchers and engineers because it is simple to build, implement, and use for robots that need speed. They still have more static and dynamic stability than legged robots because their center of gravity does not shift as they walk or stand still [11].

3.4 PATH PLANNING TECHNIQUES

Until delving deeper into path planning strategies and implementations, researchers must first understand what path planning is, why it is relevant in mobile robots, and what factors go into designing a path plan. Strandberg [12] defines robot path planning as the process of determining a collision-free path from one location to another. When the robot collides with obstacles, strays from the road, or takes too long to reach its target, path preparation is deemed insufficient. A few considerations should be addressed when designing a route for a mobile robot, including the setting of the robot workspace, the path planning algorithm, and the various types of path planning techniques.

The workspace's surroundings or atmosphere may be classified as static or dynamic. As all objects or obstacles in the workspace are static, they cannot move, while when the obstacles will move, such as another mobile robot occupying the same workspace or a person jumping around, they are called dynamic. There are two types of path planning algorithms: national and local path planning. When all of the barriers in the workspace are static and known to the robot before it begins, it is referred to as a global route planning algorithm. The robot's motion can be disrupted by a small shift in the direction of an obstruction. A robot using a local route planning algorithm, on the other hand, does not know about the workspace barriers and must build its own path when going. The robot can use sensors to attempt to achieve its mission while removing obstacles [13].

According to Cai intelligent robot path planning can be broken down into two types: point-to-point optimization path planning and full coverage optimization path planning. Many projects and researchers are currently focused on point-to-point optimization route planning; however, researchers are less interested in full coverage optimization path planning. Coverage Route Planning (CPP) is described by as the task of determining a path that passes through all points of a region or some space while avoiding obstacles. CPP is used in robotics such as collector robots, vacuum cleaner robots, lawn mowing robots, and so on.

3.5 COVERAGE PATH PLANNING (CPP)

Coverage Route Planning (CPP) is the function of seeking a path that passes through all points of an area or spaces while avoiding obstacles, according to. Many robotic applications, such as vacuum cleaner robots, autonomous mobile robots underwater, paint sprayer robots, and others, depend on this role. The time it takes for the algorithm to cover all the free space in the configuration space is typically the main concern in this methodology. It seems that generating a direction that covers all feasible points in the configuration space would take a long time. Furthermore, if the configuration area contains moving obstacles, the problem becomes significantly more difficult. Researchers published the first study on CPP in which they identified the standards and parameters that a robot must fulfil in order to conduct coverage operations. Journal of Robotic Systems mentions the following requirements and criteria:

- To reach the goal region, a robot must traverse all its points.
- The robot must be able to travel around the area without crossing over its own routes.
- Continuous and orderly operation is required, with no duplication of routes.
- The robot must avoid all obstructions.
- To simplify the control, utilize straight lines and circles.
- Under existing conditions, the "optimal" option is favored.

3.6 Collection system

The collection method is based on a vacuum pump that we retrieved from a 12v DC car vacuum We were able to retrieve the vacuum motor and reallocate it with our own design that is connected to our collection basket and a hoe, for the ball to be easily collected in the collection basket.

Figure 8 Vacuum Motor

4.Result and discussion

4.1. Prototype

The following Figure 9 shows the final design of the prototype with a dimensions of (WxLxH) of(15x50x10) CM and Figure 10 and Figure 11 shows the false positive detection technique and accurate detection methods.

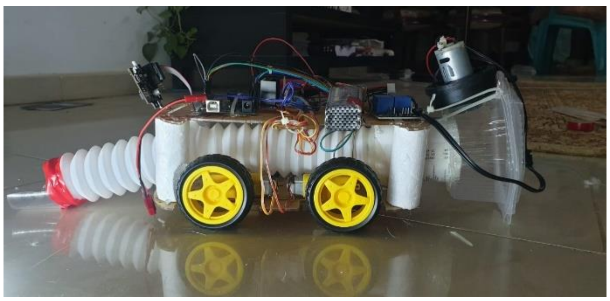

Figure 9 Final Prototype

Using the PixyMon software we were able to alter all the variables to improve the detection of the Pixycam camera to find the ball and eliminate all the noise and false positives, in addition to increase the detection speed.

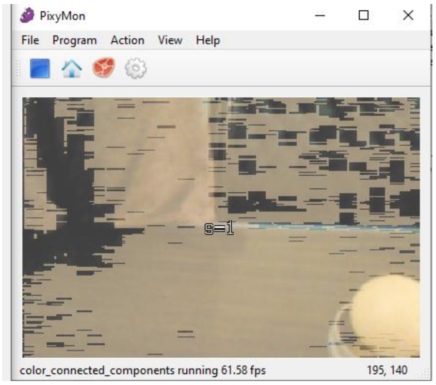

Figure 10 False positives detection

Figure 11 Accurate detection

4.2. Results

The code is sent from Arduino Software to Arduino Uno after connecting the Arduino to all the components using jumper wires. After all the circuits have been installed on the body, the circuits have been tested. In conclusion, the prototype construction serves three primary purposes. The initial step is to search the room until it detects the ball that must be collected. Second, the robot uses area calculations to travel towards it until it reaches a certain distance, and then it gathers it using the vacuum collecting mechanism. The process is then repeated. Several experiments have been conducted out on an automated tennis ball retriever robot. It has been found the test robot retriever was able to recover the tennis balls very well. For example, in 10 repeats plays, the total balls that were collected were around 60 percent (12/20 balls) However, there were instances where the balls were collected and the robot was unable to retrieve all the balls, 0 percent (0/20 balls) due to the malfunction of the servo motor and the failure to retrieve all the balls.

Conclusion

By the aid of artificial intelligence, we were able to build a robot where the table-tennis balls are sucked into a lightweight basket on top of the robot by a rotating fan. The fan is spun at a high RPM speed by a brushed motor. The robot has its own intellect on board, which includes a microprocessor and an artificially intelligent camera (Pixycam). The robot may go wherever it wants and attempts to find our pre-selected object. It gathers it using our collecting system after detection, and then continues the process until it detects the next signature, and so on.

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Disclosure

The author reports no conflicts of interest in this work.

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