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Development of an Autonomous Tennis Ball Retriever Robot As an Educational Tool

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Abstract

Over the years, research into robotics has yielded many applications in several sectors such as manufacturing, domestic and sports industries. This paper discusses the development of an autonomous tennis ball retriever robot for the sports sector. The robot was developed with the aim of saving the time and energy of the tennis player from manually collecting the tennis balls after training sessions. The developed autonomous robot is able to retrieve tennis balls by sweeping around the tennis court. The paper discusses the system configuration in terms of mechanical and controller subsystems, the navigation and system performance. The knowledge and experience gained from the development of various sub-systems of the robot is useful for educating the undergraduate students.

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Keywords: robotics, autonomous, retriever, tennis ball, educational tool

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1. Introduction

Nowadays, Robotics is a multi-disciplinary field of technology that is applied in several sectors such as manufacturing, domestic and sports industries. Recently, the use of robotics in the sports sector has received extensive attention from robotics community. In particular, intelligent robotic systems are increasingly used in the detection of the dynamical variations of environment using sensor, selection and generation of proper movement in order to realize the goal task[1].

Tennis is known as one of important sporting event which has gained popularity in recent years. Correspondingly, coaching or training sessions have increased where the feedback received from majority of tennis trainees is the daunting task of collecting the tennis balls manually after each training session since the tennis courts often become cluttered with balls when they are being used. The literature review that has been carried out in the course of this study shows that a number of robotics tennis balls retriever have been developed over the years as indicated in[2-11]. However, there are many drawbacks. The drawbacks of current method of collecting the tennis balls have resulted in waste of time, insufficient resting time for tennis players which results in more energy exhaustion and unsatisfactory performance of the tennis players during training sessions. Therefore, the objectives of this study are to develop an autonomous robot that can sweep around the tennis court to collect tennis balls autonomously, enhances tennis coaching/training quality, saves time and energy of tennis players and most importantly, serve as an educational tool.

This paper is organized in the following manner. Section 2 discusses the design requirements of the autonomous tennis ball retriever robot, section 3 describes system configuration followed by the description of the implementation details in section 4 and finally conclusion in section 5.

2. Design Requirements

The diameter and weight of a tennis ball is 6.67cm and 57.7 grams respectively. The typical size of the tennis court is 29.80 meter long and 14.63 meter wide. In each training sessions, a coach will feed lots of tennis balls to tennis trainees, and hence there will be a lot of tennis balls scattered at the back of the court. Fig. 1 illustrates tennis balls scattering on the court after each round of training[12].

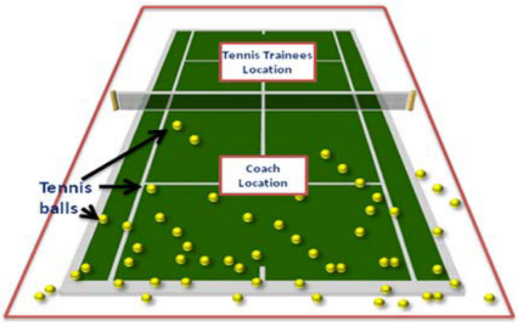


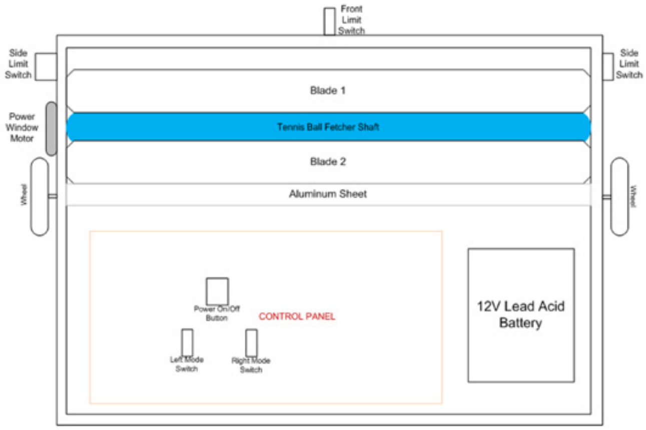
Fig. 1. Tennis balls in court[12]

3. System Configuration

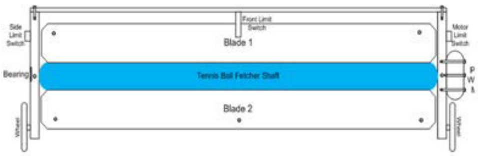
The autonomous tennis ball retriever robot is divided into mechanical and control sub-systems.

3.1 Mechanical Subsystem

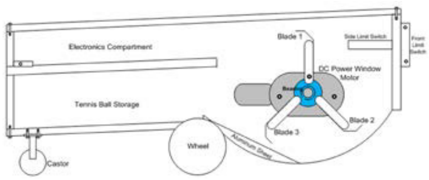
The mechanical subsystem of the autonomous tennis ball retriever robot is shown in Fig. 2 with different views. Top view shows the control panel of the robot. From the front view of design, it can be seen that the robot consists of three limit switch, tennis ball retriever, wheels, and motors. The limit switch is activated when it is triggered by obstacles. The tennis ball retriever consists of 3 blades to sweep in the tennis balls into the storage. In the meantime, the DC motor is used to spin the tennis ball retriever.



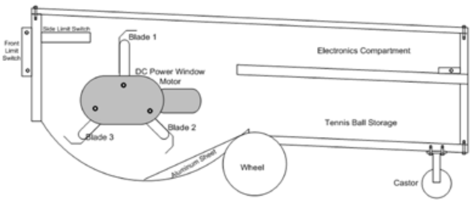
(a) Top view of the design

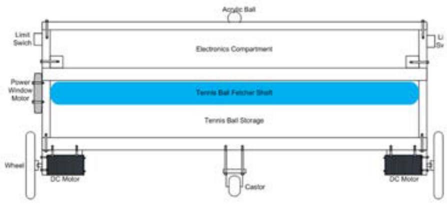


(b) Front view of the design



(c) Right side view the design





(e) Rear view of the design

(d) Left side view the design

Fig. 2. Mechanical Subsystem

From the other views of the prototype, it can be seen that the tennis ball storage is used to store the tennis balls that have been swept in by tennis ball fetcher. Electronics compartment is used to put all the controller system of the robot as well as battery. The castor is free to rotate according to the navigating of the wheels. The rear part of the robot consists of two DC servomotors which are used to control the robot's navigation directions.

3.2 Control Subsystem & Navigation

Fig. 3 shows the control subsystem. The control sub-system consists of front and side limit switch boards, motor driver board, power supply board to regulate 9V to 5V, microcontroller board and L298N motor driver board.

3.3 Navigation

The navigating/collecting area of the robot is determined based on the literature review, where it mentioned most of the tennis balls will be distributed around the back of the court. Hence, this robot will sweep the court as shown in

Fig. 4 and the navigating of the robot follows one method, which is left side navigation. This is shown in Fig. 5.

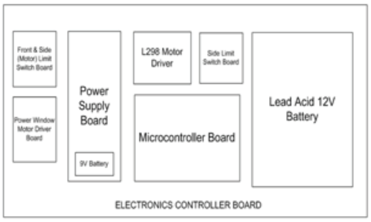


Fig. 3. Control Subsystem

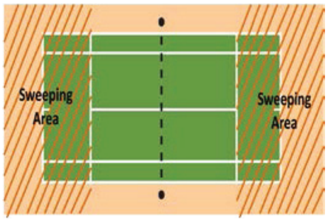


Fig. 4. Collecting tennis ball area by robot

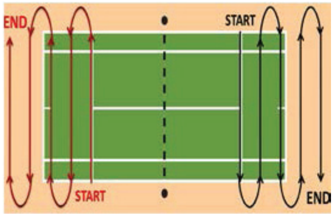


Fig. 5. Method of navigation

The algorithm for the navigation is illustrated in the flowchart shown in Fig. 6.

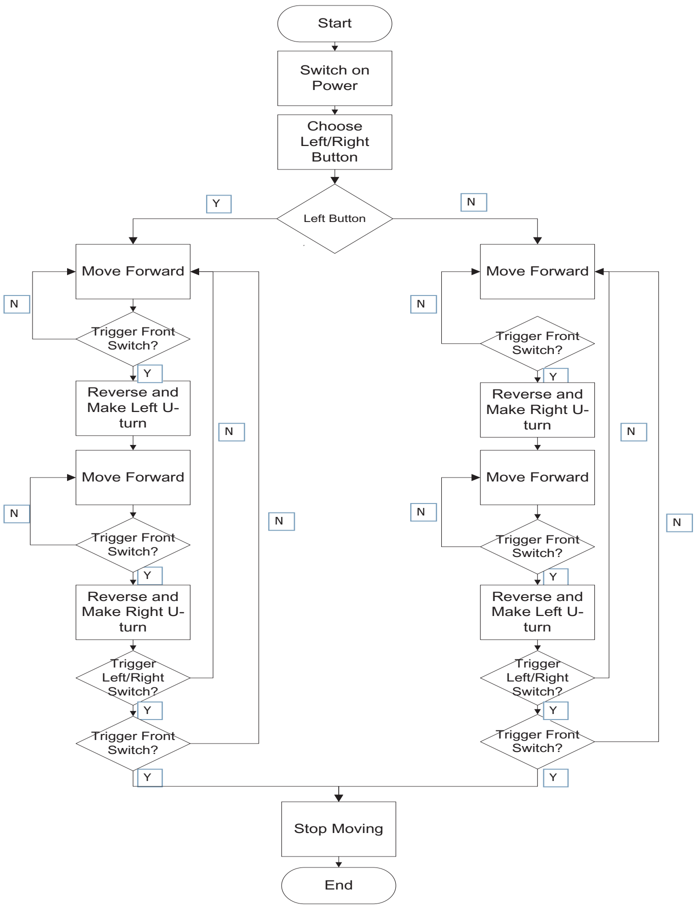


Fig. 6. Flowchart of the navigation system

Initially, the user needs to switch on the power. In the case of the left button is being pressed, the robot will reverse and make a left U-turn if its front switch is triggered. Then it will continue to move forward. If the front switch is triggered for the 2nd time, the robot will reverse and make a right U-turn for this time. Then, it will continue to move forward again. The same step will repeat again whenever the front switch is triggered by making left and right U-turn alternately. Another condition is that, if the left/right switch and the front switch are both triggered, meaning it is detected that the robot has reached a corner and it will be stopped.

4. Implementation Details

The final assembled robot is shown in Fig. 7 and Fig. 8 shows the control sub-system.

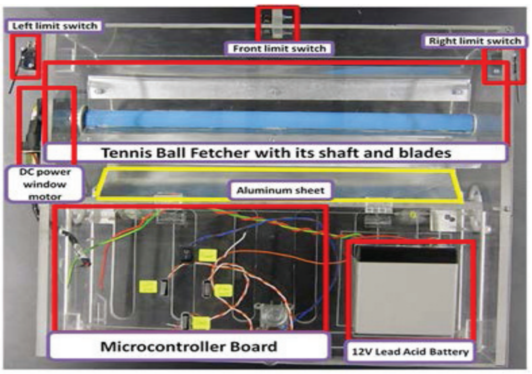


Fig. 7. Mechanical Subsystem of the Assembled robot

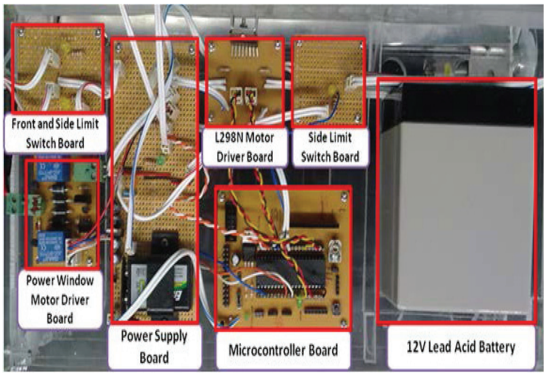


Fig. 8. Control Subsystem of the Assembled robot

The mechanical subsystem assembly can be seen from the top view. The design of the robot is rugged and stable. The control subsystem consists of front and side limit switch board, DC motor driver, power supply board, L298N motor driver, side limit switch board, and microcontroller board.

Several experiments were conducted on the developed an autonomous tennis ball retriever robot. It was found the retriever robot prototype was able to retrieve the tennis balls quite satisfactorily. For example, in 10 repeated runs, the average balls that were collected were about 60% (12/20 balls) However, there were situations when the robot could not retrieve all the balls, 0% (0/20 balls) due to malfunction of the servo motor and the inability to retrieve the balls. However, it should be emphasized that the main objective of the research is achieved, which is to design a machine to collect tennis balls autonomously as an educational tool. In this regard, the tennis ball retriever robot balls consists of a mechanical structure, a controller system, and a navigation system which equips the undergraduate students with necessary knowledge and skills. Modification need to be done in order to produce better results. The prototype could be improved by adding new features such as solar powered and distance sensor in replacement of a limit switch and by incorporating fuzzy, sensor and swarm based controllers given in research works[13-15].

5. Conclusion

In this paper, it is shown that a prototype tennis ball retriever robot was developed and tested. Although the performance of the robot was quite satisfactory, however it needs to be improved further. In future studies, enhancements on the navigation and the size of the storage compartment could be carried out. The knowledge and experience gained from the development of various sub-systems of the robot is useful for educating the undergraduate students.

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