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# Developing a control system for a racket-wielding robot using a combination of promoximity sensor and pneumatic actuator to optimize shuttlecocck hit

**M Khairudin[1], and Soeharto[2]**

Department of Electrical Engineering Education, Yogyakarta State University, Yogyakarta, Indonesia

E-mail: moh_khairudin@uny.ac.id

**Abstract.** This study aims at developing a stroke control system in a racket-wielding robot using a combination of proximity sensor and pneumatic actuator to optimize a shuttlecock hit. As the shuttlecock can come at any time and from any directions, this racket-wielding robot is developed to produce accuracy in its serving distance, service timing, and arm swing, resulting in an optimum hit. A research and development method was employed in this study with every stage of the sub-system development was tested for evaluation and revision. This study has developed and implemented a prototype of a stroke control system for a racket-wielding robot on the bases of proximity sensor and pneumatic actuator. The shuttlecock-wielding arm has functioned properly with a success rate of 100%, while the achieved hitting rate was 70%.

## 1. Introduction

A robot arm (also referred to as a robot manipulator) is a type of robot that is designed to carry certain load. As a payload, this robot offers more advantages compared to a conveyor does: it can lift a payload to different places, it is made of thin material, it is lighter, more energy-efficient, as well as easier to operate and manufacture, and it only requires a small actuator [1].

Features of the easiness in operating this robot arm include not only the time and distance accuracy but also the ability to carry or hit object until it reaches the designated area. This accuracy relies heavily on the type of sensor and actuator used. Therefore, a careful analysis and selection of the right type of these two elements are vital to produce the desired moves.

In developing a robot, especially a robot arm, the use of an accurate sensor for the right usage is very important. The sensor needed by a robot arm is the one that can reach, touch, or encounter objects accurately.

Other than a sensor that functions as the move controller against the presence of nearby objects, a robot needs an actuator/motor. A wrong choice in selecting the actuator type may cause the robot arm to have problems in moving to reach its target. An electric actuator is considered inappropriate to be used as an actuator for a racket-wielding robot. That is why in this study the researchers focus on the use of pneumatic actuator in a racket-wielding robot.

Employing a robot arm for moving things from one place to another is more advantageous than employing a conveyor. A robot arm can be used in many applications starting from goods delivery, microsurgery, and nuclear maintenance to space robotics [2]. The most challenging problem is related to the control system of the robot arm, specifically the long-distance control system, considering that a robot arm is often used in a danger area.

## 2. Result and Discussion

For practical applications, robot arms are chosen for they provide more flexibility in their applications so that the process of controlling and maintaining the accuracy of the arm position is quite challenging. For this purpose, it is very important to identify the flexibility nature of the thin material used through a mathematical model [3].

In calculating the characteristics of the robot arm's moves mathematically, Wang and Mills employ the Finite Element (FE) method to derive a dynamic model for vibration control in a one-link robot arm [4]. The flexibility of the one-link robot arm has already been calculated using the Particle Swarm Optimization algorithm [5]. Meanwhile, the flexibility and characteristics of a two-link robot arm are identified using the Assumed Mode Method [6]. Other researchers, Tian *et al.* have used the Absolute Nodal Coordinate method to predict the flexibility of a robot arm [7]. In addition, to anticipate over-flexibility, Olalla *et al.* have developed a robot arm controller using a strong control system [8].

An ultrasonic transducer is used to control a robot arm using the AT89C51 microcontroller. The distance between the arm and the targeted object is measured based on the time lapse in the detection of ultrasonic echo, resulting in a quite precise measurement. This method requires the operator to set a threshold value to obtain a minimum limit of the ultrasonic echo magnitude when the object is detected. This setting is done by a device called a potentiometer of which the value is often inconsistent due to the worn out sensor. When using this method, the microcontroller has to wait for the reflection wave to come. This waiting time is burdensome for the microcontroller, especially for microcontroller with heavy tasks like controlling a robot's move.

In order to decrease the dynamical equation of motion, the total energy related to the robot arm system must be calculated using a kinematic formulation [9].

This study focuses on designing a racket-wielding robot that can serve a shuttlecock to the opponent. The design of this robot is presented in Figure 1.

**Figure 1.** The Design of the Racket-Wielding Robot

The specifications of the developed racket-wielding robot are presented in Table 1.

**Table 1.** The Specifications of the Racket-Wielding Robot

| | |
|---|---|
| Length | 1100 mm |
| Width | 1100 mm |
| Height | 1400 mm |
| Materials | Aluminium profile, Acrylic, Iron, Nylon, Rubber |
| Battery | 24 V ,8 AH |

This racket-wielding robot is intentionally designed in a length, width, and height of 1100 mm, 1100 mm, and 1400 mm respectively to make the robot able to make a service. First, the shuttlecocks are stored in a shuttlecock tube. If the switch is turned on, the bottom lid of the tube will open and the shuttlecock will fall. When the shuttlecock is falling, it will be detected by the proximity sensor and thus trigger the racket actuator.

The data processing system in this racket-wielding robot utilizes the IC ATmega128 as both an ADC that can detect analog signal from a joystick and a PWM pulse generator. Later, the digital PWM signals are used to control the motor and the PWM servo controller. The voltage source used to supply the circuit and the motor is a lithium polymer battery with a capacity of 24 Volt, 8 AH.

The electronic circuit is attached to the robot body and is protected with a box made of an acrylic board. In that way, the circuit or the components inside the box will be safe whenever there is a shock caused by the robot's moves.

**The Court.** The court used to test this racket-wielding robot is an internationally standardized badminton court, exactly the same as that used in badminton by humans. The court used in this study is the one located in the former hall of Faculty of Engineering. Regarding the court dimensions, the length is 13.41 m and the width is 6.10 m. Meanwhile, the structure of the court is illustrated in Figure 2.

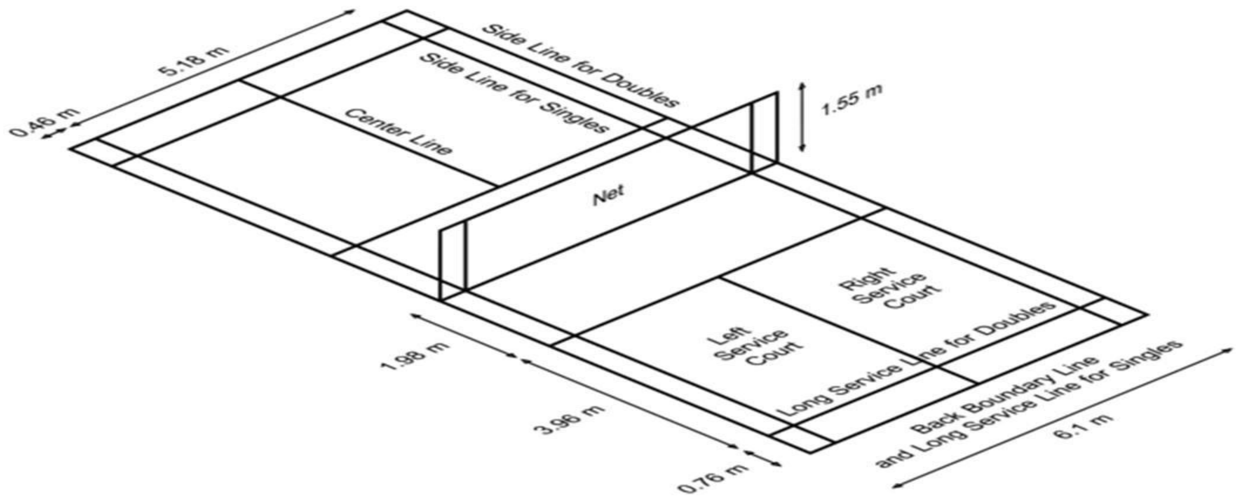


**Figure 2.** The Badminton Court Diagram

The green area is the playing space, the yellow area is the service area for the robot, and the gray one is the operator area. These three different colors are expected to help the robot make a service more specifically.

## 3. Conclusions

This study has developed a racket-wielding robot with manual functionality that is run by an operator. The swing made by the robot is that performed in serving a shuttlecock dropped by the racket-wielding arm with a pneumatic actuator. The forearm is used to make a low stroke, while the upper arm is for a high stroke. The shuttlecock-wielding arm has functioned properly with a success rate of 100%, while the success rate of the forearm in returning the opponent's stroke was only 70%.

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