PROBLEM DEFINITION AND DESIGN SPECIFICATIONS

PROJECT: Design of an Automatic Table Tennis Ball Pitcher

1 Definition of the Problem

Table tennis is a sport that keeps rising in popularity day by day, as it can be easily enjoyed by all age groups, and the rules are easy to pick up. Aside from being an Olympic sport, it is also widely played as a hobby by a large number of people, and some studies even suggest that for children and the elderly, the sport has various physical and mental health benefits. Taking these into consideration, it can be seen in Figure 1 that the demand for the sport is increasing each year.

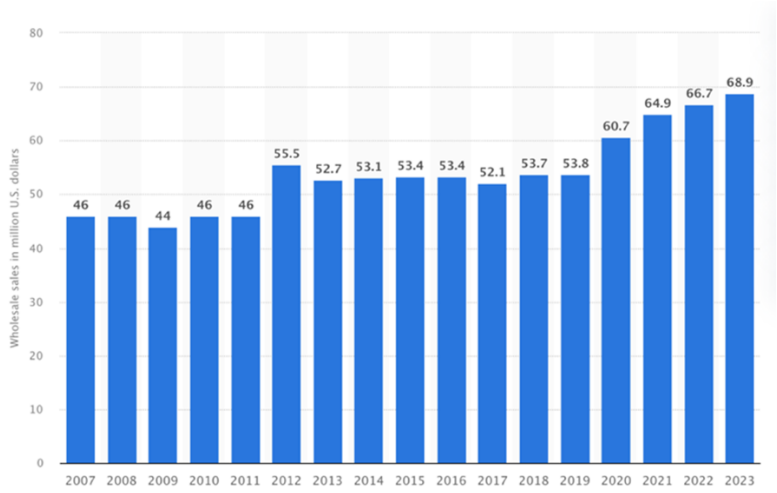

Figure 1: Table tennis equipment wholesale sales in the U.S. from 2007 to 2023 (in million U.S. dollars) [1]

For such a popular sport that spans from a professional and competitive scene to leisure time hobby for a large demographic, a prominent issue may be expressed as its requirement of two people to be played. A willing partner to practice with may not be readily available at all times, and this poses a problem for both professional players who need to practice and hone their skills for competition, and the general population who seek to play it for various reasons ranging from pastime hobby to a healthy lifestyle. For this reason, the need for a product that allows people to practice the sport on their own is apparent. However, the already existent products on the market are either too expensive to serve a broader customer population or lack some features that may result in a poorer experience. This project aims to fill the gap and create a table tennis ball pitching machine suitable for players of all skill levels, from amateur to professional.

To accomplish this goal, the machine should be adjustable from an easy operational mode to more complex and harder-to-predict operations to imitate a real person as closely as possible. It should be able to perform simple and basic pitches, as well as adjust to give the ball various spin options, pitch the ball at different locations, pitch at varying speeds and frequencies, and switch between these variations automatically. Additionally, a mechanism should be implemented to ensure the machine can recycle the returned balls to self-supply for longer and more continuous operation, allowing for uninterrupted and more efficient play time.

2 Project Requirements

- The design should feature an adjustable serving frequency, allowing for a varying number of balls per minute.
- The serving speed should be adjustable, with automatic adjustment preferred, ranging from low to high velocity.
- Balls should land on the side of the table across the net for normal shots.
- The machine should be able to throw the ball back from the net and have it bounce once on each side (optional feature).
- Serving angles should be automatically adjustable within a specified range of degrees.
- The horizontal position on the table from which balls are launched should be manually adjustable.
- The design should have a large enough capacity to contain a sufficient number of balls.
- The design should be lightweight, ensuring it can be carried and assembled by a single person.
- Balls returned from within a defined area on the table and up to a certain height should be recyclable into the system.
- The system should be compatible with standard table tennis tables, as defined by the ITTF.
- The design should accommodate standard table tennis balls.
- The machine should be able to launch balls with no spin.
- The system should have a user-friendly interface for adjusting serving speed, angle, spin, and frequency.
- The machine should operate on standard mains electricity (220-240V, 50-60 Hz).

3 Design Specifications

- Serving frequency range: 25-80 balls per minute.
- Adjustable serving speed range: 4 m/s to 25 m/s.
- A minimum of 7 serving points on the table, including both sides, as seen in Figure 2.

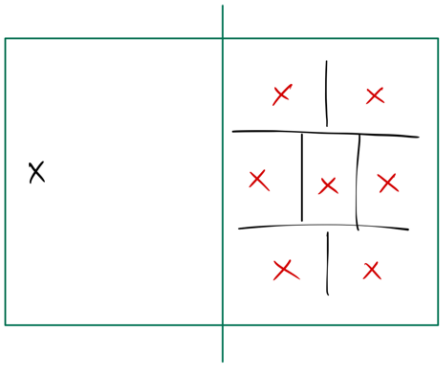

Figure 2: Table Tennis Serving Points on Table

- The thrown balls should hit the 7 serving points within the 5 cm radius range.
- Pitch angle adjustable within -20 to +20 degrees.
- Yaw angle adjustable within -5 to +5 degrees.
- Minimum storage capacity of 100 balls.
- Maximum weight of 15 kg for portability.
- Recyclable ball height: Up to 1 meter.
- Standard table dimensions: 2.74 m x 1.525 m.
- The machine should serve over a net height of 15.25 cm.
- Ball specifications: 40 mm diameter, 2.7 g weight.
- Lifetime of a single ball in the cycle should be at least 1000 throws.
- Spin capability: 36 different spins (top spin, back spin, side spins).
- The design when un-assembled should fit inside a $1m^3$ box.

4 Design Criteria

1. Serving Frequency (15%): Adjustable within 25-80 balls per minute.
2. Automatic Feeding and Collecting (15%): Allows for uninterrupted training.
3. Serving Speed (15%): Adjustable between 4 m/s and 25 m/s.
4. Different Scenarios (10%): Supports various training modes.
5. Adjustable Serving and Yaw Angle (10%): Adjustable within specified ranges.
6. Portability (8%): Maximum weight 15 kg, easy to set up.
7. Capacity (5%): Minimum storage of 100 balls.
8. Ball Durability (5%): Balls should withstand at least 1000 throws.
9. Power Consumption (3%): Energy efficiency prioritized.

10. Spin Options (10%): Ability to generate 36 spins for varied training.
11. User Interface (4%): Adjustable settings for ball trajectory, speed, and spin.
12. No Spin (5%): Optional feature to throw without spin.
13. Special Serving (5%): Optional feature for specific serving modes.

References

[1] Statista, "Wholesale sales of table tennis equipment in the u.s. 2007-2023," May 10 2024, accessed: 2024-10-15. [Online]. Available: https://www.statista.com/statistics/258665/table-tennis-equipment-wholesale-sales-in-the-us/