AN IMPLEMENTATION OF VIBRATION-BASED AUTOMATIC SCORE-KEEPING SYSTEM FOR TABLE TENNIS GAME

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Abstract

In sport tournaments human factor plays an important role to evaluate the game. Table tennis is an example of this kind of sports. In order to avoid erroneous human decisions and to enhance referees' decisions an automatic score-keeping system for table tennis game is designed and implemented with low cost vibration sensors attached underside of the tennis table. The purpose of using vibration sensors is to detect ball colliding with the surface. An additional vibration sensor is also used to detect ball touching the net, determining let state in the game. Petri net scheme is used to model the operation of the system, making it easy to visualize its operation. We believe that the proposed system will contribute much to better evaluate the various phases of table tennis games and to aid the referees to make better decisions.

Keywords: Automatic Scorekeeping, Petri Net Modeling, Table Tennis

INTRODUCTION

Generally referees' decisions in sports games have been a lingering debate, and it has been seen that some of them ended with unacceptable results. To improve decisions given in games, a computerized system should come in where referees observe scene unclearly and fall into hesitance. In amateurs games such computerized systems may be used to serve as an arbitrator. In such games score-keeping is another task to be carried out easily and

correctly. So, a need for replacing the persons to fulfill the above tasks arises.

There are some private entrepreneurs who implemented automatic scorekeeping systems [2-5] some of which are commercially available. Except [2], most of them are designed to increment score manually. Table 1 shows the comparisons of the scorekeeping systems in market. Since most of them are commercial

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products, their details are not well-known. In the publications related to table tennis scoring many methodologies, such as vision based [6-10], acoustic based [11] and vibration based [12] are presented to detect the collision of the ball with the table. In ref.[6-10], vision-based systems are mainly used for detecting ball position and predicting its trajectories with the help of sensors mounted on rackets. The sensors are responsible for detecting angle and speed of racket. The cost of the system mentioned is high due to utilizing high precision sensors and equipment. Although the main purposes of those studies differ, what they all have in common is to be able to keep game scores.

In this study it is aimed to implement a hardware system that automatically keeps the scores in a table tennis singles match and decides which player scores, serves service, faces a let state. The system also resolves the winning side of a set and game in the match. The system is also intended to be used not only by beginners and amateurs but also by referees to support their decisions in sport tournaments. Unfortunately, although it has many

advantages it has been seen that automatic score keeping devices are not used in official matches, where in general manually incremented electronic boards or static cards are used.

PETRI NET MODELING

Modeling of table tennis game to simplify the design of the system is another challenge in this automation. Petri net modeling is best suited for this project. Using Petri nets one can model any discreet event system and visualize behaviors comprising concurrency, synchronization and also resource sharing [1]. As automation industry grows over time, many of the applications requiring labor work are being replaced with automated counterparts. In two last decades, there exists a considerable increase in the number of automated systems, which become more complex as well [13,14]. Petri net, invented by Carl A. Petri in 1962, is very useful tool for analyzing and modeling of systems. He established a mathematical model for his study of communication.

Table 1. Comparison of Table Tennis Score Keeping systems

	[2]	[3]	[4]	[5]	The Proposed System
Service Pass	Automatic	Manual	Manual	Manual	Automatic
Incrementing Score	Automatic	Automatic	Manual	Manual	Automatic
Net Touch (Let)	Detected Automatically	Not Applicable	Not Applicable	Not Applicable	Detected Automatically
Deuce	Detected	Not Applicable	Detected	Not Applicable	Detected
Open Source Model	Commercial Product	Commercial Product	Commercial Product	Commercial Product	Research and Development Product Open source
PC connection	Not Applicable	Available	Not Applicable	Not Applicable	In development
Ball Hit detection	Precision Vibration Sensor	None	None	None	Low cost Vibration Sensors

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The graphical representation is one of its important advantages. In addition, Petri net modeled systems can easily be adapted to many automation tools. Further advantages of Petri nets is to ease the understanding of systems both for engineers and customers. Since its invention of Petri-nets model, Petri nets are used in many different areas namely communications, manufacturing systems, automation industry, and software engineering [13, 14]. In addition to conventional application areas of Petri-nets, they are used in sport areas such as football video analysis [15] or basketball video analysis [16]. An example of Petri net is shown in Figure 1.
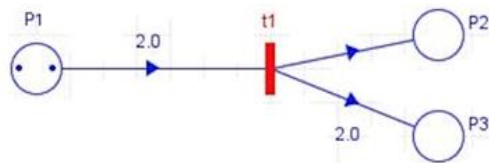

Figure 1. A simple Petri Net

Petri net model has four important parts such as places, transition, line (input or output), and line weight.

Place: can have token.

Transition: is the rule of changing locations of token.

Line: shows the direction of token between place and transition. Lines can not be drawn between places or between transitions.

Weight: shows how many lines there are between transition and place [13-15].

To best our knowledge, this is the first Petri net modeling application of table tennis. For modeling of this Petri-net the RT-Studio Program of Dr. Rachid Hadjidj and Dr. Hanifa Boucheneb was used [17]. Transitions are triggered by the impulses acquired from vibration sensors. Petri net model operation of table tennis game is shown in Figure 2.

The meanings of transitions in Petri net model shown in Figure 2:

t1: Table A vibrated

t2: Table A vibrated

t3: t=3s

t4: Table B vibrated

t5: Net shaken

t6: Table B vibrated

t7: t=3s

t8: Token of net memory<2

t9: Token of net memory=2

t10: Player A or player B gain a score

t11: Fading out of the vibrations of tables A and B.

t12: The number of score of player B>=threshold

t13: The number of score of Player B<threshold

t14: Table A vibrated

t15: Table B vibrated

t16: Table B vibrated

t17: t=3s

t18: Table A vibrated

t19: Table A vibrated

t20: Score of player A<threshold?

t21: Score of player A>threshold?

t22: t=3s

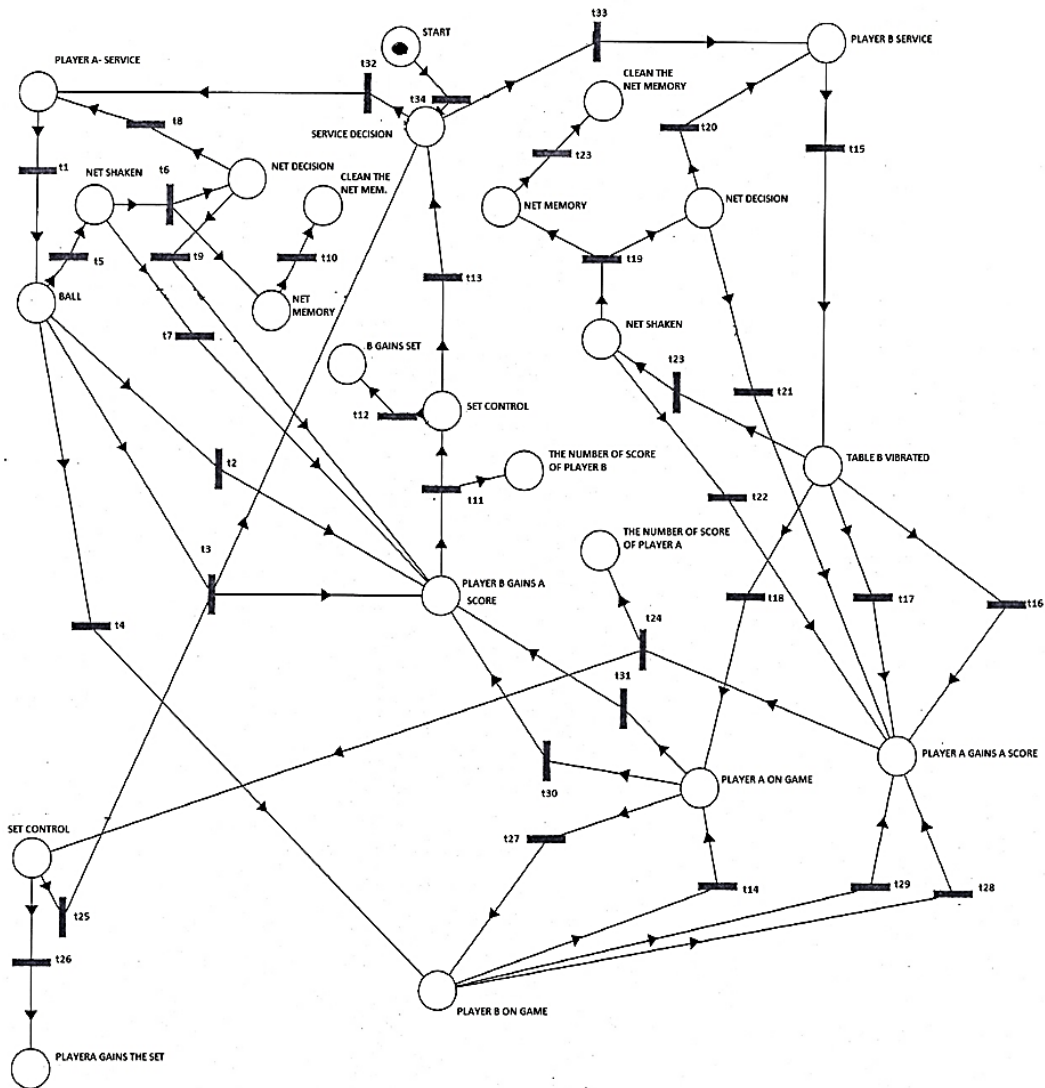t23: Player A or player B gain a score

Figure 2. Petri Net Model for The Operation of Table Tennis Game.

t24: Fading out of the vibrations of tables A and B.

t25: The number of score of player A<threshold

t26: The number of score of player A>=threshold

t27: Table B vibrated

t28: Table B vibrated

t29: t=3s

t30: t=3s

t31: Table A vibrated

t32: Total number of score (player A + player B) mod10<5

t32: Total number of score (player A + player B) mod10>4

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Hardware Implementation

In our study we have used general purpose, low cost vibration sensors to detect collision of ball with the table surface. There are many advantages of choosing this vibration sensor such as low computational load, cost and ease of implementation. In addition, it comes with signal conditioning circuit, generates binary output, and so makes it quite easy to process the ball collisions. A block representation of the complete system is illustrated in Figure 3.

There are available eleven vibration sensors used, ten of them are situated underside of the table and the one is attached to the net. The sensors are so placed that the sensing range of each sensor is overlapped that of its neighbors and all together cover the entire table surface. They sense the vibration produced by ball collision, convert it into electrical signal and then transmit it to the microcontroller to be processed. The microcontroller carries out the necessary operations to decide which half of the table the ball collides. Using the Petri net modeling the state of the game is determined and afterwards appropriate action is taken to be shown on the display. In addition the buzzer sounds to alert the players about status change. Actions to be displayed are score increment, let state, service change, set winner and match winner. In Figure 4 a picture of hardware system implemented is given. Evaluation of the system performance in percentage is tabulated in Table 2.
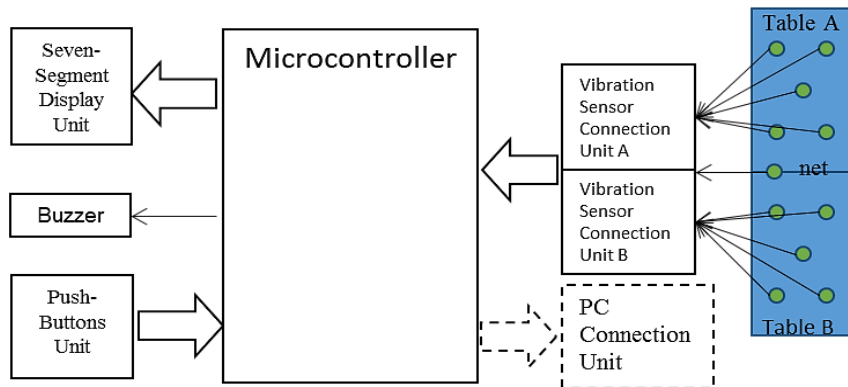

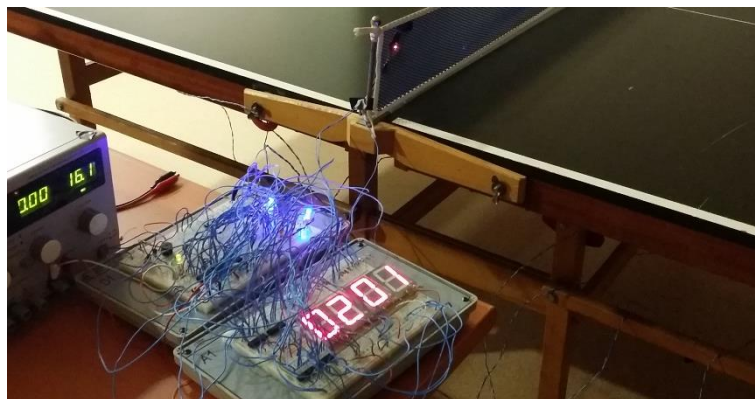Figure 3. Block Diagram of Table Tennis System

Figure 4. A Picture of Implemented Table Tennis Automatic Scorekeeping System in Action

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Table 2. Percent success of the system

	Success Percentages
Service Pass	93
Let State	99
Scoring in game	95

CONCLUSION

In this study, a vibration-based technique to model and implement a score-keeping system for table tennis game is presented. To the best our knowledge it is the first implementation of Petri net modeling for table tennis games. When compared with the other investigated score keeping systems, it seems that our system is superior in some aspects such as low cost, let state detection as evidenced in Table 1. The implemented system has been successful over 93 percent in the areas of table tennis service pass, let state, and game scorekeeping as depicted in Table 2. A manual score increment and decrement facility is also added to the system to be able to compensate such errors. For future study it is planned to establish a PC connection via USB or RF transmitter to better visualize the game results and to record statistics.

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