A study on quantizing high level table tennis for robot training in India

Dinesh Jayabalakrishnan[1] and Rajath Kamal Achanta[2]

[1]Checkmate Table Tennis, Bangalore, India

(Tel: +91 9686568560; E-mail: checkmatettclub@gmail.com, dinesh.j@nsn.com)

[2]SDAT-AKG Table Tennis Development Centre, Chennai, India

(Tel: +91 9884218626; E-mail: kamalrajath@gmail.com)

Abstract: innovative and effective means of training are needed to catapult the ability of an athlete to high level and compete at elite level. The hypothesis of the study is that by implementing statistics and simulation based robot training the athlete's performance is enhanced manifold. The study aims to create a test bench to evaluate the effectiveness of robot based table tennis training to multi-ball training. The research will consist in 1) conducting a survey on effectiveness of robot training, from a group of coaches in India and getting feedback on capabilities and limitations of table tennis training with robot in India; 2) collecting athlete specific quantized data (sample from club level onwards) during multi-ball training session; 3) preparing robot training based on collected data and implementing training schedule for athletes with robot; 4) verifying coherence between multi-ball training and robot training as substitute for each other and thereby enhancing athlete performance and skill; 5) validating the hypothesis defined for the study or justifying the observation based on the study.

Keywords: robot training, table tennis, coaching, simulated training, multi-ball.

1. INTRODUCTION

Table tennis training with robots is an emerging trend in India as in many other countries. However the effectiveness of its usage has been intriguing with subjective mixed opinions. Table tennis being a duel game, the effectiveness of training is proportional to the strengths of the challenger. The availability of suitable level sparring partner is a big challenge for organizing any training sessions. Coaches of advance and high level players face more of this challenge, to find a right partner for training. One of the means to overcome this challenge and have a very effective training session for technical and tactical aspect is by using multi-ball training [10].

Fig. 1 indicates the trend for partner based training and multi-ball training across different levels of play.

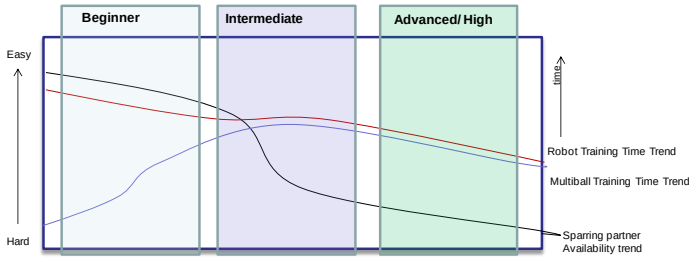

Fig. 1 Training trend across levels of play.

From Fig. 1 it becomes evident that robot training has a unique potential on the easiness to play the role of practice partner at all levels and be as time-wise effective as multi-ball training. Therefore the aim of this study is to use the determinant parameters for high level table tennis [1] by which the different aspects of table tennis is broken down into measurable components. A few selected strokes from different categories [8] are quantized to the determinant parameters at different levels of play. Multi-ball training method for different levels of play is subject to ball fall point analysis [3] and data samples are

collected. The data is then analyzed and processed to convert them into procedures or inputs that can be used for organized robot training. Relation between training methods are analyzed by variation tests and coherence between them is derived to evaluate usage of robot training for high level athletes. Such robot training can be further extended to match simulations, opponent specific trainings and even to create virtual opponents.

For high level table tennis athletes, simulation training enhances athletes' performance [6] and is mainly done using sparring partners or multi-ball training. In each of the above methods the bottle neck on the effectiveness of the training is on the availability of partner or coaches time respectively.

In India, robot training is less preferred for higher level athlete, hence not used for any simulation training. A survey [2] among the elite coaches in India is done to take stalk on the extent of usage and potential causes for the restricted use of robot training. By quantizing the elements of the game and measuring them at both multi-ball training and robot training would indicate the association between the two methods. The level of coherence between both the methods would prove the null hypothesis that robot training can be used for simulation training thereby enhancing the performance of athletes.

Usage of robot training for defining strategies, practice and playing exercises part in the work flow of applied match analysis [5] is considered in the study. The study also paves way for using statistical data from match analysis to be used in robot based simulation training. The scope of study is confined to a single SmartPong robot [4].

2. METHODS

The proceeding of this study is done in a two step approach. The first being a survey among the table tennis coaches in India to take stock of the motive, effectiveness and perceived usage of robot training for table tennis. Inputs from present and previous national level coaches, coaches with decades of experience in table tennis have actively participated in the survey and provided valuable feedback. The second step is to quantize table tennis to the basic elements and group the influence of these parameters for stroke play and its emphasis at each level of play. This information is used to device test methods to find the correlation between effective table tennis training methods. Multi-ball table tennis is one of the most effective means of table tennis training at all levels of play [10]. A correlation between robot training and multi-ball training is attempted for different training types based on the quantized parameters of table tennis and there by associating the effectiveness of table tennis training with robots even for high level table tennis.

2.1 Survey on effectiveness of robot training in India

The survey was conducted to study the current perceptions of the Indian coaches on robot training to develop the game of elite athletes. The survey had 16 questions with four sections namely demography, usage of robot, purpose of robot training and limitations of robot training. The survey was sent to 60 coaches all over India through online surveys, emails and hard copies. Responses from 54 coaches were used further in the study. Among the respondents 30 % coaches were elite coaches who have produced or coached at least an international ranked player. The average coaching experience of the respondents was 15 years. 70% of the coaches had used robots in their training sessions. The results of the survey convey the general perception of the coaches in India about robot training. In India there hasn't been a prominent use of robots for training. Around 77% of the coaches feel that robot training is only for junior and beginner level development and that it cannot serve the elite athletes.

2.2 Fundamental quantize parameters and significance in each stroke at each level of play

The primary elements of the game [8] are categorized and ranked for the different strokes in the games applicable at different levels of the game (Table 1).

Table 1 Dominant parameter in stroke for different level of play

	Spin			Speed			Placement		
Stroke	High	Intermediate	Beginner	High	Intermediate	Beginner	High	Intermediate	Begi
Service	1	1	2	2	2	3	1	1	1
Push	2	1	1	3	2	3	1	1	2
Topspin – Loop	1	1	-	2	3	-	1	2	-
Topspin – Fast	1	-	-	1	-	-	1	-	-
Block	2	3	-	1	2		1	1	-
Counter-spin	1	-	-	1	-		1	-	-
F/H Flick	2	-	-	1	-		1	-	-
B/H Banana Flick	1	-	-	1	-	-	1	-	-
Drive	3	2	3	1	1	2	1	1	1
Smash	3	3	-	1	-	-	1	2	-
Lob	1	-	-	2	-	-	1	-	-

Placement factor plays a dominant role at all levels of play and under all stroke types. Since the study focuses on elite level we will concentrate on the factors that dominate the strokes of elite athletes. The elite level players are characterized by very aggressive and tactical approach. We can see that this level focuses on placement of the ball equally with spin and speed. The most dominant stroke in this level is the fast topspin. Elite players rarely get a chance to attack and when they do so they want to play a really powerful stroke. This stroke has spin, speed and placement in equal proportions. Another prominent stroke here is the counter-spin. Elite players do not block the ball from their fore-hand; instead they counter attack the topspin. This stroke is also characterized by equal amounts of spin, speed and placement. A very new and versatile stroke in the elite level is the backhand banana flick. This stroke also has the three components equally.

2.3 Test procedure for deriving effectiveness of robot training in association with multi-ball training

A subset of strokes and combination of parameters of speed, spin and placement are performed at different frequencies of play matching to the levels of play in table tennis. One playing side of the table is court mapped to 9 different regions [3]. The parameters used for evaluating the skills in the game [9] are used also comparing the effectiveness of training methods. A fixed expected sequence of play is trained using multi-ball and using robot training, the results are captured and analyzed using a sports camera for the exact ball fall point. This data is further analyzed to bring out the differences and similarities between the two methods of training. Close to 400 samples were taken for multi-ball and robot training under these tests.

The four different combinations of test setups considered are:

1. Placement – spin test
2. Spin – placement test
3. Placement – speed test
4. Speed – placement test

Speed considered here is the time delay between two successive ball fall points, thereby making it proportional to the reaction time available for a player to perform the stroke.

The test setup is shown in Fig. 2.

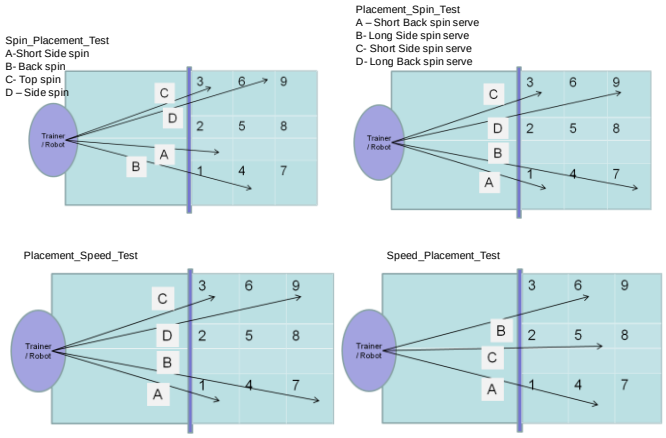

Fig. 2 Test configurations for robot training

A single wheel robot was used for the study [4]. As in single wheel robot there is a direct relation between speed and spin of the ball, this variation was not considered for study.

2.3.1 Placement-spin test: the significance of this test was to have maximum ball displacement with different spins. A service receive sequence was simulated with different service drop points and spins in the service.

2.3.2 Spin-placement test: different spins were simulated

for each ball, with differences in placement of the ball. The sequence similar to short serve – long push – top spin – counter side spin was simulated for robot training.

2.3.3 Placement-speed test: the balls were played to different table mapped positions at varying speeds. The speed is marked inversely proportional to the ball fall point interval. Similar tests were made for multi-ball and robot training (Fig. 3).

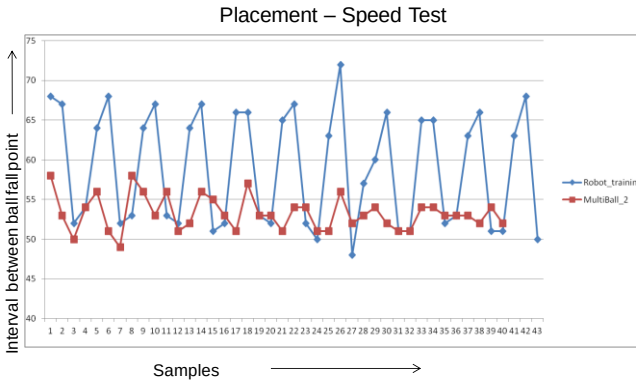

Fig. 3 Placement speed test variations

The consistent pattern of ball delivery by robot over the variations in multi-ball is observed from the Fig. 3.

2.3.4 Speed-placement test: the speed of delivery of the ball varied for each table mapped position. Similar tests were made at varying speeds for multi-ball and robot training as seen in Fig. 4.

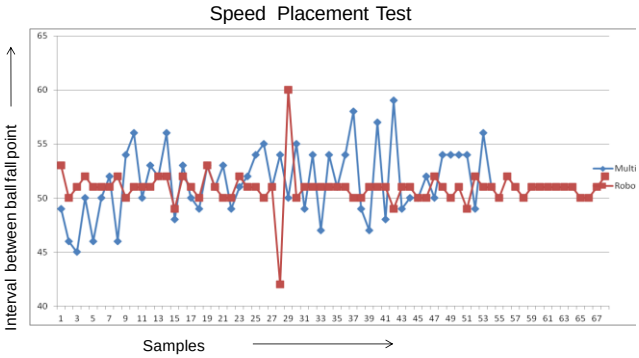

Fig. 4 Speed placement test variations

These tests were done for different speed settings for both robot and multi-ball training.

3. RESULTS

3.1 Observations and summary

The survey results have got some important points for the study. Most of the survey questions had multiple answer choices. Hence the percentages are the number of coaches who also chose that particular answer apart from other answers. Some prominent results of the survey were as follows:

Table 2 Summary of findings from survey among table tennis coaches

Need for robot

Mandatory	Optional	Differentiator	No need
23 %	54 %	8 %	15 %

Purpose of robot

Technique correction	Footwork	Consistency/Accuracy
62.5 %	75 %	75 %

Level of athletes for robot training

2 – 5 years training	More than 5 years training	District/State level	High level
46 %	15 %	46 %	23 %

Limitations for using for elite athletes

Predictable randomness	Lack of variations	Lack of match simulation	Serve/receive sequence
28 %	71 %	28 %	28 %

Measures to overcome above limitations

Multi-ball training	Sparring partner	Restrict usage of robot
40 %	60 %	20 %

All the coaches suggested that if the robot is highly advanced (able to play the serve/receive pattern, 3 and 5 ball sequence), thus eliminating the current limitations

stated, at a low cost and easy to handle mechanism, then they would use it for elite athlete's training. One key finding from the survey was that there is lot of potential for robot training in India, as many of the restrictions observed are not applicable to different robot models [4] available in market.

3.2 Placement-spin test results

The success rate from ball fall point for placement as part of service stroke from robot was close to 100%, but the amount of spin in the serve by robot could not be proportionately varied for long serves. This procedure of robot training can be used effectively for improving service receives of short serves.

3.3 Spin-placement test results

The correlation between expected and observed fall point was increasingly negative for faster training routines.

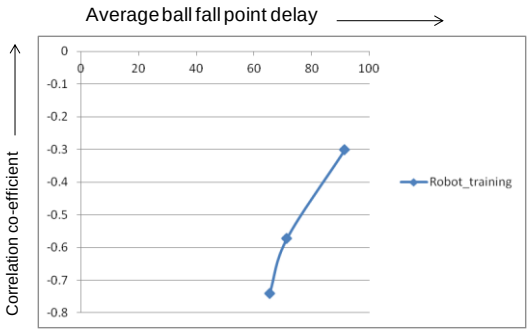

Fig. 5 Spin - placement result

3.4 Placement-speed test results

The results for placement speed tests are very positive for robot training. The correlation coefficient is positive consistently and increases significantly with slower speed of training.

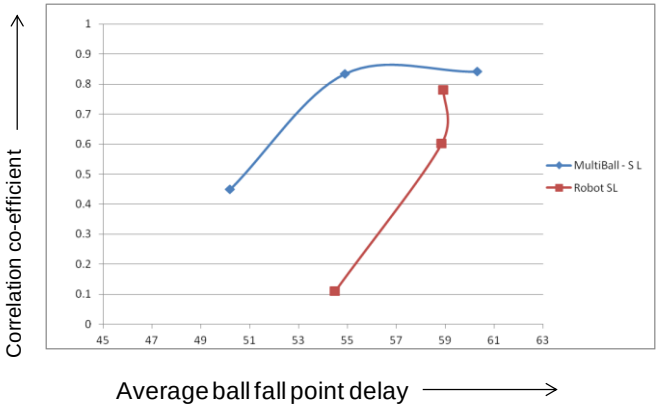

Fig. 6 Placement speed results

3.5 Speed – placement test results

There were promising results for robot training in comparison with multi-ball training. Increasing positive correlation is observed from the results.

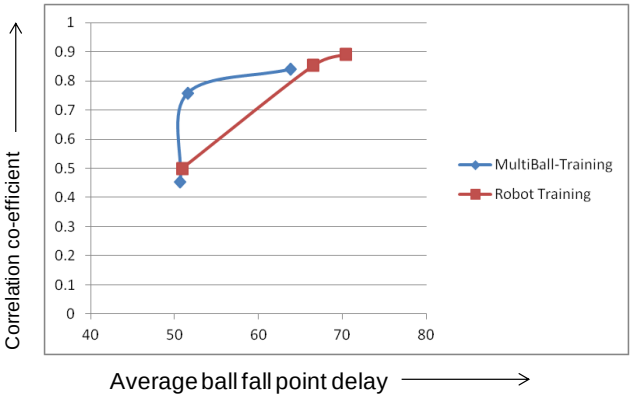

Fig. 7 Speed – placement results

4. CONCLUSION AND SUGGESTIONS

Conclusion

Correlations of tests with parameters of speed and placement are highly positive and the results from robot training are comparable with multi-ball training results.

Correlations of tests with parameters of spin and speed or placement are negative at higher level of training. For any spin variation based training multi-ball training is more recommended than robot training.

In the common event of missing high level sparring partner, multi-ball training helps to facilitate simulation training and thereby enhancing the performance of athletes to next level. The high degree of replication

between multi-ball training and robot training can be seen from the test results. This associative property can be used to infer that training with table tennis robots can be used effectively to enhance the performance of athletes at high (all) level of play.

Suggestions

The study can be enhanced to academic/research level robots for table tennis training.

Tests combining speed, spin and placement variations can be studied further to narrow down the differences between multi-ball training and robot training.

Testing procedures can be done on other robots to reaffirm test results.

Software based analysis of matches to provide training routines or settings for robot training would add the automation dimension to the study.

The challenges are many to simulate table tennis completely by robotics [7], but usage of robots for table tennis training provides many opportunities for automation in the training procedure for table tennis.

REFERENCES

[1] Seydel, R. Determinant factors of the table tennis game, - measurement and simulation of ball-flying curves. *International Journal of Table tennis Science*, 1, 1-7, 1992.

[2] Survey on effectiveness of table tennis training with robots. From: http://www.surveycrest.com/survey/summary/5119e4ad22dca

[3] Yang, F., Ushiyama, Y., Lui, J., Zhang, H.Y., Iizuka, S. and Kamijima,K. Analysis of the ball fall point in table tennis game. *International Journal of Table Tennis Science,* 6, 131-137, 2010.

[4] SmartPong table tennis robot specifications. From: http://www.youtube.com/playlist?list=PLC95C780609CA962F&feature=mh_lolz

[5] Leser, R., Baca, A., Baron, R. and Kain, H. Qualitative game analysis in table tennis. *Proceedings of the 10th International Table Tennis Sports Science Congress, Zagreb*, pp. 99-103, 2007.

[6] Qin Zhifeng et al, Simulated Training – a study on its scientific principles and its application on Chinese national table tennis team, International Journal of Table tennis science No 1 (1998).

[7] Katharina Mulling, Jens Kober and Jan Peters, Simulating Human Table Tennis with a Biomimetic Robot Setup, 11th International Conference on the Simulation of Adaptive Behavior, 273-282, 2010.

[8] Wu, X.Z. and Escobar-Vargas, J. Notational analysis for competition in table tennis (part 2) – non-format method. *Proceedings of the 10th International Table Tennis Sports Science Congress, Zagreb*, pp. 109-118, 2007.

[9] Kamijima, K., Ushiyama, Y., Zhang, H.Y., Yang, F. and Iizuka, S. The examination for evaluating skills during the rally of the table tennis game. *International Journal of Table Tennis Sciences*, 6, 127-130, 2010.

[10] Multiball training method in table tennis: technical and tactical application of combination. Master Thesis, China Papers, 2012. From: http://mt.china-papers.com/6/?p=202756.