TrainIt: Detection and classification of wrong played strokes in table tennis

Habiba Hegazy, Mohamed Abdelsalam,
Moustafa Hussien, Seif Elmosalamy

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Abstract

In sports, coaching plays a huge role in the performance of the players. Moreover, in table tennis coaches plays an important role to guide their players to get the shooting of the ball right, and this is based on different parts of the body. The main idea of the proposed project is to have a a full training system for the table tennis player called The Table Tennis Trainer. The system will detects and analyzes incorrect behaviors in the shooting strokes movements made by the player. This is done with the aid of sensors such as the accelerometer and gyroscope, in addition to an IR depth camera; which enables our proposed system to record the table tennis strokes to detect incorrect movements. The system notifies both the player and coach when an incorrect movement occurs. Feedback in our system will be done via a vibration sensor and Augmented Reality application for the player and web/mobile application for the coach.

1 Introduction

1.1 Background

Table tennis has three fundamental and basic strokes: the push, the drive and the topspin. This strokes based on the wrist, elbow, shoulders and waist. If the player had been mistaken in any part of those while doing the stroke then the stoke goal won't be achieved. Improvement of table tennis strokes/movements could be done by enhancement and aiding currently available coaching techniques.

Therefore,Our project aims to detect wrong movement patterns and technique using IR depth camera and smart band. Our system aims to inform the player the wrong movement done and where it was, also it aims to give guidance about how the movement could be corrected. In addition, the system aims to give a full report about the player performance which includes the count of correct and wrong strokes made.

1.2 Motivation

1.2.1 Market Motivation

According to statistics the number of participants in table tennis in the United States from 2006 to 2017 became popular to reach 16 million players [1]. Overall, Coaches have stated that the extreme problem, when more than player starts to train at the same time there is different personal capabilities for the players, some train right and some get 50 percent of the movements right. in addition, the table tennis movements are based on different parts of the body to result the movement right, some unknown mistakes could take place and not to be recognize by the coach. By using The Table Tennis Trainer System, the application could help the coach in:

1. Coaches get full knowledge report about their players performance (the count of correct and wrong strokes made through out the training).
2. Mistakes detected and acknowledge the players by it on time.
3. Preferences for coaches planning/structuring of the practice and program.

1.2.2 Academic motivation

Our work is motivated by both application domain and previous work. Waraporn Viyanon, Vimvipa Kosasaeng, Sittichai Chatchawal and Abhirat Komonpetch [19] have developed an android application which analyzes users motion data gathered from accelerometer and gyroscope sensors on a smartphone attached on the users wrist and gives feedbacks to improve users swings. Peter Blank, Julian Hobach, Dominik Schuldhaus and Bjoern M. Eskofier [4] proposed a detection and classification system by attaching a sensor to the racket itself. Marko Kos, Jernej Zenko, Damjan Vla and Iztok Kramberger [9] presents an autonomous wearable IMU device for tennis stroke detection and classification placed on the forearm of the player.

1.3 Problem Definitions

Provide online real-time feedback for enhancing the player stroke shooting style by classifying the correct and wrong strokes using sensor device and IR depth camera.

2 Project Description

2.1 Objective

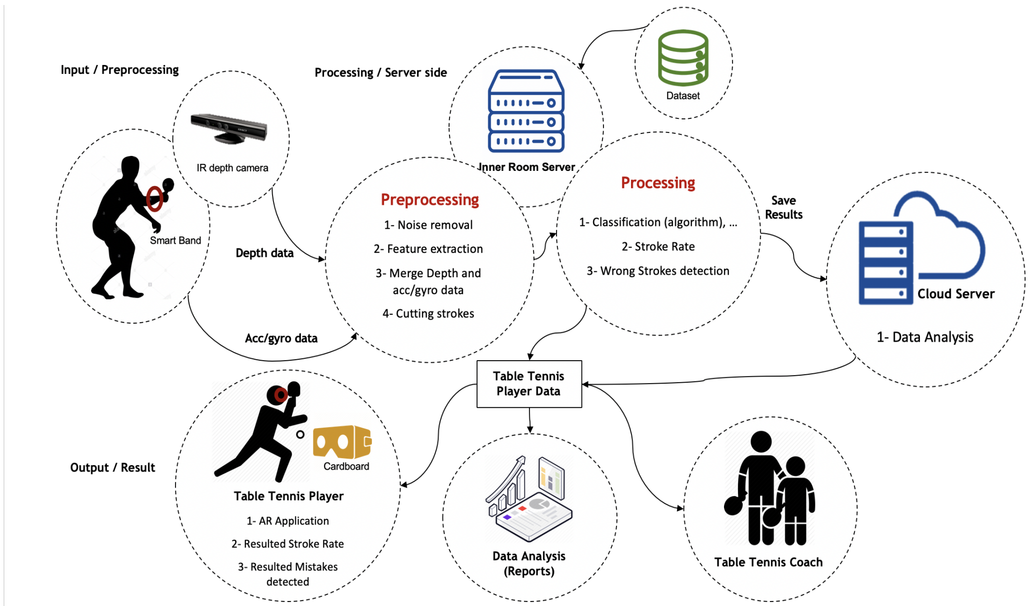
Our objective is to build a professional ecosystem for Table-Tennis players to help them achieve the highest accuracy in their plays. The game consists of Forehand and backhand topspin, push, and drive. Several algorithms will be used in the assist of Microsoft Kinect, Smartwatch and Android Mobile app, we will correct the player faults and let him try till he succeeds.

2.2 Scope

The system will cover several things inside its scope:

1. The system will detect joints using Kinect sensor and smart band sensors.
2. The system will detect the whole stroke movements according to different parts of the body.
3. System will have different users (coach and player).
4. Coach can monitor the player stroke shooting behavior.
5. Coach can view a full report about his players.
6. Immediate Alert to the player if there is a wrong. stroke.

2.3 Project Overview



First we are going to use the Smart Band and IR depth camera to detect the joins needed (Wrist, shoulders, elbow and waist). Then the collected readings is passed through a pre-processing phase that supposedly to get better results by using Kalman filtration and Signal interpolation / extrapolation. The filtered data will then pass to an inner door server will be used for the classification of the movements and detect mistakes, algorithms that might be used is fastDTW, SVM, RCNN, Deep learning time sries .. etc. Moreover, Player behavior will be analyzed and stored. Eventually, the analyzed data takes two ways, the rating data is always sent to data storage cloud to show reports later and AR application and vibration alert will be produced to the player when detecting wrong behavior of the strokes. Moreover, the report can be used by the coach to monitor the ratings of the players by monitor the reports.

3 Similar System Information

3.1 Similar System Description

SwingPong: Analysis and Suggestion based on Motion Data from Mobile Sensors for Table Tennis Strokes using Decision Tree [19]: an Android application analyzer for the stroke motion of the table tennis players. It provides suggestion to the players to improve there swings through giving a full report to the player. It records the users moves during their training and compares it to the pre-collected dataset. They used the Decision Tree algorithm to match the users actions to the standard action. The results are proven to show accuracy in which 77.21% and 69.63% from the test data set for forehand and backhand drives respectively.

Sensor-based Stroke Detection and Stroke Type Classification in Table Tennis [4]: present an approach for table tennis stroke detection and stroke type classification using miPod sensor attached to the racket. They used vector machine with radial based function kernel for classification and Butterworth filter in a forward and backward manner. As a result to thier work the detection precision was 95.7% and classification accuracy was 96.7%. Also the paper gives a full comparisons between different algorithms.

Tennis Stroke Detection and Classification Using Miniature Wearable IMU Device [9]: a system to detect and classify three most common tennis strokes: forehand, backhand and serve in real time. The device uses different sensors like MEMS-based accelerometer and gyroscope with 6-DOF. They used a simple equation for classification, as it results for an overall accuracy of 98%.

Augmented Learning for Sports Using Wearable Head-worn and Wrist-worn Devices [21]: They discuss the idea of making AR application to be used in sports training to give constant guidance and feedback. The system used a sensor data from the wearable devices to be streamed to a host using either Bluetooth or WiFi technology. Unity 3D game engine to implement the framework and TensorFlow for deep learning. We will have the same idea of using an AR application in our system to give guidance for the movements made.

Hand Gestures Classification with Multi-Core DTW [3]: The paper tries to make a increase of classification accuracy and decrease the time of had gestures using DTW over multi-core processors. As a result of the work done using DTW on multi-core, it shows that performance and classification speed had increased. The application would be useful in the case of our system to speed up the classification process and decrease the time needed.

Low-cost motion sensing of table tennis players for real time feedback [5]: The problem was to support players whether it is for professional athletes to enhance their performance, educational applications or entertainment. The contribution was to present a motion capture device for table tennis using wireless inertial measurement units (IMU) embedded in the rackets (mini-MO) to measure angular velocity (gyroscope) and acceleration (accelerometer) integrated in a custom electronic card that transmit the data wirelessly using the IEEE protocol. As the result of the paper shows the superposition of the 37 forehand drive strokes for the 6 data channels revealed that less motor adaptation is required during service, producing reduced variation in the data.

Sports Motion Recognition Using MCMR Features Based on Interclass Symbolic Distance [20]: They discuss the idea of Recognition of human motions and gestures to serve movement guidance and analysis. They used smart phone embedded sensors and applies Max-Correlation and Min-Redundancy strategy to select proper features based on interclass symbolic distance metric. moreover, the algorithm used was DTW algorithm and tradtional distance equations to detect and analyze basic movements in dance practice. The paper concludes that the fusion of accelerometer and gyroscope with 6 dimensions reaching accuracies around 95.67% in average and 98.33% at best would be a better trade-off between time and accuracy.

DTWDir: An enhanced dtw algorithm for autistic child behaviour monitoring [17]: They proposed a system for monitoring autistic child behaviors by analyzing accelerometer data collected from wearable mobile device. The behaviors are recognized by using a novel algorithm called DTWDir that based on calculating displacement which is calculated by DTW classifier and direction between two signals. DTWDir is evaluated by comparing it to KNN, classical Dynamic Time Warping, and One Dollar Recognition ($1) algorithms. The results show that DTWDir accuracy is higher than the others with average 93%.

Online detection and classification of dynamic hand gestures with recurrent 3D convolutional neural networks [13]: They proposed a novel recurrent 3D CNN classifier for dynamic gesture recognition. It supports online gesture classification with zero or negative lag, effective modality fusion, and training with weakly segmented videos. These improvements over the state-of-the-art are demonstrated on a new dataset of dynamic hand gestures and other benchmarks. It achieved accuracy of 83.8%, outperforms competing state-of-the-art algorithms (HOG+HOG2, improved dense trajectories (iDT), super normal vector (SNV), two-stream CNNs, and convolutional 3D (C3D)), and approaches human accuracy of 88.4%.

Table tennis performance analyzer via a single-view low-quality camera [18]: This paper presented how a single-view low-quality camera together with the different algorithms Background subtraction, HSV transformation, and morphological processing to analyze the performance of a table tennis player. They worked on analysis the player performance according to the ball movement which is somehow not a measurement of performance. The result shows that the accuracy of the proposed approach is 96.29%. We will use the idea and algorithm to obtain different joints classification using IR depth camera

Improving joint position estimation of Kinect using anthropometric constraint based adaptive Kalman filter for rehabilitation [6]: In this paper, Microsoft Kinect (IR depth camera) plays an important role in issues like rehabilitation and clinical assessments of stroke patients. The problem was that the Kinect data was surrounded with noise due to the nature of the structured light-based system which is affecting anthropometric data for body segments connecting any joints. Therefore, they used Kalman filter to track the body joints and to de-noise the unwanted joint vibrations. The algorithm they used was second order Kalman filter to reduce the variation in the joint center position. According to two healthy population ranges, the experimental results achieved at least 52% and 34% improvement in standard deviation of bone length. Their future work is to update the estimation of Kalman filter and to make their approach more robust.

Optimization approach to adapt Kalman filters for the real time application of accelerometer and gyroscope signals filtering [10]: This paper, the problem was about the accelerometer and gyroscope signals filtering as an effective noise filtration impacts on the signal reliability of the moving object position and orientation. They managed to apply Kalman filter in a real time application for acceleration and signals filtering. The main techniques they used were Kalman filter (KF) design and adjusting of KF parameters. The final results of signals filtering prove that the aim of the use was achieved and designed Kalman filters are suitable to use in real time application of acceleration and signals filtering.

Human posture recognition using human skeleton provided by Kinect [11]: There were difficult problems related in working with conventional cameras. Human posture recognition is the challenging topic that the low-cost device Kinect with its SDK gives the possibility to resolve these problems. They explore information from using skeleton provided by Kinect as they conduct 7 different experiments with 4 types of features extracted from human skeleton. The main algorithm the used was support vector machine (SVM) to recognize the human postures from the extracted feature. The obtained results show that this device can detect with high accuracy four interested postures (lying, sitting, standing, bending).

On-site Personal Sport Skill Improvement Support Using only a Smartwatch [12]: In this paper, they discussed the use of wearable devices specially in the sports field by attaching sensors to a body and analyzing the movement from the acquired data but there is nothing to do on the spot to provide feedback for form and skill improvement. They developed a sports skill improvement support system using smartwatch sensors and feedback screen. They used simple equations for their calculations and comparisons for the accuracy of accelerometer and gyroscope data. The results demonstrate the effectiveness of smartwatches as an individual skill improvement support system in sports where arm movement is greatly related to skills.

Light Sport Exercise Detection Based on Smartwatch and Smartphone using k-Nearest Neighbor and Dynamic Time Warping Algorithm [14]: In this paper, they discussed the problem of implementation of human activity recognition in daily life related to health issues. They developed a system that able to recognize the movements made by the user and calculate the number movements as light sport exercise activity detection system that can be easily done by person. The main algorithm they used were Dynamic Time Wrapping (DTW) and k-Nearest Neighbor algorithm. Based on the results, we can conclude that k-Nearest Neighbor and Dynamic Time Warping can classify the light sport exercise activity. Keywords with reliable accuracy with 76.67%, 80%, 96.67% for different sport exercise activities. Future work is needed to improve the processing time.

Human Action Recognition Using Dynamic Time Warping [15]: In this paper, the main problem was human action recognition because of its wide variety of potential applications. they focused to recognize some human actions such as waving, clapping using Dynamic Time Warping (DTW) because of its robustness against variation in speed or style in performing action. Depth camera (Kinect) was also used to capture the human motion. They examined their approach to recognize several actions and they confirmed their method can work well with several experiments. Further experiment for benchmarking the result will be held in near future.

Microsoft Kinect as a Tool to Support Training in Professional Sports [16]: There are many sports practiced daily and depends on the speed of players on how they react and how they play and train in professional way but needed more support to reach to higher levels. This paper presents an augmented reality (AR) trainer system based on the Microsoft Kinect (Depth camera) to help in improving performance when training high-precision techniques in judo. This system used 2nd generation Kinect sensor and a developed software written in C#. results on that the system can detect joints with high accuracy according using the Kinect SDK for getting data.

Wearable Motion Sensor Based Analysis of Swing Sports [2]: In this paper, the discussed how can the wearable motion sensor devices can improve the user experience and enrich it by tracking an individuals physical activities. they proposed the design of a sports analytics system with underlying methodologies that efciently distinguish intricacies of players hand movements for a given sport. Under this system, they discussed generalized approaches for detecting shots. They used algorithms for classification with mRMR and CNN and BLSTM neural networks. The accuracies obtained for three swing sports show promising trends. In the future work the user experience will be more improved and enriched using wearable device/smartphone for analysis.

MV-Sports: A Motion and Vision Sensor Integration-Based Sports Analysis System [22]: The paper discussed the idea of using smart technologies and how it will be useful for sports like tennis. The problem was for coaching and practicing specially and how to satisfy the requirements of playing. Therefore, they presented MV-Sports, an effective system for real-time sports analysis based on motion and vision sensor integration. They aim to recognize player shot types and measure ball states. they used a long short-term memory (LSTM)-based framework to integrate MV data for training and classication and an extended Kalman lter (EKF)-based approach to combine ball motion physics-based tracking and vision positioning-based tracking to get more accurate ball state. The results showed the approach can achieve accurate player action recognition and ball state measurement with sub-second latency.

Low-cost accurate skeleton tracking based on fusion of kinect and wearable inertial sensors [7]: They address the limitations of Kinect sensor and present the idea of the fusion between internal sensors and kinect. They created a framework that allows the efficient fusion of these complementary data sources. As a result more accurate joint angle measurements was detected.

Deep learning for time series classification: a review [8]: This study was on the current state-of-the-art performance of deep learning algorithms for TSC by presenting the most recent DNN architectures for TSC. The study will mostly important to take in concentration that will help reducing the time needed in classification.

3.2 Comparison with Proposed Project

Paper Title	Method device	Accuracy Achieved	Stroke Type	Feedback	Sensor Placed	Training Samples	Algorithm used
Sensor-based stroke detection and stroke type classification in table tennis	miPod sensor	96.7 %	Forehand and backhand push, block and topspin.	offline	Inertial sensor in the racket	collected data of 8 different basic stroke types from 10 amateur and professional players.	vector machine with radial based function kernel for classification and Butterworth filter in a forward and backward manner.
SwingPong: Analysis and Suggestion based on Motion Data from Mobile Sensors for Table Tennis Strokes using Decision Tree	Mobile Device Sensors	Backhand 69.63% Forehand 77.21%	Forehand strokes and backhand strokes	online	Mobile attached to the wrrist	collected dataset from four players.	Decision Tree algorithm.
Tennis stroke detection and classification using miniature wearable IMU device	IMU device	98 % - 100 % according to stroke type	Serve, forehand, and backhand.	offline	Right wrist	real-world dataset.	Simple equation for classification.
Low-cost motion sensing of table tennis players for real time feedback	IMU device embedded in the rackets.	-	Forehand Drive	online	Inertial sensor in the racket	single dataset	Several algorithms and evolution made using standard deviation.
Our Proposed System	Sensor and camera reading	-	Forehand and backhand push, drive backspin and topspin.	online	Right side of the body	created dataset	-

4 Project Management and Deliverables

4.1 Tasks and Time Plan

Task	Start	End
Proposal presentation	09/09/2019	06/10/2019
Implementing Prototype		
Designing Class Diagram		
SRS presentation		
SDD presentation		
Validation and Testing		
Delivering Papers		
Delivering Thesis		
Final presentation		

4.2 Budget and Resource Costs

- IR depth camera (Kinect Sensor): 200.00 dollars.
- Smart Band: 41.99 dollars.
- Google Cardboard: 14.74 dollars.

4.3 Supportive Documents

Bjoern Eskofier <bjoern.eskofier@fau.de> Thu, Aug 1, 9:05 PM

to me, Ayman, Mostafa, mohamed1601665@miuegypt.edu.eg, seifelmosalamy@gmail.com

Dear Ms Hegazy,

Thank you for your interest. You will find everything that you need under this link:
https://scholar.google.de/citations?user=H9T8YScAAAAJ&hl=de
(look for ACM Symposium on Wearable ...)

Viele Grüße
Bjoern

Social Media: find out more about

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Table Tennis Graduation Project MIU

Habiba Habiba Hatem Nagah Hegazy <habiba1611146@miuegypt.e...
to fawzyibra

Dear Mr Fawzy,

We are a group of Egyptian students From Misr International University working on a graduation project for table tennis and using the latest technologies to train and practice players to increase their accuracy and professionalism.

Our idea is to develop an application to reveal wrong behaviors in table tennis strokes. Therefore, we would like to know more about table tennis strokes and incorrect behaviors in those strokes to help in our research.

Moreover, we would like to invite you to be one of our main stakeholders in the project.

Yours sincerely,

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