AI-DS Professional COSC2778

AI/DSP Final Project

SWIMCOACH & SWIMTRAIN

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Introduction

Swimming is considered as the most athletic and loved sport across the globe. However, has anyone ever thought of the analytics that is involved in performance enhancement of an athlete and a beginner. For instance, for both swimmers and their coaches the analytics part plays a prominent role to categorize a good swimmer, average swimmer, and a best swimmer. To evaluate the performances of an individual and to chart out the weakness analytics is a remarkably effective source. Swimming Analytics makes the decision making easy with regards to a particular team. The chosen topic swimming analytics revolves around the analytics scenario in which we will be discussing about the certain movements of swimmers that are involved in generation of data. For this topic, AI (Artificial Intelligence) application and 3D (3 Dimensional) mapping will be incorporated in the analysis. The scope of this analysis will result in the automated swimming analytics engine which will in return postulate useful data to help coaches and swimmers. The coaches, swimming institutes, athletes and the beginners will be the target stake holders with regards to this study. The importance of this analysis will help to reduce the manual performance tracking of the swimmers. Furthermore, this analysis will help in evaluation of individual performances with regards to the body movements, swimming techniques and swim velocity analysis. Additionally, the analysis will also enable to track and evaluate the performances of multiple swimmers at a time. Lastly as we know that the manual tracking and watching recorded videos are time exhausting, this analysis will help in making all these steps automated resulting in reduction of team efforts.

Background

As observed from the previous studies for instance, (Zecha, Greif, and Lienhart 2012) only computer vison techniques are employed to record their performance parameters which are time consuming, and the output result is also not efficient for the analysis.

Another example which we can discuss is of work (Victor et al. 2017) in his analysis the most common issue is that the video which gets recorded needs to be further investigated with regards to find out performance of an individual athlete from a multi athlete recorded video.

The above discussed frameworks have a familiar issue of measuring the accuracy of body movements which has been mostly overlooked. The basic concern of the above techniques is to measure the behavior instead monitoring them.

Problem Statement

Prior to the analysis and providing a detailed solution for the challenges faced by certain people who were involved in making the swimming analytics automation. For instance, the traditional methods utilized computer vison techniques to assess the performance with regards to swimmer's stroke rate and its count. Furthermore, in the process of doing this the basic issue is that at a certain point of time in the video only one swimmer is trackable. So, the coach must watch numerous videos in-order to chart out the stroke counts and rate of a swimmer which is

time consuming. Also, the technology incorporated in recording these videos were not so advanced to capture all the significant postures and body movements. From all the discussed issues the most impacted people are the swimming coaches and the

swimming institute analysts who are unable to deep dive in the performance analysis of their athletes.

To resolve these issues, we will be developing a desktop application named SWIMCOACH which will be using 3-dimension swimming pose detection technique which integrate Multiview synchronized CCTV cameras. The basic principle involved will capture the swimming methods using the machine algorithms namely, Open CV object detections and CNN. Additionally, we will be developing a mobile application named SWIMTRAIN. This application identifies the swimmer's action and transmit the data to the servers. The AI algorithms will compute the velocity, arms movement, feet actions, rounds count and time, and distance.

Significance

Swimming is tied in with refining your strategy, amplifying preparing time to improve. It's tied in with swimming more astute. Presently swimmers approach innovation made explicitly for them that can help improve their strategy and develop their affection for the game.

Swim coaches have been utilizing innovation to distinguish and address issues in their swimmers' strategies for quite a long time. Because of its non-uniform character, competitive swimming is hard to dominate. Having the option to lessen haul through appropriate structure is perhaps the main gifts in the game. Because of the assortment in body structures and bulk across competitors, there is no single "ideal method" that works for everybody. Swimming is a continually evolving sport, and at regular intervals, a coach will profess to have found another procedure that would improve productivity. Submerged cameras and sensors, for instance, can be utilized to feature parts of a swimmer's stroke that should be improved, making it a helpful apparatus for coaches everywhere on the world.

We present a technique for collecting swimming metrics on a pool-wide scale that is automated, as well as wearable swimming devices, in this study. Both swimmers and coaches can benefit from swimming analytics in terms of enhancing performance in the short and long term. They provide ways that can be measured. for measuring a swimmer's ability and improvement over the course of his or her career. Every day, a wealth of relevant swimming data is gathered. For example, we may create a mobile application that uses AI and Machine Learning algorithms to determine your swimming techniques, performance, and energy expenditure with unrivalled accuracy. We may utilize a wearable swimming application that turns your phone into a fitness tracker utilizing cutting-edge technology and a waterproof armband of your choice, with more accurate results the more you swim. This is due to the fact that the technology it employs is constantly studying your swimming style and, in effect, learning how you swim. It uses smartphone sensors for measures such as gravity and acceleration sensors, as well as the

gyroscope and magnetometer, so if someone swims for an hour, it takes 5 million data points, which are then translated into various metrics to help you improve your swim training.

With regards to analyzing swimming races in pool circumstances, we think about three segments to difference: camera points, venue, and swimming itself. The location of cameras in a pool is heavily influenced by the course of the pool. The pool is long enough that numerous cameras are required to avoid the swimmers' relative size being reduced to a tiny fraction of the frame. To operate effectively in data analysis and providing adequate feedback, a collection of all the variants over the full dataset is required, which is discussed in the methodology of this report.

We introduced the initial phase in a report aimed at analytics for swimming that is automated. We began the process of creating a dataset by identifying the significant variables. parts of information assortment and comment. The outcomes recommend that information can be proficiently gathered from a video by clarifying edges at a few edges each second. A recognition framework can exist under ideal conditions, according to this analysis. Finally, the results of this investigation were an overall instinct of how profound learning discovery models react to swimmer information.

With such methods and devices close by it will expand the effectiveness as it will finish a lot bigger and complex undertaking unbound by human constraints and won't ever get drained. We will have lower human error rates as when an undertaking is monotonous its simpler for people to lose focuses yet the Ai framework is modified for the capacity so they will eliminate the danger of human mistake delivering a more exact outcome and give the swimming trainers an additional hand to improve the swimmers by their accessible information and reports. We will likewise have a more educated dynamic cycle as the systems will reach a conclusion based on the apps and statistical data available, as well as its past historical data, so that after processing the training data, the model will categories the incoming data.

There is likewise a component where individuals can prepare in a group. Assuming you showing swimming in any neighborhood/state/national club the application can make a profile and register everyone around there. This way we can track and check progress, status, make reports, follow live preparing, and substantially more by utilizing this application. This will help mentors in observing a huge gathering of individuals which is impossible without the utilization of innovation in a more proficient and effective manner. Another advantage is the ability to track your progress, as anyone may challenge their friends, compare results, and get a lot of fitness and enjoyment by completing a series of achievements aimed at improving their swimming experience and performance. It's critical to have continual communication with fitness specialists who can develop routines to help you improve your training even more.

Artificial intelligence's expertise is constantly updated with real-time data. Sports scientists and coaches expand on this knowledge, resulting in even greater performance refinement.

Proposed Solutions

Previous Work in Field

A major issue associated with competition swimming is the presence of multiple swimmers in the pool at any given time. This issue has plagued attempts by both (Zecha, Greif and Lienhart 2012) and (Victor et al 2017) at utilizing computer vision techniques to draw analysis on swim footage. Both bodies of work are not capable of processing multi-swimmer footage, meaning competition video would require editing to isolate swimmers, which is time-consuming and is not always possible.

Another issue is the adaptability of the system to different facilities. This is highlighted in the work of (Sha et al. 2013), which utilized a range of trackers to determine the state of a swimmer. However, the system requires recalibration for every facility. This means coaches must recalibrate their system when changing facilities, or that every facility has a system.

Technologies developed by Mooney et al, Formswim and Tritonwear deal with the limitations of video footage utilizing wearable accelerometers. However, these devices can be impractical and affect fluid dynamics. Further, regulations imposed by swimming regulatory bodies may prevent swimmers from using these devices in competition.

Older systems such as RaceTek utilize cameras placed in a facility's grandstands, which can be costly to set up. Newer attempts such as FINIS Lane Vision utilize smart phones to overcome the introductory cost barrier associated with specialized equipment. FINIS allows a coach to walk poolside, filming a swimmer. However, the major drawback of this technique is that analysis cannot be delivered in real-time using continuous video feeds.

In summary, the limitations on relevant previous work include issues associated with the pool environment, the use of wearable technology, accessing real-time analysis and cost barriers.

Proposed Solution

The solution consists of two parts: desktop application for coaches and wearable device for swimmers. The first element requires a video feed (pool CCTV, or an alternative camera) and a desktop application, SWIMCOACH. The video feed enables the coach to monitor the swimmers pose as they are moving through the water and delivers real time annotations on stroke and kick form, and overall body posture. In addition, coaches will be able to receive analysis on the swimmers turn and dive form. Coaches can use SWIMCOACH while the swimmer is training, allowing them to facilitate feedback from poolside. Coaches will be able to save footage to view with swimmers to discuss training reformations.

The second element is a system for the swimmer, SWIMTRAIN. The swimmer will wear a small accelerometer style device in the water with the aim of being able to measure training elements specific to swimming. These include common metrics such as heart rate, calories burnt, and distance travelled. In addition, the wearable device will also measure features such

as lap speed, speed of turn, speed of dive from blocks to water, stroke rate, breath rates etc. At any point within a session the swimmer can check in on their performance using their smart phone.

FATE Analysis

Fairness

A major fairness issue relative to this type of swim coaching technology stem from ensuring that there are minimal financial barriers to use. Therefore, SWIMCOACH & SWIMTRAIN have been developed to include the use of equipment that is cheap enough that it could be purchased by swimmers or coaches, or easily fundraised for by sports clubs.

Another issue requiring consideration is differing body types of swimmers. Therefore, the system would be trained using footage of swimmers that are of varying heights and body mass to ensure that the system gives actionable insights for swimmers of all body types. In addition, when considering fairness for all genders, differing swimsuit types worn by different genders must be considered. Therefore, the system must be trained with swimsuits styles that do and do not cover the chest area, to account for all genders.

Accountability

When producing software, accountability must be taken for the effects that the software may have on its users. Therefore, a training and coaching guideline document should be included with both SWIMCOACH and SWIMTRAIN to outline healthy training habits, to remind swimmers and coaches that they are using the software to improve the swimmer's technique, not to achieve impossible perfection. This measure is to help reduce and take accountability for the negative effects SWIMCOACH or SWIMTRAIN may have on its users.

Transparency

To achieve transparency while using SWIMCOACH, documentation will be included outlining the application’s functioning. This will include explanations on how SWIMCOACH assesses pose and how it concludes that a technique is being poorly performed. There should also be information included about data storage and the ability to permanently delete previous swim sessions included for both applications.

Ethics

The nature of competition sport presents an array of ethical issues. The most prominent issue being that swimmers and coaches alike will need to ensure they are abiding by league regulations when using SWIMCOACH in different venues or competition. Coaches will need to navigate official channels to access footage provided by venues, such as freedom of information requests.

Many may also argue that the use of such intelligent coaching systems can remove the competition element from competitive sports. Noninvasive software such as the proposed SWIMCOACH & SWIMTRAIN do not directly enhance an athlete’s performance. Instead, both applications aim to inform and improve training practice.

Methodology

In this section we are going to discuss about methodology based on the above proposed solutions. This section is subdivided into 3 parts which are Equipment specification, Dataset creation and training the model.

Equipment specification – Our first solution swimcoach desktop application deals with the 3-dimension swimming pose detection technique with the help of Multiview synchronized CCTV cameras which should have minimum image resolution of 1296*972 (Woinoski, T., 2020) . In order to record data of a swimming candidate the best possible way to capture the complete movement is by capturing it with help of camera positioned in x-y-z axis of coordinate system which we can translate it as top view, front view and back view angles.

Top view camera installation will be in the perpendicular direction of the swimmer so that it will be able to capture the swimmers' major transitional activities start off with dive-in, mid of the pool swimming and turning at the end of pool very consistently.

Front and back view camera installation will be at closely located to start and end points of pool at gaze level of a normal standing person's height. The main advantage of this is since at starting of any king of race the swimmer kick off with dive-in process which is quite quick and include some complex movements so a good gaze angle with close distance of camera is required to capture these movements.

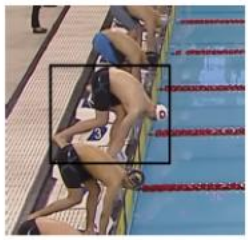
For broadcasting also weather it is Olympics or any national level swimming competition from media point of view also the recording is done on standing humans' gaze level (pool level) and top view (pool level) so that viewers can understand movements and enjoy competition easily on TV. (Woinoski, T., 2020)

Dataset creation - In order to create swimming pose detection system a reliable one we need to establish baseline dataset so to achieve this we can collect data from authenticated sources which are easily available in public domain which can be used as reference without any monetary expenditure. Olympics Sports broadcasting video footages are freely available on Youtube website. Along with this data can be obtained from many other digital platforms like Swim USA productions, Australian Sports Commission or Canadian Sport Institute Pacific.

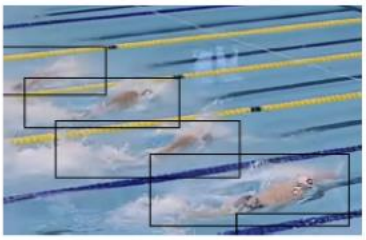
Training the model - In order to train our model, we need technology which can work on high-speed activities with good amount of accuracy. We aim to achieve this by neural network approach using Computer Vision Object Detection technique. Image bounding box annotation technique is widely used in fields like Robotics and self-driving cars. So, in order to increase flexibility of our solution we are going to use R-CNN algorithm for boundary box annotation to detect multiple swimmers. The motivation of our solution is inspired from the AI system already installed in traffic signal cameras to detect vehicles.

Using this method we aim to first detect all the swimmers in the swimming pool arena and then put boundary boxes around them so that multiple swimmers can be tracked. In object detection neural network, a swimmer's video is split into multiple frames and in consecutive frames every second frame is compared with first frame to match the detection process and this process takes place continuously for each frame to keep track of a swimmer within a specifically devoted single boundary box. (Victor et al 2017)

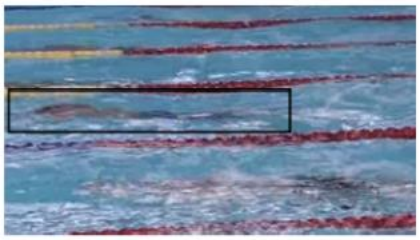
Since during a swimming competition a swimmer is involve in 6 major transitions, so we need to detect and classify these transitional activities correctly into separate classes with annotation by assigning smallest bounding box to cover swimmer's posture. (Sha et al.2013)



(a) Swimmers on blocks

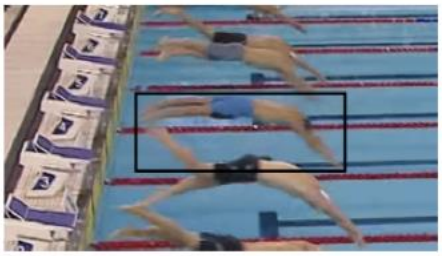


(b) Swimmers swimming



(c) Swimmers underwater

(a) Swimmers turning



(b) Swimmers diving

(c) Swimmers finishing

Class 1- On block position- At this point of time swimmers are about to kick off and at starting position. The transition in class will occur when they are no longer in contact with land.

Class 2- Diving process- In this period the swimmer is in middle of air when the candidate is neither on land nor in water. The transition in class will occur when swimmer is no longer is in air and touches the water with a splash because of collision of body with water.

Class 3- Underwater swimming- This state is achieved usually after diving process when swimmer's body is submerged inside water.

Class 4- Swimming- In this period swimmer is performing forward strokes continuously with the help of hands and legs movement. In this state swimmer is not in contact with any of the swimming pool's wall and ground.

Class 5- Turning – In this period the swimmer is approaching towards the pool's end wall and having a transition from swimming state.

Class 6- Finish- This is the state when the swimmer completes the swimming race and is near the end point in stationary state for a longer duration of time with body touching pool's ground and half the body is out of water.

In the complete process of swimming from start to end we aim to follow the annotation process when maximum part of swimmer's body is visible to camera, and we can set this visibility criteria to 80%. Since there are 3 dimensional cameras already installed in pool arena with different angles to cover every moment of swimmer there is very less chance of missing any frame of swimmer. The size of boundary box during swimming will change continuously according to the earlier mentioned classes. For example, during swimming when swimmer's body is completely stretched the length of boundary box will get stretched and will get shrink during turning or in on-block position. (Woinoski, T., 2020)

Similarly, we can collect data for distinctive styles of swimming and can create multiple models according to the specific swimming styles with different data subsets so that we have large amount to dataset in our database and models can be train and tested as per requirements.

Second part of solution which is intended to enhance the swimming analysis is based on fitness tracking mobile app named as swimtrain. Our solution is inspired from already available smart watches and fitness band which can calculate heart rate, steps count etc. The wristband fitness device will be installed with 4 major sensors which are gravity, acceleration, gyroscope, magnetometer. These 4 sensors will record important activities during swimming which are speed, time, distance covered and frequency and angular velocity of arms and legs movement. Gravitational sensor will be used to calculate acceleration effects of a swimmer during each swimming phase. Gyroscopes are advanced versions of accelerometers which can calculate angular velocity and orientation of swimmer during swimming (ElProCus). Magnetometer is widely used in aircrafts and are used to calculate the change in direction and location and in our case this sensor can detect and calculate the transitional movements like turning of swimmer easily. (Sciencedirect.com. 2018. Magnetometer) Our device will convert the data collected from sensors in physical SI units which can be converted and presented into a matrix format of swimming measuring scales. Based on the collected data with help of basic machine learning classification algorithm we can split it into different sub-activities as explained earlier so that for each activity analysis is clearly available.

Below is the prototype of the analysis for freestyle swimming which we wish to receive as a result from our desktop application SWIMCOACH and mobile application SWIMTRAIN.

Swimmer details	Posture Accuracy
Participant 1	63%
Participant 2	82%
Participant 3	75%
Participant 4	91%
Participant 5	54%

Participant 3	Average Speed	Time taken	Posture Accuracy
On block position	0 m/s	3 sec	65%
Diving process	4 m/s	2 sec	85%
Swimming	15 m/s	34 sec	80%
Turning	8 m/s	4 sec	70%

Conclusion

With automated swimming analytics, we can make significant progress. We will use the steps outlined here to collect additional data from a variety of sources and create a clear dataset for swimming. Then, as in (Bewley et al. 2016), we will construct improved tracking systems that incorporate swimmer dynamics, and we will construct metric collection solutions that automatically compute popular swimming measures like the number of strokes and the length of each stroke. The nature of this work is special, and therefore, it very well may be depended upon once the readiness is finished. We are certain that, whenever finished, this task will altogether expand the assortment and the use of swimming analytics, which will benefit coaches and competitors at all levels of the sport, as well as increasing public interest in swimming.

Artificial intelligence is giving both swimmers and coaches more information. Artificial intelligence's contribution to sports should never be underestimated. As AI technology advances, it is predicted to impact the sports industry's future. Through the advancement of AI technology, we will uncover new training methods, approaches, and current ways of engaging with spectators. With the existing artificial intelligence applications, it is only natural to expect that AI technology will be used more frequently in the future.

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