Proposing of Planning System for Sports Domain: A Tool for Professional Coaches

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Abstract

This paper introduces the System for Sports Training Planning (SSTP), which aims to be used as an automated planning application that generates training plans for individual athletes. This paper mainly presents the sports domain, the system's high-level architecture, ongoing development, and its challenges.

Introduction

Recently, athletes performance developed beyond all expectation and prediction. Old records, which were considered as unbreakable, are reached even by amateurs during their training units. These have been enabled especially through better nutrition and improved training methods (Bulchandani 2012). In all sports, the key to reach high level performance lies in the athletes preparation in trainings. There cannot be a success without proper training planning and corresponding training execution on the highest level (Meżyk and Unold 2011). Nevertheless, training planning is a well-known problem in the sports domain and only top level coaches are able to deliver training plans of sufficient quality to enable athletes to perform on their very best. Training planning is a complex process, which is affected by a multitude of factors that also vary according to different sports. These factors include variables such as athletes predispositions, athletes health conditions, competition goals, weather conditions, and others (Smith 2003). The vast amount of variables makes planning a process, which depends on basic principles that are provided in the coaching literature.

The purpose of this research is a development of an automated planning system that uses a specific sports knowledge base and desired goals as an input for a planner that will create individual training plans for athletes. This will provide efficient solutions for coaches from various sports to create plans without having a vast background knowledge or the need of being an expert in automated planning. In order to reduce the complexity of having very varied requirements in diverse sports, one specific sports domain, namely kickboxing, has been chosen as a case study. The chosen domain will serve as a stepping stone and proof of concept for further development.

Sports Domain

In the 21st century, computing and network technologies are daily life necessities and also play more and more significant roles in sports training. The most significant progress has been made in the usage of computing in scientific sports training, which leads to a systematic approach of training, performance measurement, and competition analysis. This contributed to training efficiency improvement, athletes performance and it also helped to prevent some sports injuries (Hou 2015). Computing technologies involved in the sports domain usually are data acquisition and data processing, databases, modelling and simulation, which are used in training and coaching, biomechanics, sports equipment, and computer applications. In addition, usage of AI is no exception either. Most of the research concerning AI in sports domains is focused on the prediction of sports outcomes, game-time analysis to enable efficient decisions during competitions, sports biomechanics for performance analysis, which is facilitated by expert systems and neural networks to gait analysis (Lapham and Bartlett 1995). Another commonly used AI technique is pattern recognition, which is for example used in football game analysis and weight training (Novatchkov and Baca 2013).

However, no literature on sports training planning seems to be available. As a result, the intention of this article is to outline an ongoing project that deals with utilising automated planning in sports domains. For that reason there is a need to identify what is meant by a sports domain and what elements will be used as an input for automated planning.

At first, there is a need to address what sports explicitly means. Collinsdictionary.com (2016) defines sport as:

> an individual or group activity pursued for exercise or pleasure, often involving the testing of physical capabilities and taking the form of a competitive game such as football, tennis, etc.

The term sport has many definitions, but all of them suggest that sports are primarily concerned with reaching the best possible performance in a particular discipline. Essentially, athletes in order to achieve required outcomes and performance during competitions, have a need to adequately train before the competition takes place. Athletes are typically guided by coaches, who provide them with knowledge in the specific sports domain. This knowledge is usually transferred by means of training units, which are planned according to coach experiences. In other words, the main objective of sports training is to reach the very best performance in the planned competition.

Sports training can be defined as a set of training methods and exercises, which are executed by an athlete in order to prepare for a competition. To be able to utilize the best from training, it is necessary to carry out the methods and exercises in precise manners. For that purpose a tool called annual training planning has been developed. Nevertheless, this tool requires vast knowledge and time resources.

Annual Training Planning (ATP)

Kassa (2011) describes the annual training plan as a tool used by coaches, which serves as a base for all scheduled training activities over a year. The annual training plan is an important tool for enhancing an athletes performance. An ATP is constructed on the concept of periodisation, which divides an athlete's year into manageable training periods (Milanović and Šalaj 2014). These periods are focused on development of different abilities such as strength, endurance, and speed (Bompa 2009). Furthermore, periodisation is a process, which allows to formulate sports program in systematic fashion.

Forming an ATP has following steps (Olander, 2015):

- Information gathering
- Analysing the last programme
- Assessing athletes performance
- Input the peak events of a year
- Dividing year according to periodization
- Outlining objectives of each phase
- Determining activities of each phase
- Identifying of volume intensity and recovery relationship within a season
- Determine a total number of training hours to be complete.
- Identify appropriate training units for each phase

To perform all these steps, it is necessary to have a high level of knowledge in the field of sports science. Also, it is essential to have a great understanding of athletes, who are being trained, be aware of all possibilities and circumstances, which can occur during the season and most of all possess a great deal of planning abilities. In order to have accurate and precise input for an ATP and objective outcomes, there is a need to understand athletes' performance and methods by which it can be measured.

Performance Evaluation

One of the best known definitions of sports performance was defined by Hay and Reid (1988): performance as the manner in which all movements comprising motor skills – a series of voluntary movements of the human body designed to achieve a specific goal - are executed. In other words, performance is a goal-directed set of movements, and the process of evaluating and analysing an individual athlete's execution of a specific task and a level of skill involved in the task. That said, there is a need to evaluate performance in all sports as it is used for determining competition winners and also for sports training improvement. One of the main purpose of performance evaluation (PE) is to obtain sports specific data, which are analysed in order to detect errors in training process and adopt corrective actions (Owusu 2007).

Higgins (1977) views PE as a complex process that includes numerous stages, which are:

- Describing what should happen
- Describing what happened
- Comparing expectations with results
- Taking corrective actions

Contribution to the view of Higgins' PE have been done by Fairs (1987), who described five steps in performance evaluation:

- Data collection
- Diagnostics
- Prescribed plan of action
- Implementation
- Evaluation

The process of PE typically includes collection and analysis of large amount of biased information about athlete's performance. According to Fair's data collection is fact-finding part of PE process, where data are drawn without making any conclusion or interpretation. He claims that the data collected in this step can be of an objective and a subjective manner. Subjective data are usually provided by an athlete, while objective data are collected by evaluator using specific equipment for explicit measurement.

The PE procedure is based on several expertises and it can differ according to various sports. Further, sports performance can be measured in many possible ways and it usually involves qualitative and quantitative analysis of human motion, coaching methods and biomechanics. The qualitative analysis of sports performance is based on a visual observation of human motion. This analysis is usually done by evaluators and accuracy of this method depends on their experience and equipment they use. This method is inclinable to errors as it relies on the evaluator getting a clear picture of joint movements as they occur, which can be in some situation difficult (Fernandes, Anes, and Abrantes 1996). On the other hand, the quantitative approach retrieve an objective data, which have a form of biochemical profile of motion, which is being analysed (Owusu 2007). Nonetheless, this approach is vastly time consuming. One of the reasons is that biomechanical quantification is a manual process.

In addition, Maglischo (2003) describes blood testing processes for monitoring heart rate with reference to training managing and monitoring. Also, Friel (2016) describes proper and effective methodical approach of making training logs, which are aimed to create better experience of training preparing phase usage. These two papers are stepping stone into methodological training and performance testing methods that are used for the research.

With a rising number of analysed athletes, the complexity can radically increase. This can be seen in situations when the coach has to remember information about more than twenty athletes. This information consists of their personal information (age, weight, height, etc.), number and performance of athletes competitions, and their strengths and weaknesses. Retaining and analysing of these information brings difficulties, which usually are reflected in training efficiency, and therefore in performance efficiency.

It is therefore not surprising that numerous computer-based systems have been developed in order to increase the speed and quality of performance evaluation (Owusu 2007). A large number of these systems are visual. The principal idea of these systems is to capture the complete athlete motion into digital form and then input these visual data for quantification into computers, where these data are analysed. Consequently, this provides enormous possibility for AI techniques. Nevertheless, AI techniques in PE have currently only limited capabilities. The main reason is that sports domain lacks of characterisations in terms of quantification of sports science. This fact is also one of the obstacles for this research.

For this reason, there is a need for a sports domain specification that will provide input for a planner, which will result in generating an annual training plan. In order to create a sports domain model, there is a need to examine sports performance, physical abilities, training methods, training planning and testing of athletes, and adapt this concepts on concepts of automated planning.

Proposed System Architecture

The proposed planning system will be developed on an ontology core that will provide a clear formalism and user-friendly environment for domain experts, namely coaches and sports science researchers, to be able to encode sports domain knowledge. The encoded knowledge and an input required for creating initial and goal state will be transferred into Planning Domain Description Language.

The system architecture (depicted in Figure 1) is based on two main AI concepts, which are automated planning and ontology. A high-level architecture of the system can be seen in figure 1. In proposed scenario ontology outlines the sports domain itself. In other words, the system ontology will consist of objects definitions, their relationships, and hierarchies, action types and methods. Classes will represent individual body elements, such as energy systems, muscular system and technical and tactical capabilities. Action types will consist of action name, logical preconditions and effect. Methods will be used as an abstraction of the actions. In other words, methods will be used as high-level tasks that consist of actions which have an explicit ordering.

The input part of the architecture is focused on generating a planning problem that is going to be created by inputting three main parts, the first is an athlete's current performance, peak events for which the athlete is aiming for, and correction values that will be provided by analysis of the athlete's previous annual training plan. These three parts will be used for generating initial state, objects, and a goal state.

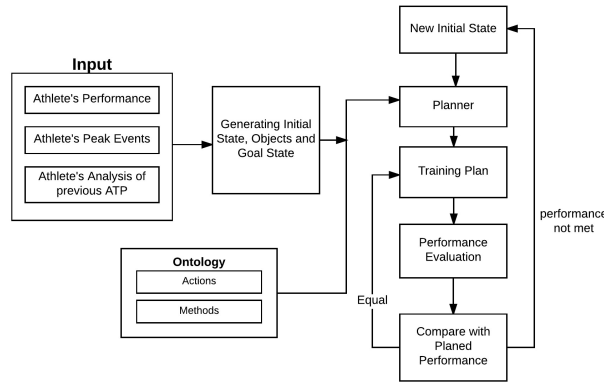

Figure 1: Proposed system architecture.

The next step in the process of planning is fetching the domain and planning problem into chosen planner and generating the annual training plan.

After the plan is generated, it has to be executed for a specific amount of time (chosen by coach). The chosen time period has to be long enough for the athlete's body, therefore the athlete's performance, to respond. When this time frame runs out, a performance evaluation process takes a place. Reached performance is compared with the planned goal state. If the goal state is met, the athlete continues with plan execution. Otherwise, the reached state becomes the new initial state and re-planning process is initiated.

Ongoing Work

The system architecture described above provides a main concept of the research idea. Nonetheless, there is still need to completely define the sports domain, which would connect sports training methods, and exercises with their impact on a human physiology and automated planning concepts.

The Next Steps

The first attempt to produce automated training plan will be done through a knowledge encoding tool called KEWI. KEWI was developed in order to provide for domain experts, who are not experts in AI planning, a user-friendly solution for encoding classical planning domains. This tool can export domains into PDDL that can be used with standard planning engines (Wickler, Chrpa, and Leo McCluskey 2014). The concept of KEWI is building on an ontology that furnishes necessary parts of classical planning, such as objects, their hierarchies, action types, preconditions, effects and methods (Wickler, Chrpa, and Leo McCluskey 2014). In order to be able to encode the knowledge into the ontology that is specifically developed for classical planning use, there is a need of major simplification of sports science constructs.

Example The athlete's sports performance can be broken down into four main categories, which are energy systems, muscular system, technical and tactical skills. Each activity (training method, or simply exercise) has a different impact on individual abilities of the athlete. The activity impact is only hardly measurable, which makes it almost impossible to define activity with accurate effects. Furthermore, each activity has to be executed for a certain amount of time and be placed in a time frame (training unit). As the domain is being developed under classical planning, the time requirement has to be relaxed.

Challenges

The domain has to be concrete in the sports science findings. The fact that sports science is based on several other sciences, such as anatomy, biomechanics, biochemistry and bio-kinetics, makes the encoding of the domain very challenging. The domain specification itself brings several problems that have to be dealt with. These are for example:

1. Quantification of four different performance abilities.
2. Automation of sports training methods and exercises with correspondence with automated planning concepts.
3. Addressing activities duration requirement.
4. Incorporate specific breaks between individual exercises.
5. Identify how to prioritize actions.
6. Identifying of a goal state.

Currently, different types of automated planning are being addressed, which could satisfy the system requirements. Momentarily, the main focus is on classical planning as it can provide a working prototype of the proposed system. Nonetheless, the sports domain has some needs, which classical planning cannot facilitate. For example, each action in the sports domain requires for an execution certain amount of time. That could be supplied by temporal planning that is allows for expressing time explicitly. Executed actions or planning operators do not have an immediate effect, but incur a pre-defined delay. Temporal planning could also provide a solution for incorporating breaks between individual exercises as each durative action has effects with two sets. One set represents the effects taking place during execution and the other set represents the effects that take a place after the execution of the action. Further, this could be used as representation of athletes' power supplies. After execution of an exercise an athlete would require a refreshing of power supplies in order to execute the next planned exercise. This process would continue until the athlete's power will be completely depleted or the training session will terminate.

Conclusion and Future Work

In this paper, we have introduced an automated planning application on a real case scenario concerning sports training planning. In other words, this paper presents a sports training planning system architecture and its ongoing development. This work is carried out in order to develop a planning system that will enhance the sports training process. It will create training plans based on the latest sports science research and explicit athlete performance data. This would be a significant enhancement in sports training as currently there is no sophisticated tool that could provide any level of training planning automation. Subsequently, the development of the sports domain, even though with specific orientation, could provide a tool for a range of sports scientists that would benefit from using this system.

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