08372 Abstracts Collection
Computer Science in Sport - Mission and Methods
— Dagstuhl Seminar —

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Abstract. From 07.09. to 10.09., the Dagstuhl Seminar 08372 "Computer Science in Sport - Mission and Methods" was held in Schloss Dagstuhl – Leibniz Center for Informatics. During the seminar, several participants presented their current research, and ongoing work and open problems were discussed. Abstracts of the presentations given during the seminar as well as abstracts of seminar results and ideas are put together in this paper. The first section describes the seminar topics and goals in general. Links to extended abstracts or full papers are provided, if available.

Keywords. Computer science, modeling, robotics, sport technology, doping

08372 Executive Summary –Computer Science in Sport - Mission and Methods

From September 7 to 10, 2008 about 30 experts from computer science and sport science (see Appendix B) met at the Leibniz-Zentrum für Informatik in Dagstuhl to discuss interdisciplinary issues in the area of computer science in sport. Five topics were selected for discussion (see Appendix A): doping, modeling and simulation, pervasive computing, robotics and sport technology. A total of 17 presentations dealt with selected projects and issues in the above-mentioned fields.

Dagstuhl Seminar Proceedings 08372
Computer Science in Sport - Mission and Methods
http://drops.dagstuhl.de/opus/volltexte/2008/1690

Keywords: Computer science, modeling, robotics, sport technology, doping

Joint work of: Wiemeyer, Josef; Baca, Arnold; Lames, Martin; Lyons, Keith; Nebel, Bernhard

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2008/1682

Using Affective Technologies to Increase Engagement and Motivation in Fitness and Sports

Elisabeth André (Universität Augsburg, DE)

Work by Picard and others has created considerable awareness for the role of affect in human computer interaction. In fact, a strong new field is emerging in computer science: affective computing. In my presentation, I presented first ideas to make use of affective technologies in fitness and sports.

Keywords: Affective computing

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2008/1684

Pervasive/Ubiquitous Computing in Sport

Arnold Baca (Universität Wien, AT)

The integration of modern sensor-, information- and communication technologies provides promising means for developing systems to acquire, process and wirelessly transmit data during sportive activities. Four fields of application are pointed out and illustrated by recent examples. Coaching is considered first, introducing the concept of remote coaching. Sensors acquire athletesŠ performance data; the digitized signals are transmitted to a mobile client and from this sent to an internet server. Coaches and sports scientists may thus give fast feedback not only at the training site but also from remote locations. The potential of markerless and wireless tracking methods is outlined then, giving an example from marathon running, where athletes are informed on their position and average velocity as well as the position of their running partners during the race. Third, systems for quantifying and/or qualifying sports and physical activity are discussed. They include systems for collecting distances run and for estimating running intensities, systems for supervising rules and regulations and systems for supporting judges. An example from taekwondo is given, where force sensors in body protectors assist judges in scoring correctly. Applications in leisure and entertainment activities are finally considered. Concluding, some future expectations are given.

Keywords: Ubiquitous computing, remote coaching, tracking, activity measurement

See also: Proc. 1st Joint Int. Pre-Olympic Conf. of Sports Science and Sports Engineering, Vol. 1: Computer Science in Sports, Y. Jiang, A. Baca, H. Zhang (Eds.), pp. 1-5.

MODELLING FATIGUE AND TASK FAILURE AS NON LINEAR PROCESSES

Natalie Balagué Serre (INEFC - Barcelona, E)

Two main assumptions have been basing until now the controversial available research on human muscular fatigue and task failure: the component-dominant nature of our organism and the linear nature of the biological changes produced during the fatigue process at different levels (biochemical, cellular, organic or sensory). According to it the main site or mechanism of impairment depending on each task under investigation and the quantitative changes of the related variables (H+, lactate, glycogen, neurotransmitters, impaired cortical impulsationÉ) are the focus of the mentioned research.

However in our view before continuing with the study of the controversial causes of fatigue and failure it seems necessary to respond the following previous questions: - is our organism a component-dominant or an interaction-dominant system? - are the continuous changes observed in the related variables able to explain the abrupt macroscopic change that characterises the task failure? Our objective is trying to find a general underlying mechanism to explain task failure in the framework of the complex nonlinear dynamical systems interpreting differently the nature of the system we deal with. The possibilities of modelling fatigue and task failure as non linear processes will be discussed. Particularly, we will emphasise the impossibility of modelling the abrupt change (i.e. task failure) on the basis of linear models of continuous change of constraints that signify developing fatigue.

Keywords: Fatigue, task failure, interaction-dominant dynamics, non-linear modeling, fluctuations, critical point

Joint work of: Balagué Natalia; Hristovski, Robert

Use of Self Organizing Maps in Technique Analysis

Roger Bartlett (University of Otago, NZ)

This study looked at the coordination patterns of four participants performing three different basketball shots from different distances.

The shots selected were the three-point shot, the free throw shot and the hook shot; the latter was included to encourage a phase transition between shots. We hypothesised lower variability between the three-point and free throw shots compared to the hook shot. The study uses Self-Organizing Maps (SOM) to expose the non-linearity of the movement and to try to explain more specifically what it is about the coordination patterns that make them different or similar.

The SOM proved to draw the researcher's attention to aspects of the movement that were not obvious from a visual analysis of the original movement either viewed from video or as computer animation. A speculative link between the observational learning literature on the importance of the kinematics of distal segments in skill acquisition and the visual information a coach or analyst may rely on for qualitative technique analysis was made. Although making the distinction between the three shooting conditions was meant to be a trivial exercise, in many cases for this dataset the SOM output and the natural inclination of the movement analyst did not agree: the SOM may provide a more objective method for explaining movement patterning.

Keywords: Biomechanics, technique analysis, SOM, Artificial Neural Networks

Joint work of: Bartlett, Roger; Lamb, Peter; Robbins, Anthony

Robot Sport Competitions - Benchmarks for AI and Robotics

Sven Behnke (Universität Bonn, DE)

In my talk, I argue that well designed robot competitions foster progress by providing a standardized test environment, which allows for direct comparison of different approaches to mechanical construction, perception, and behavior control, and by facilitating the exchange of ideas.

Examples for such competitions include Robo-one (marital arts), the AAAI robot competition (conference participation), the DARPA Grand and Urban Challenges (autonomous cars), and robot soccer competitions, organized by FIRA and the RoboCup Federation. Because my team participates in the RoboCup Humanoid League, I give some details on the RoboCup soccer competitions, in particular for humanoid robots. Since 2002, robots with a human-like body plan compete in the Humanoid League. In the few years the leagueŠs existence, the performance of the humanoid soccer robots improved significantly. Now, the robots of the best teams manage basic skills like walking, kicking, and getting-up sufficiently well, show soccer skills, like dribbling, passing, and obstacle avoidance, and play together as a team.

I also present technical details from our humanoid soccer team NimbRo, which won the RoboCup KidSize soccer tournaments in 2007 and 2008. I cover mechanical construction, electronics, perception, hierarchical reactive control, and learning.

Keywords: Robotics, RoboCup, AI, Autonomous agents, benchmark

Predictors of metabolic energy expenditure from body acceleration and mechanical energies in new generation active computer games

Harald Böhm (TU München, DE)

The following paper is an original research project which uses state of the art sport science physiological and biomechanical approaches to gain information about active computer games.

This project is found to be particular relevant for the field of computer science in sport, since biomechanical and physiological knowledge is required to model, track and understand human motion during computer game play.

Keywords: Computer games, energy expenditure, health

Joint work of: Böhm, Harald; Böhm, Birgit; Hartmann, Matthias

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2008/1685

Acquisition of performance parameters in race-bike training

Thorsten Dahmen (Universität Konstanz, DE)

We develop methods for data acquisition, analysis, and visualization of performance parameters in endurance sports with emphasis on competitive cycling.

For this purpose we created a bicycle simulator based on a Cyclus 2 ergometer and our own PC-based control software. The main components of the simulation are:

- a computer controlled pedal resistance according to the height profile of a cycling track
- the recording and visualization of training data measurements (speed, cadence, power, heart rate, heightprofile etc.)
- and a video display of the cycling track that shows the current position.

Our goal is to familiarize cyclists with unknown tracks and optimize their performance by means of training control and performance prediction based on physiological models

Keywords: Race-bike, ergometer, physiological modeling

Joint work of: Dahmen, Thorsten; Saupe, Dietmar

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2008/1686

3D Scene Reconstruction by Stereo Methods for Analysis and Visualization of Sports Scenes

Margrit Gelautz (TU Wien, AT)

The 3D reconstruction of image and video scenes by stereo analysis is an important topic in computer vision research. In this talk, we first present some principles of stereo algorithms and recent developments. We then demonstrate two applications of stereo reconstruction for the analysis and visualization of human movement: (a) We employ depth maps derived from sport scenes for novel view synthesis, and (b) we show how stereo processing can be used for expressive visualization of human motion in a comic-like style.

Keywords: Computer vision, 3D reconstruction, stereo analysis

Joint work of: Gelautz, Margrit; Bleyer, Michael; Markovic, Danijela

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2008/1687

Net-based process analysis in sport games

Andreas Grunz (Universität Mainz, DE)

Central objects of net-based game analysis are the positions of players and groups of players together with the corresponding activity patterns. Because of the complexity of such patterns, conventional methods like mathematical or statistical approaches are less helpful. In contrast, self-organizing maps (SOM, KFM, DyCoN) reduce the complexity without erasing necessary information.

The result of a net training in the area of games usually is a collection of position patterns represented by the neurons, which in turn form types of position patterns as clusters of similar neurons.

In the net-based analysis, each step or phase of the game is mapped to a corresponding neuron. Connecting those neurons to a time-depending trajectory then results in a 2-dimensional representation of the high-dimensional playing process.

Finally, the neurons can be "coloured" semantically regarding the meaning of the corresponding position pattern, which enables for transforming the 2-dimensional trajectory of a process to a 1-dimensional phase-diagram and therefore helps for similarity and striking feature analyses.

Keywords: Game analysis, artificial neural networks, SOM

Joint work of: Grunz, Andreas; Perl, Jürgen

Emerging actions and tactic solutions under constraints in training and competition

Robert Hristovski (University of Skopje, MK)

The presentation aims to show how selection of actions emerges under the changing constraints taking as a movement model the hand-striking in boxing sport. Two experiments are discussed. The first deals with the attacking modes of action while the second with defensive modes of action. In both experiments it is shown that there are critical regions in the control parameter space (configurations of constraints) that maximize the meta-stability of actions. Those regions are characterized by the maximum unpredictability and diversity of actions due to the maximal decoupling of particular action modes. Furthermore, it is shown how by changing the constraints configurations the number of choices and affordable actions changes abruptly through the mechanism of bifurcations. Hence, there are regions of control parameter space in which the action systems are not much sensitive to small changes in the control space and others in which the susceptibility of the perceptual-action system to small changes in the control space brings about qualitative restructuring between action couplings. This means that couplings between the modes of actions are highly sensitive to perceptual information (affordances for action). This also leads to the meta-stable dynamics of action sequences. Moreover, it is discussed how the strategic positions between boxers may spontaneously emerge without external instructions, but merely by discovering and perceiving one's own affordances and affordances of the opponent. The main message is that the constraint configurations (i.e. the context) during practice should be tuned in that way that guides the athlete to a whole continuum of possible solutions emphasizing the constraint configurations which keep her/him in the meta-stable region of actions which enables the maximum diversity of learned as well as maximum probability of discovering novel efficient actions. Meta-stability is the key of diversity and creativity in sport.

Keywords: Dynamic system, emerging action, meta-stability, perception-action, motor control

Joint work of: Hristovski, Robert; Balagué, Natàlia

Modelling and simulation: Some perspectives from sports science

Tim McGarry (University of New Brunswick, CA)

The aim of this work was to present an overarching view of the research techniques of computer modelling and simulation from the perspective of sports science. To this end, consideration was given first to the scientific method which looks to describe and explain behaviours of interest. These explanations typically make use of theory with particular aspects of theory tested with data using

formalized hypotheses. In a sense, models are analogous to theory in that both require a set of variables to be interconnected in some way. Indeed, models are very useful as they offer an excellent way of investigating theory by simulation. Before simulation, however, the model must be validated.

Two types of model validation were identified, the first type being validation of the model's construction. This type of validation usually requires input from observed data and the output from the model is then contrasted against that same data. For example, the shot selections and outcomes (winners, errors) of players from a squash game might be input to a stochastic model and the output such as game outcome, number of winners and errors produced by each player, the number of rallies produced, the length of the rallies and the like, would then be contrasted against the game statistics. The second type of model validation is to then contrast the behaviour of the model to real world behaviour using simulation. For example, imagine four squash players A, B, C and D where A plays against B and C plays against D. Now A is to play C and data of A (against B) and C (against D) are available for input. The question of interest, and moreover the purpose of the model development in this example, is to determine whether the output of the model (A versus C) conforms to the game behaviour produced, without reference to that game data beforehand.

Simulation techniques allow the researcher to examine model behaviour. From the sports science perspective, however, investigation of model behaviour is useful only when the model represents a good proxy for theory. Put another way, the model should not become divorced from theory which seeks to advance understanding of the real world behaviour of interest. Given this caveat, investigating the workings of the model by examining its range of behaviour using systematic manipulation of input variables advances theoretical understanding of the real world behaviour, which is the focus of interest for the sports scientist.

Keywords: Modeling, simulation, theory, validation, squash

Robotics: Some perspectives from sports science

Tim McGarry (University of New Brunswick, CA)

The aim of this work was to present an overarching view of robotics from the perspective of sports science, with particular reference to issues of motor control and motor learning. To this end, consideration was given to the ongoing development of robotics which might be advanced from a number of directions, from an engineering perspective for example as well as from a life science perspective. From the life science (sports science) perspective it might be instructive to consider how a robot might be built and function as if it were human. Thus, issues such as information transmission between neurons, force-length properties of skeletal muscle, "hard-wired" and "soft-wired" control structures such as reflexes, central pattern generators, muscle synergies, and motor programs were

identified for consideration, as well as other issues such as learning, intelligence and personality. Interaction with the surrounds was identified with reference to the linkages between perception and action, as well as inter-personal interaction be that interaction between human and robot or between robots themselves. Finally, a brief overview of aspects of control and coordination were introduced including the view of intelligent design (control), as well as whether control is prescriptive (top down), emergent (bottom up), or some combination of both. A brief consideration of multiple agent systems with acknowledgement to robot soccer was also provided.

Keywords: Robotics, motor control, motor learning

Doping or no Doping

Jürgen Perl (Universität Mainz, DE)

Some of the results of the Olympic Games 2008 raise the question, if particular performance development or performance profiles are understandable without assuming dope abuse.

Doping analyses can answer the physiologic part of the question only in case of positive results. It sometimes seems like a contest with the analysts as the second winners.

The system dynamics part of the question can be attacked using methods from modelling and simulation: Is it possible to generate certain performance profiles with and/or without doping? By means of the performance potential meta-model PerPot we will discuss some of the phenomena of increasing speed, decreasing fatigue, and unbelievable high levels of performance. Without being able to definitely answering the crucial question, the analyses might help to better understand what the major dynamics of training-performance-systems are.

Keywords: Doping, performance profile, performance potential, modeling

Analysis of Player Motion in Sport Matches

Janez Pers (University of Ljubljana, SL)

The system for analysis of player motion during sport matches, developed at University of Ljubljana is presented. The system allows for non-intrusive measurement of positions of all players in indoor sports through whole match, using only inexpensive video equipment - cameras mounted on the ceiling of the sports hall.

Tracking process (obtaining trajectories from videos) is automatic and only supervised by operator, to initialize player positions at the beginning and correct the mistakes during the tracking. The software provides means for user friendly

calibration of video data - using court markings of each supported sport as reference coordinates. The system has been tested for European handball, basketball, squash and tennis. Manual annotations can be added, to complement the quantitative data. Software keeps synchronization between annotations and trajectory data and provides means to use custom annotation dictionaries. Due to calibration, the results are provided in court coordinates (meters, centimeters) and can be exported (synchronized with annotations in same file) for further analysis with any application (e.g. Microsoft Excel, SPSS).

Software itself supports several types of graphical data presentation.

Keywords: Motion analysis, computer vision, performance analysis

Joint work of: Pers, Janez; Kristan, Matej; Perse, Matej; Kovacic, Stanislav

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2008/1689

When Robots Learn to Play Soccer

Martin Riedmiller (Universität Osnabrück, DE)

Making computer systems that can learn from their own experiences of success or failure is our main research area. To explore the capabilities of such learning systems, robots, that learn to play soccer by themselves is one of our application testbeds. In this talk, I will give a short overview of the results obtained so far. I will further try to identify potential contact points to application scenarios in human sports.

Keywords: Machine Learning, Autonomous Robots, Reinforcement Learning

Technology - Coaching - Computer Science

Karen Roemer (Michigan Technological University, US)

The aim of this presentation was to discuss how technology, coaching, and computer science can work together. Using a research project on motion analysis of volleyball spikes as an example, it was discussed how technology and computer science can be used to investigate human movements. It was shown, that new parameters for the quantification of shoulder movements can be defined applying modeling methods. But also the opportunities of using the same technology to visualize the findings and to transfer the knowledge to coaches were discussed. One outcome of the discussion was that in particular modeling and visualization methods from computer science should be used to allow an easier communication and interaction between athletes, coaches, and scientists while discussing research problems or the results of research projects.

Keywords: Sport technology, coaching, motion analysis, volleyball, luge

Joint work of: Roemer, Karen; Link, Daniel

Robot Plays Table-Soccer

Dapeng Zhang (Universität Freiburg, DE)

Our research focuses on learning approaches with robot KiRo. KiRo is a table soccer robot which can challenge even advanced human players. Previously, we developed a method using learning by imitation, by which KiRo can automatically acquire the demonstrated actions. Recently, we constructed a game-recorder which collects data from the human-played games.

The in-process work is about explaining the recorded data, which is to classify and to evaluate human's skills. A brief overview of the previous work is addressed, and the perspective is discussed.

Keywords: Table Soccer Robot, Learning

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2008/1683