06381 Abstracts Collection
Computer Science in Sport
— Dagstuhl Seminar —

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Abstract. From 17.09.06 to 20.09.06, the Dagstuhl Seminar 06381 "Computer Science in Sport" was held in the International Conference and Research Center (IBFI), Schloss Dagstuhl. 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. Modelling and Simulation, Multimedia, Sports management, Soft computing / computational intelligence E-learning, Distributed games, Interdisciplinary collaboration, Behavioral process analysis, Net-based pattern analysis, Information and communication technology, Game analysis / notational analysis, Training and competition analysis, Training and competition data management, Performance analysis, Biomechanics, Assisted mobility

06381 Executive Summary – Computer Science in Sport

Arnold Baca (Universität Wien, A)

The seminar dealt with a dynamically developing interdisciplinary area, where qualitative and non-deterministic paradigms from Sport like behavioural processes and modelling meet technological and structural paradigms from Computer Science. New demands, new concepts and technologies, and future trends in both disciplines were discussed.

Internationally well known researchers as well as researchers from the younger generation participated in this seminar and discussed their recent work and actual tendencies in Computer Science in Sport.

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Computer Science in Sport
http://drops.dagstuhl.de/opus/volltexte/2006/833

Keywords: Modelling, Data acquisition, RoboCup, Biomechanics, Motion tracking, Multimedia

Extended Abstract: http://drops.dagstuhl.de/opus/volltexte/2006/818

Computer Science in Sport - a Historical Survey

Arnold Baca (Universität Wien, A)

In 1975, an international congress entitled Creative Sports Informatics was organized in Graz, Austria. At this time, and in particular in the framework of the congress, Sports Informatics mainly dealt with questions of sports information with special emphasis on activities in documentation and dissemination of information. Through-out the last 30 years Sports Informatics has become a scientific discipline ("Computer Science in Sport") in a more general meaning of informatics/computer science. Working areas have evolved, national and international associations have been founded, journals are published and congresses are organized regularly to present research activities.

The following main areas of research have developed:

+ Data acquisition, processing and analysis
+ Modelling and simulation
+ Data bases and expert systems
+ Multimedia and presentation
+ IT networks / communication

There are many (research) activities that cut across these areas. Most of them can be assigned to one of the following topics:

+ (Biomechanical) motion analysis
+ Game and competition analysis
+ Motor learning, training and performance analysis
+ Pattern recognition
+ Complex systems
+ Application and adaptation of soft computing methods
+ Pervasive Computing
+ Development of hard- and software tools
+ Instruction, training, education
+ Information and documentation
+ Virtual Reality

These developments and the increasing importance of knowledge in information and communication technologies and computer skills for career perspectives of students of sport science show consequences in curricula. Lectures not only on basic tools of informatics but more and more also on complex tools, concepts and advanced methods are integrated into their education programs.

Keywords: History, Sports informatics

Humanoid Soccer Robots

Sven Behnke (Universität Freiburg, D)

Humanoid robots are enjoying increasing popularity as a research tool.

As step towards the long-term goal of winning against the FIFA world champion, the RoboCup Federation added in 2002 a league for humanoid robots to its annual soccer competitions. Now, the young Humanoid League raised the bar again. After less demanding competitions, soccer games with humanoid robots were started in 2005.

In the talk, I will explain the rules of the league and discuss the different approaches for the design of the robot hardware and the software for perception and behavior control. I will cover the robots of my team NimbRo in detail.

I will review the results of the 2006 competition in Bremen and give an outlook to the research issues that must be addressed in the future.

Keywords: Robots, soccer, hardware, software

The future synergy of computer modelling and smart technologies in sport

Peter Dabnichki (Queen Mary College - London, GB)

Computational modelling in biomechanics and specifically in sport performance has been constantly evolving and developing. However, frequently emphasis has been put sometimes complex modelling and sometimes extremely simplistic techniques that yield results impossible to validate and have little or no practical impact. An example of the former is modelling of cartilage as a multiphase continua and the latter is very evident in a number of publications devoted. However, the problems are normally attributed to modelling but they also lie in the provision of input and validation from both experiments and competition.

The above point is illustrated by a practical example of a project on the scale of the propulsive force in swimming. The project relied on combination of computational modelling, experimental data collection including the construction of a robotic arm and data from competition level training sessions. As a result it is now known the level of forces involved in front crawl swimming, and will soon be possible to optimise the stroke trajectory in terms of maximum thrust generated. However, is this sufficient? The human being is not designed to swim so to talk about optimal stroke is ill-founded. Such "optimum" is dependent on physiological constrains and hence more multidisciplinary approach is needed.

The problem with the analytical approach presented above is that it enhances the scientific knowledge and understanding but does not show the way ahead in terms of how practically this could be achieved. Currently strong emphasis is given to the rapid feedback provision for the athletes. But this has a lot of

limitations as it is hardly rapid and depends on the individual interpretation of the data collected by coaches and technical staff.

A parallel development and it up to now a separate one are the so called smart technologies, the best known examples of which are smart materials such as piezoelectric ones and memory shape alloys. Up to know mostly smart materials have been developed and used. They have the propensity to react to change in the environmental parameters. However, their response is limited to a small number of parameters. However, the more recent trend is towards "intelligent" technologies and materials that could offer a variety of responses and differentiate the factors contextually. The author believes that computers will be playing a more prominent role in this development. This is illustrated with some ongoing projects devoted to drug testing and individualised comfort. Possibilities for the use of these novel technologies in sport are discussed. The author strongly believes that such approaches should end the deeply flawed statistical approaches in very near future.

Keywords: Smart Technologies, Intelligent Systems, Computational Modelling

Full Paper: http://drops.dagstuhl.de/opus/volltexte/2006/819

eLearning - Potentials, Perspectives & Curriculum Integration

Christian Eder (Universität Wien, A)

Throughout the last years increasing efforts in developing and using multimedia based courses and materials in sport science can be observed. Currently available software authoring packages offer numerous options for the development of educational applications and for the integration of multimedia materials.

Several multimedia projects (SpInSy, Sport multimedial etc.) and master thesis in this area have been accomplished at the Institute of Sport Science, University of Vienna.

The integration of the developed materials into the current curriculum has been completed in accordance with the Bologna model. Credit points (ECTS-Points) for traditional courses and especially for eModules have been allocated with respect to the standards for eLearning of the University of Vienna. eLearning materials have thus been embedded in Blended Learning scenarios.

Future steps are comprehensive studies and researches on the acceptance, effectiveness and topology of the students' use.

Keywords: ELearning, Usability, Curriculum Integration

Joint work of: Eder, Christian; Strubreither, Oliver

Qualitative World Models for Soccer Robots

Alexander Ferrein (RWTH Aachen, D)

Specifying the behavior of autonomous agents or robots is a complex and sometimes tricky task. The system designer needs expert knowledge of the application domain and must be able to translate the domain knowledge into a behavior specification for the robot. In this talk we give an overview of the ongoing work to formalize strategies for soccer playing robots. Starting with soccer literature describing tactics and strategies for human soccer play we derive a formalization in the logic-based robot programming language Readylog. A specification problem arises because knowledge from human experts are represented in a qualitative fashion which cannot directly be transfered to a robot. To bridge the gap between the robot working with quantitative data and the experts we define a qualitative world model. With this world model the task of specifying the robots' behavior is eased.

Keywords: Robot, soccer, modeling

Mechanics of motor units: modeling and simulation of skeletal muscle performance in sport

Mario Heller (Universität Wien, A)

The mammalian nervous system is able to regulate force production and contraction speed in a muscle by recruitment of motor units and by modulation of the firing rates of recruited units. Research areas related to the control of the motor units attempt to explain how the nervous system might function to effect the regulation of motor unit behaviour within the muscle (De Luca & Erim, 1994) and to identify neural mechanisms which increase muscle performance after training (e.g. Van Cutsem et al., 1998).

The main focus of current work is to combine biological knowledge (physiology and neuro science) and methods from engineering and computer science for a better understanding of possible principles and mechanisms underlying nervous system's overall operation.

Actually, models of single motor unit force responses with varying contractile properties (see Heller & Witte, 2006) are compared with data experimentally observed to optimize fitted parameter values of the motor unit models.

References:

[1] De Luca & Erim (1994). TINS, 17 (7), 299-305.
[2] Heller & Witte (2006). IJCSS, 5(1), 30-40.
[3] Van Cutsem, Duchateau & Hainaut (1998). JP 513 (1), 295-305.

Keywords: Biomechanics, motor control, motor units, modeling and simulation, muscle performance

Issues in the Adoption of Innovations in Sport

Larry Katz (University of Calgary, CA)

Sport has been greatly influenced by the impact of computer science and technology. However, very little research has focused on the effectiveness of various sport technology tools and equipment. Certainly great successes have been well documented, such as the clap skate in speed skating. However, numerous effective programs have not been widely adopted. Many problems exist with the diffusion of information and the issues of technology acceptance in sport as it relates to equipment design, performance evaluation, game statistics and analysis, measurement, computerized training and computer assisted education. There has been a widening gap between changes and innovations that technology brings to athletes and coaches, and the human capacity to adapt to/cope with those changes. Fear of change, the perceived usefulness of an innovation, and the perceived ease of use of the resource heavily influence acceptance of technology at an individual level, but complex interactions between social, economic, and organizational factors are also a critical part of the adoption process. In the final analysis, the purpose of research in the diffusion of technology is to facilitate the creation of well-designed products, ensure the adoption and wide-spread use of those products, and to encourage innovative use of those resources.

This presentation highlights the adoption issues as they relate to sport and provides examples of research into the adoption of technology, the decision-making processes involved in adapting to change, and methods of measuring the level of engagement.

Keywords: Computer science, technology, acceptance

The use of Computational Fluid Dynamics (CFD) for the development of new oar blades to improve the effectiveness of aquatic propulsion in rowing

Philipp Kornfeind (Universität Wien, A)

If one looks at technical related sports like rowing, the area of sport technology has become an important part in the equipment development process. In the past 10 years, no significant changes in the functional construction of rowing equipment (boat, oars and blades) can be observed. Like in many other areas the design processes was (and is) characterized by the use of "trial and error".

Research methods such as CFD-Simulations in combination with experiments in real rowing situations (on-water rowing) shall be used to identify factors which are responsible for the generation of propulsive force on the oar blade in driving direction. In particular the hydrodynamic effects (lift, drag, vortex) caused by the movement of the blade through the water are of special interest. Many studies have been performed to determine the lift and drag coefficients of blades, hands

and comparable objects in a quasistatic situation which is far away from reality. For a dynamic situation it is nearly impossible to obtain the lift and drag force components generated on the blade (during a rowing stroke) by using common force measurement methods. However the simulation results should give a good direction for the design and construction of new blade shapes or different angles of incidence.

Based on these findings a series of prototypes shall be constructed and manufactured to verify their effectiveness in rowing.

Keywords: CFD, Computational Fluid Dynamics, Simulation, Rowing, Hydrodynamics

Tracking People and the Application in Sports Game Analysis

Thomas Mauthner (TU Graz, A)

This work gives an overview about the current work in the project of digital game analysis in Beachvolleyball and summarizes the results which have been achieved so far. Trainers of sport games need to gather automatically information about their athletes during training or competition. As the success of sport teams and athletes depends on the physical condition and tactical behaviour, coaches have to base their training methods on the requirements of competitions. The use of cameras is a simple method to monitor the athletes without having to influence their behaviour. The combination of database entries and the corresponding video data leads to a better description of the game than statistical data alone.

The integration of computer vision methods to support the user during his annotation and the supply of additional information about athletes' behaviour and game flow is a useful extension. A semiautomatic application is developed which combines manual annotation done by sport experts and image based algorithms. Several computer vision methods can resolve tasks like tracking, classification into player and background and computation of real world positions.

The first step in the application is the detection and tracking of defined objects (athletes, balls). Tracking algorithms should be able to deal with the highly non-rigid shapes of athletes during a game and their mostly unpredictable movements. Furthermore, possible mutual occlusions of players have to be coped with in order to maintain a continuous identification of players to describe the load of a player during a match. Developing and testing several tracking algorithms in the closed world of a sport activity (like in our case beach volleyball), where several constrains can be applied, can also be useful in a visual surveillance task. Examples for detection methods are color or shape features as well as background subtraction and blob segmentation methods for static cameras. KALMAN- and PARTICLE-filters deliver robust results for the sports and surveillance applications (Isard, Blake, 1998).

Although various tracking algorithms exist, specific problems require the development of new ideas. Especially the area of individual and group behaviour is

a challenging part of the computer vision point of view and may give important information to sport sciences as well as to other fields of science.

A further topic in the context of video based analysis is the detection and recognition of specific actions or interactions performed by the athletes. In sports game analysis the recognition of actions is the first step to the understanding of player behavior and game tactics. Additionally, the automated detection of e.g. jumps, sprints or attacks gives the coaches and sport scientists the needed amount of data to detect the demands of the specific game sport. Methods for this purpose are based on contours, changes in the motion flow of tracked patches, or gradient information to estimate the motions (actions) of tracked players (Mori, Efros, et al., 2003).

References:

[1] Isard, M., Blake, A. (1998). CondensationŮconditional density propagation for visual tracking. International Journal of Computer Vision, Vol. 29(1), 5-28.

[2] Mori, G., Efros, A., Berg A. & Malik, J. (2003). Recognizing Action at a Distance. International Conference on Computer Vision, Vol.2, 726-733.

Keywords: Beachvolleyball, interactive video systems, tracking

Joint work of: Mauthner, Thomas; Tilp, Markus; Bischof, Horst

On the presence of space-time patterns in squash contests

Tim McGarry (University of New Brunswick - Fredericton, CA)

We report research using the point-light method to investigate the space-time patterns of squash players. To this end, the real-time movements of squash players in a squash rally were presented on a computer monitor as single dots, rendering a two-dimensional representation of the player movements in the lateral (forward and backward) and longitudinal (side-to-side) directions similar to what would be obtained from a viewpoint located directly above the playing surface. In addition to the movements of the squash players, however, a distracter set comprising of two other dots was introduced to the visual display. Thus, a trial comprised of four dots in the visual display - two squash players and two distracters - each dot being of the same size and color making them indistinguishable from each other except for their respective movements on the squash court. Independent observers (O = 6) were tasked separately with identifying the squash dyad from the distracter set within a trial (N = 47). In the first experimental condition, the level of difficulty (D) of the distracter set was varied from the least difficult (D1) comprising of random movements through to the most difficult (D4) comprising the movements of squash players. In the second experimental condition, the size (S) of the distracter set was varied from two distracters (S1) through to six distracters (S3). Interestingly, the observers retained the ability to

identify the squash dyad beyond chance under all variations of both experimental conditions, albeit with varying degrees of success, as expected. These findings demonstrate unambiguously that the space-time interactions of the two squash players demonstrate patterned features and, furthermore, that these patterned features are specific to the squash dyad. The important information contained in the point-light display that gives rise to these patterned features will be discussed in terms of dynamical principles of self-organizing systems.

Keywords: Patterns, perception, point-light, sport, squash

Computer Science in Sport: Present Fields and Future Applications

Jürgen Perl (Universität Mainz, D)

During the last about 15 years, the spectrum of Computer Science in Sport has changed a lot. Due to the development of computers and information technology as well as of scientific concepts and methods new working areas have been developed. Meanwhile, the field of research and applications stretches from data bases to artificial intelligence. Traditional areas like game analysis and theory of training are involved as well as technologically innovative areas like internet-based coaching and e-learning.

Future development of rapidly changing fields like Computer Science in Sport is difficult to predict. There are, however, two major aspects that in general seem to increase its importance continuously. On the one hand, the amount of available data increases permanently and makes it more and more difficult to extract the useful information. On the other hand, the role of world wide communication becomes increasingly important and needs improved information technology. Both trends not only require more powerful computers but in particular better concepts and techniques in order to handle problems in a fruitful and interdisciplinary way.

Keywords: Computer Science, Data, Information, Communication, Internet

Are Oscillations of Physiological Variables a Consequence of the homeostatic Control during Exercise?

Daniel Ranz (INEFC - Barcelona, E)

The principle of homeostasis classically explains the regulatory processes involved in the physiological adaptation to exercise. It is supposed that complex neural integration of multiple inputs leads (including feedback and feed forward components) to the recovery of baseline levels. It has been suggested that the limits of exercise performance are created by these dynamically occurring regulatory processes than by absolute limiting capacity of the different physiological systems.

In the context of the homeostatic control the oscillations of physiological variables during exercise are understood as a lag between afferent and efferent neural adjustments or as unavoidable consequences of interactions between different peripheral systems.

However these oscillations can be alternatively interpreted not as imperfect features of homeostatic regulation but as the necessary fluctuations to produce the adaptation of the regulation system.

In our experiment VO2 consumption of trained and untrained subjects is registered breath by breath during an exercise in treadmill. The exercise test consists on continuous work load (5 min duration) at low intensity (below VT) followed by a continuous work load at high intensity (above VT) of same duration. Spectral analysis of the signal is performed to characterize the frequencies present at the VO2 consumption oscillations. Its dynamics of change is also studied by the time delay embedding and learnt with ANN (multilayer perceptron). The minimum error achieved by the net in each period of the exercise is studied to detect changes in the dynamics of VO2 oscillations.

Differences in frequencies and signal regularity between trained and untrained responses are observed as well as among different work loads. The role of oscillations and the homeostatic control as unique mechanism explaining adaptations to exercise are questioned.

Keywords: VO2 consumption, homeostatic control, ANN

Joint work of: Balague, Natalia; Ranz, Daniel

Markerless Motion Capture in Outdoor environments

Bodo Rosenhahn (MPI für Informatik - Saarbrücken, D)

In the talk we give an outline of our markerless motion capture system. The input is a multi-view image stream and a representation of the subject in terms of free-form surface patches. Our system extracts silhouettes using level set functions, determines correspondences between the model and the image data and finally computes the pose configuration (the rotation and translation in 3D and the joint angles). Due to the integration of 3D shape priors and statistical learning, we are able to track (complex) motions in (more or less) arbitrary environments.

Keywords: Motion Capture, Segmentation, Pose estimation, statistical learning

Analysis and visualization of space-time variant performance parameters in endurance sport training

Dietmar Saupe (Universität Konstanz, D)

A brief project sketch. In this research project we develop methods for data acquisition, analysis, and viszualization of performance parameters in endurance sports with emphasis on road biking.

There is a rapidly growing palette of commercial measuring devices, ranging from common "bike computers" capturing speed, cadence, heart rate, temperature, and barometric pressure to more complex ones for GPS localization. Moreover, there are (expensive) power meters and spiroergometric devices that measure ventilation and gas exchange. For scientific research it is desirable to combine several such devices, thus, creating the need for methods for data fusion and synchronization. The amount of data collected can get very large requiring methods for appropriate analysis and visualization. Also biofeedback methods require complex data processing. The talks surveys some of the initial approaches in this newly started research project, in cooperation with the Department of Sports Science at the University Konstanz and the Herzzentrum Lahr.

Identification of emotions in biomechanical gait patterns

Wolfgang Schöllhorn (Universität Münster, D)

"How is it going?" Who ever has used this term probably never thought about the connection between the meaning of the word "going" as a mode of locomotion and as an expression of inner feelings or emotions at the same time. Evidence for the correlation of feelings and motor actions is provided too by the etymology of the word emotion (e: "out of"; movere: "move"). Despite some basic work in psychological or clinical context was done, research mainly concentrated on subjective recognition of different facial (Ekmann et al. 1978) or body expressions (Montepare et al. 1999) of emotions. The utilization of optimizing clinical therapy by means of individual characteristics (Schöllhorn et al. 2003) has been mainly neglected so far. The aim of this study was to identify emotional states of individuals in biomechanical gait patterns with artificial neural nets (ANN).

Kinetic and kinematic gait data was derived from 25Hz Video and from a 1000Hz force plate of 38 and 16 healthy subjects. The gaits were accompanied either by imagination of four emotional states (normal, happy, sad, and angry) or by listening to different types of music (excitatory, calmative, no music). After digitization and filtering the data was fed to following types of ANNs: supervised: MLP and Self-Organized Map (SOM) and two coupled SOMS (2SOM). The results show a clear distinction between individuals in all nets and some partially clear indications of emotion-recognition. Consequences on training and clinical therapy will be discussed.

References:

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Keywords: Gait pattern, emotion, artificial neural net

Joint work of: Schöllhorn, Wolfgang; Janssena, Daniel; Föllinga, Karina

Emergence of Gait in Legged Systems

André Seyfarth (Universität Jena, D)

The understanding of human and animal locomotion is a challenging and complex issue. Although much is known about the properties of the individual parts of the musculo-skeletal system, a comprehensive theory of the organisation the of motor system is still missing. Here we propose to use very simple biomechanical models to address several issues in the organisation of motor systems. First, we describe the leg function on an internal level including leg segmentation, muscle-tendon dynamics and local reflexes on joint level. Later, we discuss the behavior of legged systems with spring-like leg behavior. We find that the common gaits in human and animal locomotion, namely walking and running, are just two natural behaviors of a system with two elastic legs. This theory is a powerful basis for the development of novel legged systems either in robotics or prosthetics.

Keywords: Gait, legged systems

End-User Programming and Sport Science

Guido Töpfer (Universität Mainz, D)

The use of computers is common in our working environments and end-user computing - meaning the use of computers and prefabricated software - is no longer an exclusive domain of specialists. The next step is to enable end-users to modify existing functionality and define new functionality on their own. Since end-users are not educated in the development of software they need tools and processes supporting them.

Some possible benefits and risks of end-user programming will be discussed. Furthermore it is motivated why it seems promising to apply end-user programming in sports science and to conduct further research in this area.

As outlook an developed approach for end-user programming based on message-based component composition is demonstrated.

Keywords: End-user programming, component, sport science

Current issues of e-learning in sport - shifting from media to complex interactions

Josef Wiemeyer (TU Darmstadt, D)

The concept of e-learning undoubtedly offers surplus to university learning and teaching.

Nevertheless, research on e-learning clearly reveals that e-learning does not generally have a positive effect. Rather the complex interactions of e-learning media, learners, teachers, and the learning environment have to be considered.

The purpose of this paper is to present current research that focuses on critical factors of e-learning effectivity and efficiency and their complex interactions:

– **Equipment and attitude of learners**

A four-year survey of fresh(wo)men in sport science study programs shows that there are specific attitude differences concerning gender and course of study. We found also some particular changes within four years.

– **Equipment and attitude of teachers**

A state-survey concerning the use of and demand for e-learning content at institutes of sport science in Hesse shows, that there are good technical opportunities for e-learning, but there is also a lack of positive attitude. On the other hand e-learning needs to be supported by several actions like establishing an open-access e-learning data base, information and incentives for teachers, and development high-quality assets by interdisciplinary teams.

– **Self-regulated learning support**

When students engage in e-learning they need to self-regulate their learning. They have to plan their learning schedule, to self-monitor their learning, to decide on using internal and external resources etc. In an experimental study we examined the effect of a special two-day course enhancing the ability to self-regulate e-learning in comparison to unsupervised e-learning. We found a significant effect on learning behaviour, but not on learning outcome.

These results clearly show that in order to fully exploit the surplus of e-learning we need to take a broader perspective. For example, the further development of e-learning content should be systematically based on concepts that embody formative evaluations dealing with the application of the e-learning content in real-world settings as early as possible.

Keywords: E-learning, critical factors, teacher, learner, self-regulation