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Editorial

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Dear Readers:

This is the first issue of the "**International Journal of Computer Science in Sport**" (**IJCSS**).

The Journal is published in association with the **International Association of Computer Science in Sport** (IACSS). It is a refereed electronic journal. Research results with an emphasis on the following topics regarding the application of Computer Science and Mathematics in supporting the development of theory and practice in sport are considered:

- Modelling (mathematical, informatics, biomechanical, physiological)
- Computer aided applications (software, hardware)
- Data acquisition and processing
- Data Bases
- Simulation (interactive, animation, …)
- Development of theories
- Multimedia / Internet
- Presentation
- Education

The journal does not only serve as a forum for current research from around the world in the field of computer technology in sport. Moreover, there is place to present theories, methods and concepts, which are developed in Computer Science and Mathematics, and applied to Sport Science.

IJCSS will also publish editorials, project reports, extended essays, conference reports, forum discussions with experts and between subscribers and company informations.

This pilot issue is somewhat different from future issues of IJCSS.

It starts with two invited papers by Larry Katz and Neville de Mestre. Katz examines specific Internet opportunities in the context of sport sciences and multimedia applications. The examples presented range from multimedia video transmission and video streaming, to multimedia object repositories, online multimedia learning, and online, personalized skill evaluation. Neville de Mestre gives a summary of the best lectures presented at the First to Sixth Conference on Mathematics and Computers in Sport having been held in Australia from 1992 to 2002.

The third and fourth paper have been presented as invited lectures during the 8th Workshop on "Computer Science in Sport" in Oldenburg, organized by the section "Computer Science in Sport" of the German Society of Sport Science. Joachim Mester discusses scientific fundamentals and industrial interests in sports informatics. Aspects of security of IT based learning systems are considered by Hans-Ulrich Bierhahn.

In addition, the abstracts of the papers presented at this Workshop have been included within this issue. Full papers will be published in a special edition of this journal.

If you have any questions, comments, suggestions and points of criticism, please send them to me.

For now: good reading!

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Multimedia and the Internet for Sport Sciences: Applications and Innovations

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Abstract

The Internet provides an unprecedented forum for communication, collaboration, access to information, and dissemination of ideas, resources, and learning opportunities. Increased bandwidth for data transfer has enabled an amazingly diverse set of multimedia applications to emerge within a very short time. This paper examines these specific Internet opportunities in the context of sport sciences and multimedia applications. The spectrum ranges from multimedia video transmission and video streaming to, multimedia object repositories, online multimedia learning, and online, personalized skill evaluation. All the examples provided employ a sport or kinesiology context. As researchers, coaches, educators and designers become more comfortable with computer technology and its potential, there should be a concomitant increase in the number and nature of available applications, and a significant increase in those who adopt the technology. The flexibility inherent in using computers provides the opportunity to approach activities in new and innovative ways. This paper presents a number of suggestions for rethinking the problem solving process in order to realize that potential. Ultimately, widespread adoption of computer technology within the sport sciences and coaching fields awaits applications that are easy to use, reliable, meet the needs of the user, and are cost effective.

Introduction

Computer technology makes it possible to improve the sport experience for all participants, not just elite athletes and coaches. Through computer technology, it is possible to make participation in sport a safer and more enjoyable experience that should contribute to the emotional and physical well being of all participants. At the same time, integrating computer technology can significantly enhance performance at all levels and roles (e.g., elite and amateur athletes, coaches, officials, and administrators). The Internet provides an unprecedented forum for communication, collaboration, access to information, and dissemination of ideas, resources, and learning opportunities. Users from around the world have immediate access to resources via the Internet, (e.g., consultants, information databases, and learning opportunities). Moreover, the Internet literally, provides everyone with an opportunity to be a unique resource, that is, to express themselves and be heard no matter how obscure the idea. The Internet can also provide users with access to timely information in order to make good decisions. Filtering the good information from the bad is an enormous, ongoing problem, which is not unique to the Internet.

Originally, the Internet only supported text and graphics, but over the past few years the Internet has been adapted to enable the use of databases, multimedia objects, and video streaming, which has significantly increased its flexibility. Increased bandwidth for data transfer has enabled an amazingly diverse set of multimedia applications to emerge within a very short time. This paper examines these specific Internet opportunities in the context of sport sciences and multimedia applications. The spectrum ranges include:

- Web-based Video –Webcast and Streaming Video On Demand
- Live Web-based Learning and Training
- Multimedia object repositories,
- Online multimedia learning
- Online personalized skill evaluation.

All of the examples provided employ a sport or kinesiology context. As researchers, coaches, educators, and designers become more comfortable with computer technology and its potential, there should be a concomitant increase in the number and nature of available applications, and a significant increase in those who adopt the technology. The flexibility inherent in using computers provides the opportunity to approach activities in new and innovative ways.

1. Web-based Video –Webcast and Streaming Video-On-Demand

A number of universities and companies provide platforms for interactive broadcasting on the Internet (referred to as "webcasting") that can be accessible to athletes, coaches, parents, spectators, officials, and administrators. For example, the University of California (http://uclabruins.ocsn.com/multimedia/ucla-multimedia.html), and Columbus State University (http://athletics.colstate.edu/live.asp) in the United States provide live sports broadcasts in which Internet users can watch or listen to school team games (see Figure 1). The National Football League (NFL) in the United States also provides live sports broadcasts and allows the audience to interactively access relevant information such as team lists, coaches comments, and pre-game data (http://www.nfl.com/). There is even a website dedicated to listing live webcasts for sporting events (http://www.livewebcasts.info/)).

According to Dorey (2002), video streaming is becoming a serious business with live broadcasts providing a 360 degree viewing experience that allows users to scan an event from all sides making them feel as if they are really there. Other events such as, the US Open Tennis Championships, provide live scoring updates and live camera pictures from the court (http://www.usopen.org/ibmrealtime).

Figure 1. UCLA Web Page for Accessing Live Sporting Events and Interviews

Sports fans can indulge in vicarious participation through the concept of the "virtual spectator" (http://www.virtualspectator.com/). With satellite, cell phone, and geographical positioning systems (GPS) technology, sports spectators can now log-into the site and track races (boats, motor cars, cross country bike racing) using real-time telemetry information (see Figure 2).

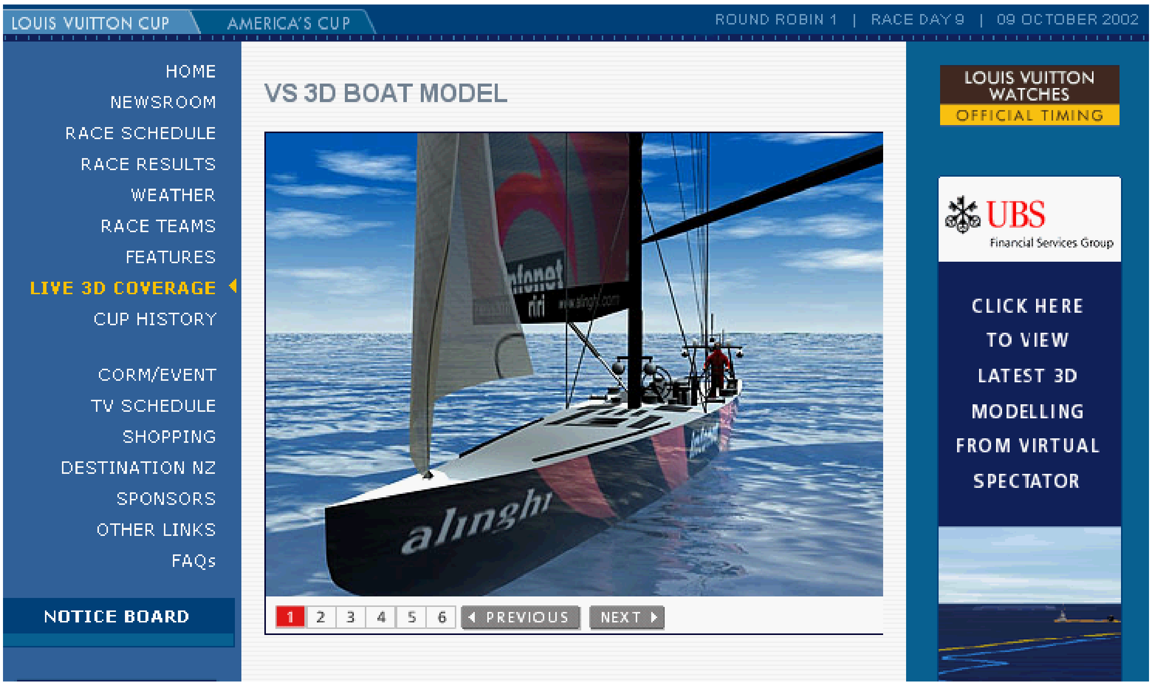


Figure 2. Virtual Spectator Live 3D image

Technically, it is possible to look at a race from multiple positions and even participate through the addition of a computer-animated entry (e.g., boat, car, and bike) that the user controls in simulated competition with the real participants (Richardson, 2000).

The Sun Microcomputer Company, on their java.sun.com website, describes a company which has developed an Internet golf multimedia program which includes a real golf club that has been customized with computerized technology which, when connected to the Internet, lets the user practice his/her golf putt and receive live biofeedback on the performance. (http://industry.java.sun.com/solutions/products/by_company/0,2343,all-3334,00.html). Similarly, athletes that use stationary equipment like bikes, rowers, and treadmills can race over the Internet with interactive courses according to FitCentric Inc. (www.fitcentric.com). A number of sites offer online consulting for coaches such as My Coach Online (www.mycoachonline.com). Whether these technologies are effective remains to be seen, but they provide insight into the potential for innovative multimedia video transmission, webcasting, and video streaming opportunities over the Internet.

2. Live Web-based Learning and Training

There are an ever increasing number of companies that have extended the notion of live webcasting to include specialized platforms for live web-based teaching, learning, interactive communication, and online training. Examples of these companies include Horizon Live (http://www.horizonlive.com), Pinnacle Systems (www.avidsports.com), Elluminate (www.eluminate.com), and Centra (http://www.centra.com/) (see Figure 3).

With the clear identification of requirements, these systems could be developed specifically to meet the needs of athletes, coaches, parents, spectators, officials, and administrators with accessibility features that make it possible for individuals to produce, deliver, attend, and participate in live, virtual meetings, live online classes and courses, conferences, and events. Coaches can hold live/virtual office hours, provide training, review performance data with their athletes, collaborating on projects and provide support, live over distance. Live audio and video communication over the Internet allows for features such as:

- instant polling (e.g., allows a coach to see how his or her athletes or parents feel about an issue by keying in a response to a question which is then instantly tabulated and the results provided to designated participants),
- interactive whiteboard (a metaphoric white board which can be seen and accessed by all individuals attending the session in order to develop ideas or share information.
- application sharing (the ability to open any application – e.g., PowerPoint – which all attendees can see, and edit if desired).
- Archive session (sessions can be captured and saved for later asynchronous access).

Figure 3. Live Real-Time Online Learning - Horizon Live Homepage

Some distance learning courses for teachers on how to use software for physical education are currently being provided by companies such as Bonnie's Fitware (www.pesoftware.com.com/online/distance.html).

3. Multimedia Object Repositories

Multimedia object repositories are databases that contain multimedia objects or elements (e.g., text, graphics, three dimensional objects, animations, and video). Relational databases are especially valuable because the multimedia objects can be organized, stored, and retrieved as needed for use as information resources, and in lectures, presentations, laboratory classes, and interactive courses. With the availability of inexpensive computer memory, high-speed bandwidth, and the Internet, web-based multimedia relational databases can be powerful and cost effective resources that are easy to access and integrate into a variety of different applications such as online multimedia learning and evaluation. Moreover, these relational databases can provide access to valuable information on a "just-in-time" basis (i.e., when you need to know the answer).

The Campus Repository of Learning Objects (CAREO), part of a Canadian initiative (http://careo.netera.ca/cgi-bin/WebObjects/Repository), is an example of a multimedia relational database.

Jennett, Hunter, Teixeira, Rankin, and Katz, L. (2002) have developed a shared repository of multimedia anatomy objects for teaching and learning based on the CAREO program (see Figure 4). A variety of objects for use in teaching functional anatomy were identified, catalogued, and stored. A sophisticated interface was designed to allow relational retrieval of the objects. Preliminary results suggest that a multimedia database with an effective, customized interface can make a difference in enhancing the instructors' role in the teaching of functional anatomy. Detailed information on the project is available on the Internet (http://www.kin.ucalgary.ca/cluster).

Such repositories can be used in sport for a variety of functions. For example, coaches can annotate, store, and retrieve events such as video clips of athlete performances using search criteria like: date performed, nature of performance, and the evaluator. These performances can then be retrieved and assessed for factors such as change over time.

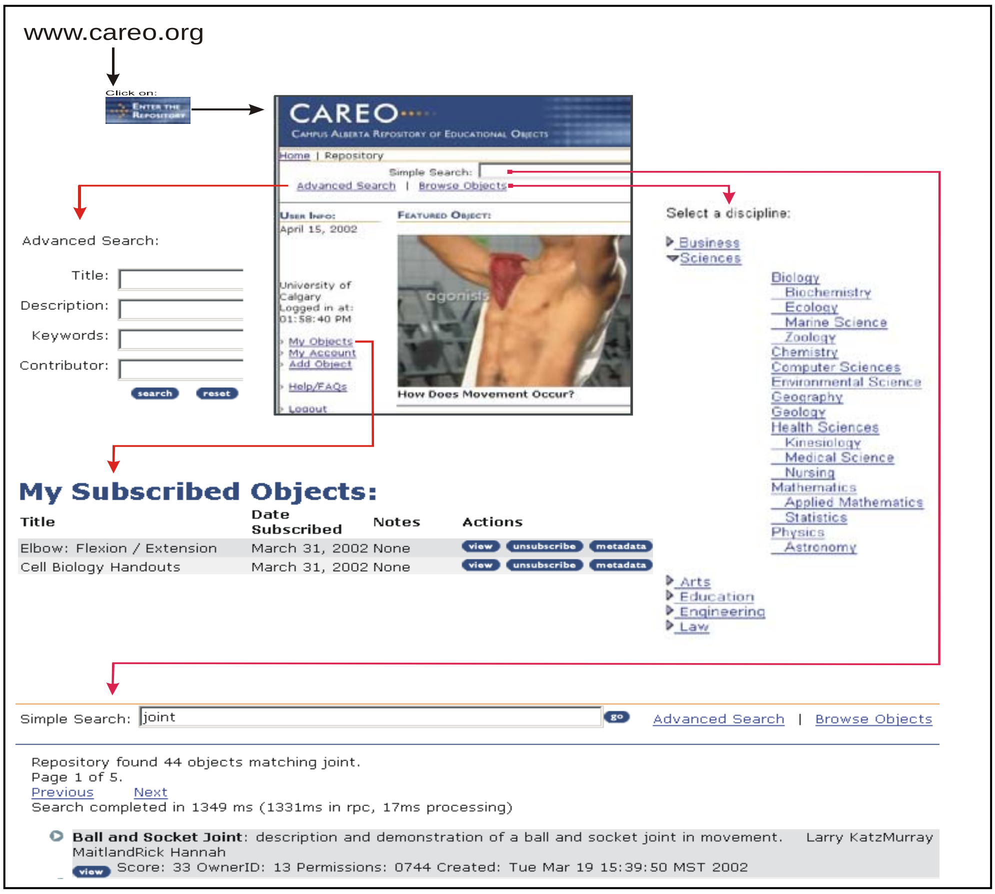


Figure 4. Example of CAREO interface with Functional Anatomy Object

4. Online Multimedia Learning

Multimedia learning systems are designed either to teach skills or techniques in a structured format typically with mastery as one of the goals, or to provide information in an organized fashion. Information oriented systems tend to be designed as resources that can be accessed to enable users to find the answer to a variety of questions or problems (e.g., When does the game start? Where can you buy a ticket? What does a quad jump look like? Who is researching sport and multimedia on the internet? How good was my quad jump?). Whereas sophisticated teaching systems provide special features like interactive lessons, tutorials, quizzes and feedback, and usually, some form of learner control. Sometimes the system can be used to enhance instructor led classes and other times it is designed to operate independently by emulating the teacher model.

Multimedia learning in the form of computer-assisted instruction has been around since the early 1960's, but the applications that were developed required large computers, local networks, and extensive memory allocation to deliver effectively. With broadband capabilities and access to large memory storage, it is now possible to deliver multimedia lessons effectively through the Internet. The Internet provides a flexible, dynamic learning environment that allows for multimedia presentations (Palloff & Pratt, 1999; Ross, 2000) and provides students with access to rich, collaborative, and powerful learning opportunities and environments (McGreal, 1997). However, from a sport and kinesiology perspective, there are very few Internet-based multimedia learning systems.

Morey Sorrentino, (2001) describes an interactive Internet site that contains video clips of expert swimmers shot from a number of perspectives. A poolside computer enabled instructors to provide demonstrations of proper technique to students viewable either from poolside or in the water. Morey Sorrentino found that students who received instruction enhanced by the Internet site did better than students who received traditional instruction.

Other examples of online sport related multimedia learning programs include Functional Anatomy Online (www.kin.ucalgary.ca/anatomy), Care and Prevention of Athletic Injuries (http://www.kin.ucalgary.ca/courses/knes471) and CanCoach (www.cancoach.com) a site which offers online multimedia sports courses and activity sets for coaches.

In the case of the Functional Anatomy Online learning site, four interactive, two-hour laboratory lessons have been developed to deliver functional anatomy material including quizzes (see Figure 5). The site incorporates a number of unique features, including rotating multimedia images of surface anatomy components that includes the surface, muscles, bones, and organs (see Figure 6); three dimensional multimedia objects which demonstrate movement concepts (see Figure 7); and the integration of the commercially available Gold Standard Multimedia dissection program (see Figure 8).

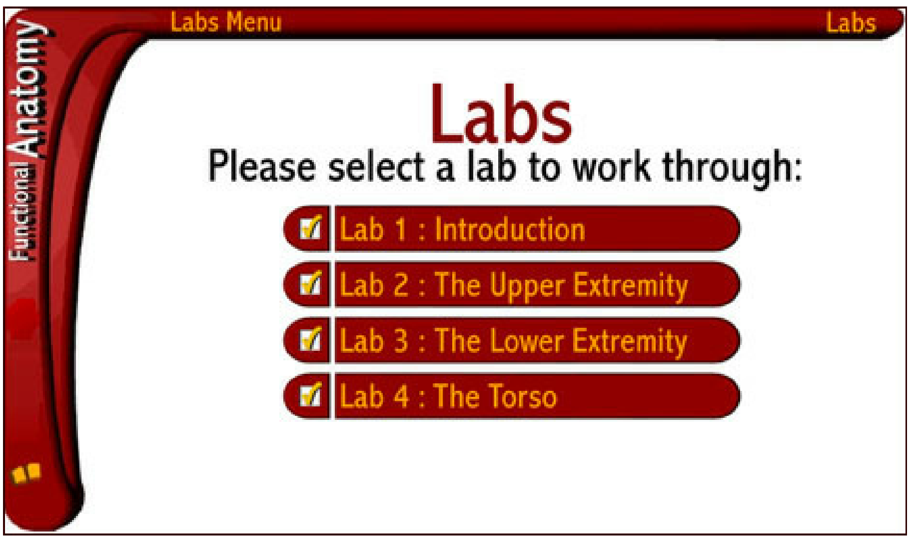


Figure 5. Four Laboratory Components to Functional Anatomy Online Program

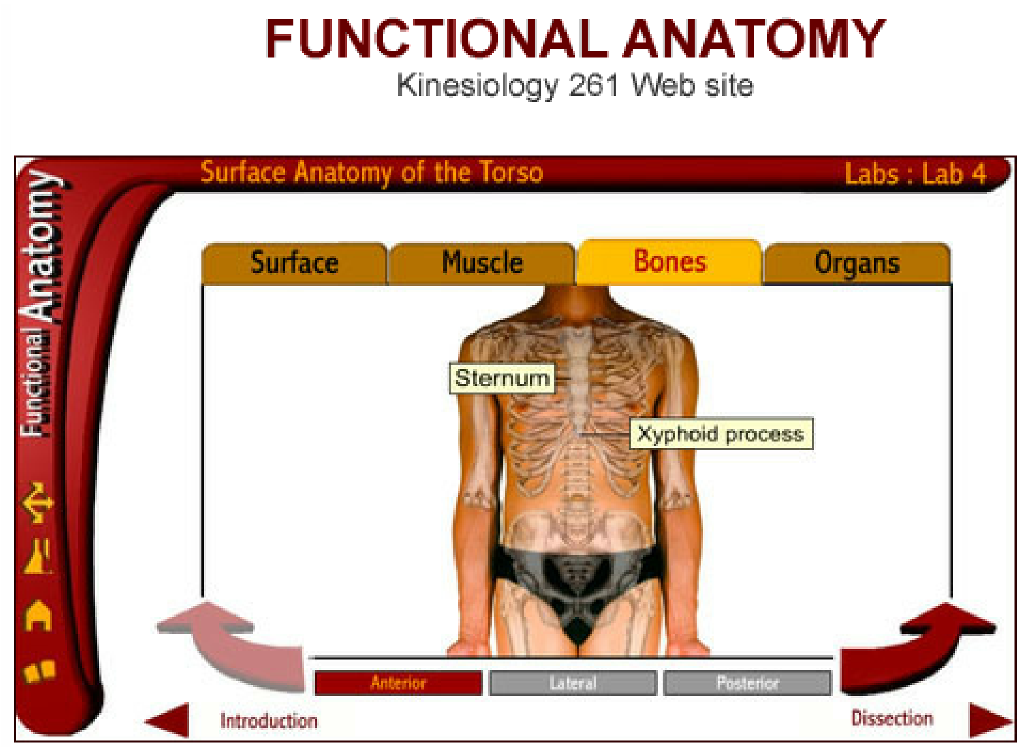
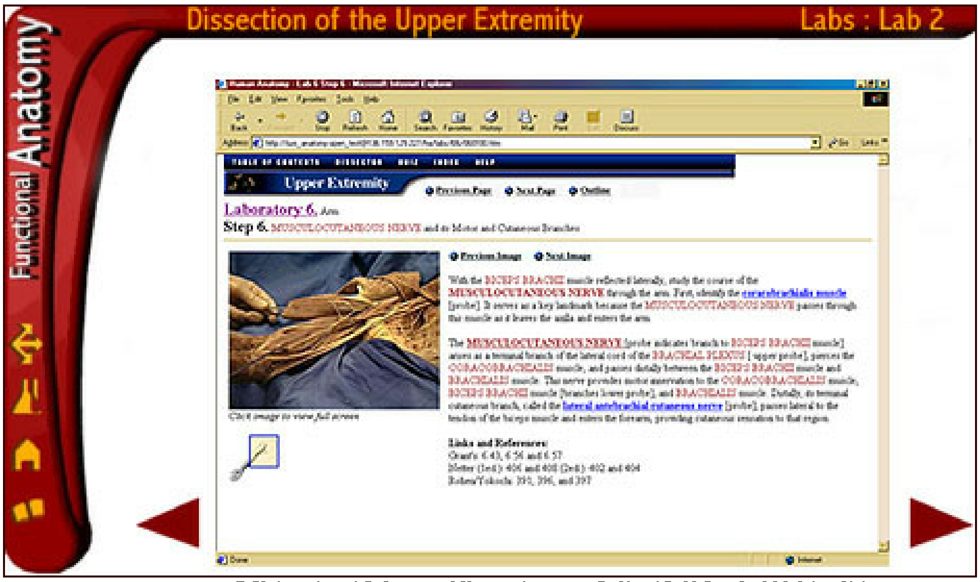


Figure 6. Surface Anatomy (Torso) Component Functional Anatomy Online Program

Figure 7. Movement Component (Lower Extremity) Functional Anatomy Online Program



© University of Calgary and Human Anatomy Online (Gold Standard Multimedia)

Figure 8. Dissection (Upper Extremity) Component Functional Anatomy Online Program

Detailed information on the Functional Anatomy project can be found at www.kin.ucalgary.ca/strc/anatomyweb2.

5. Online Personalized Skill Evaluation

As part of the initiative to develop useful, interactive, and user controllable multimedia tools, Apple Computer Inc. through its Quicktime division has developed a form of addressable video streaming. Addressable video streaming enables the instructor to map a video into meaningful chapters. The video is still shown as a continuous stream, but users can access the chapter list (i.e., table of contents) and then "jump" to the section that they wish to see. The video is buffered to the point requested, and then continues to play to the end of the video from that point. The users have complete control over the video, including stop, multiple or single frame movement (forward or backward), or further redirections by chapter.

Video models enable users to view two models side-by-side or overlaid on the screen (e.g., www.dartfish.com). Bringing this technology to the Internet so that performers can record, upload, view and compare their performance with the performance of experts or with their own top performance has great potential because:

- Assessment can be done independent of time, location, and machine.
- Expert evaluation can be carried out by leaders in the field who can provide feedback from anywhere in the world.
- Learners can view and compare performances of more than one expert or more than one skill.

Online skill evaluation involves the digital recording of performances; editing and uploading to the internet of relevant components of the recorded skills; the structured and annotated online evaluations of the performances by content specialists; the posting of the evaluations and videos to a website for use by the athletes; and, the availability of video highlighting expert models with which the athletes can compare their performance.

Developing these programs can be expensive, and the use of equipment in the gymnasium can be potentially hazardous to both athletes and equipment, so more research is required into issues such as location of equipment, quality of video and sound, and effectiveness of the interface, and level of improvement in performance attributable to the technology.

An example of a sport multimedia information resource that incorporates these concepts is the website for a University of Calgary Kinesiology course: Essence and Experience (see Figure 9). The basic principals of sport and activity (e.g., movement, force, space, equipment, control) are taught through Lacrosse (www.kin.ucalgary.ca.courses/knes201/b08).

This Kinesiology course utilizes addressable streaming video for an introduction to the course content and for online testing (see Figure 10). The video can be viewed in the computer laboratory, or through computers connected to an ethernet line located in the gymnasium. Students can have access to the video at any time.

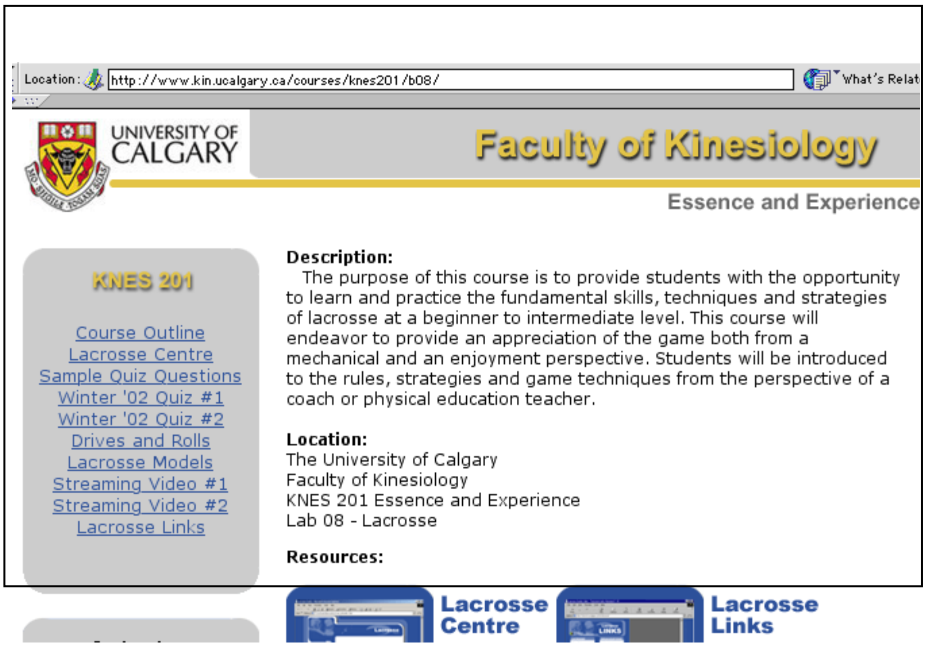


Figure 9. Essence and Activity – Lacrosse Course Website

Figure 10. Addressable Video on the Internet

Figure 11 provides an example of the video models for lacrosse that students can access and compare on screen. The video models are used to teach a variety of stick and ball skills. The menus are repeated twice on the screen. Students can access the video clips on each menu for comparison. For example clicking on the left menu “overhand left” will bring up a video of an overhand shot by a left handed expert. Clicking on the right menu “verhand right” will bring up a video of an overhand shot by a right handed expert. Both videos will play and loop continuously unless stopped. They may also be controlled individually, step by step forward or backward by using the arrow keys (see Figure 12).

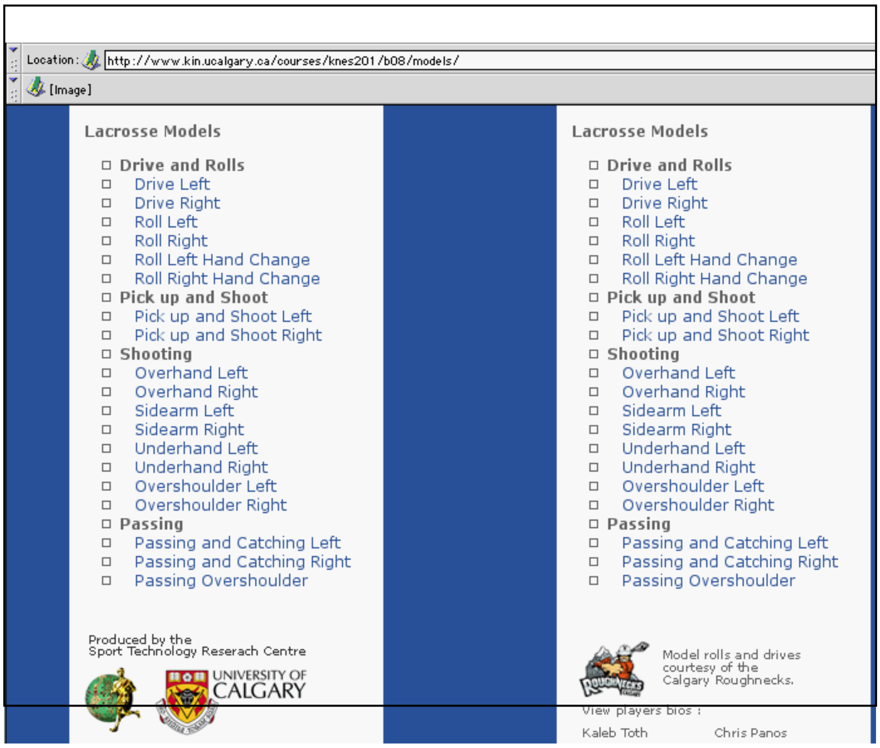


Figure 11. Video Models for Lacrosse

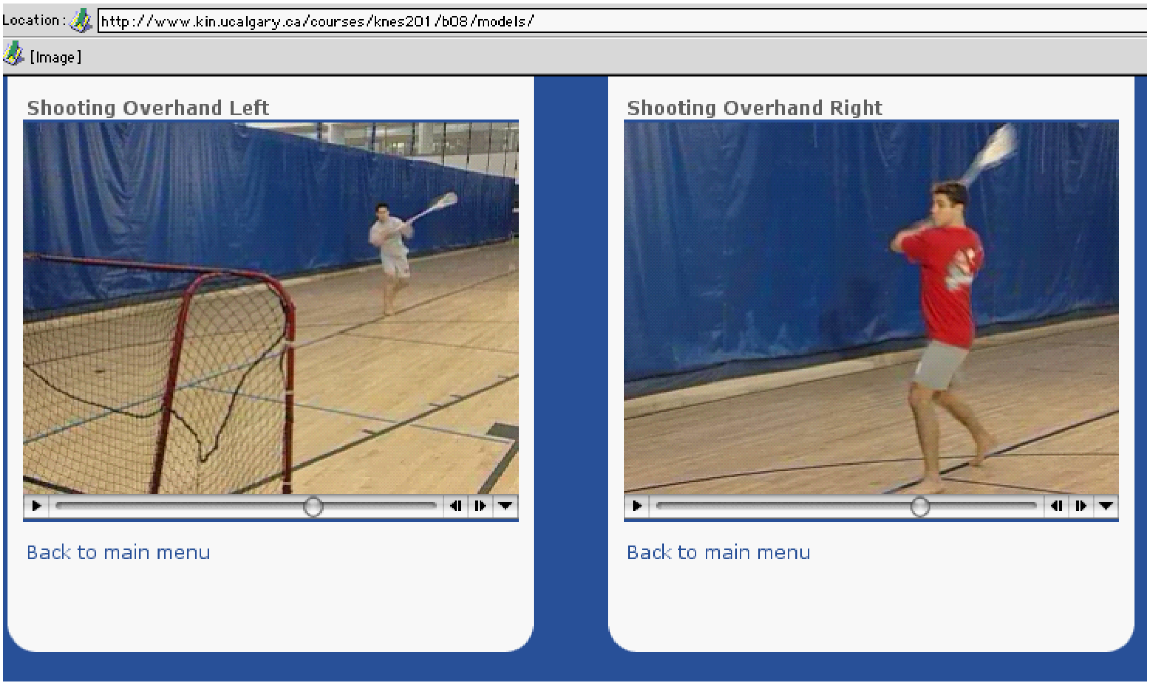


Figure 12. Expert Video clips selected from Video Models Menu

As part of the Kinesiology course, students are taught how to perform integrated skills for "driving" past an opponent and "rolling" past an opponent. They are then digitally videotaped performing the skill. Next, their performances are uploaded to the Internet and evaluated by the course instructor who gives them a grade and detailed comments on the performances. Student can then access the site to retrieve their personal and confidential results (see Figure 13). Students can also view either or both skills, compare their performances with the expert, or look at the criteria against which they have been evaluated (http://www.strc.ucalgary.ca/newlac).

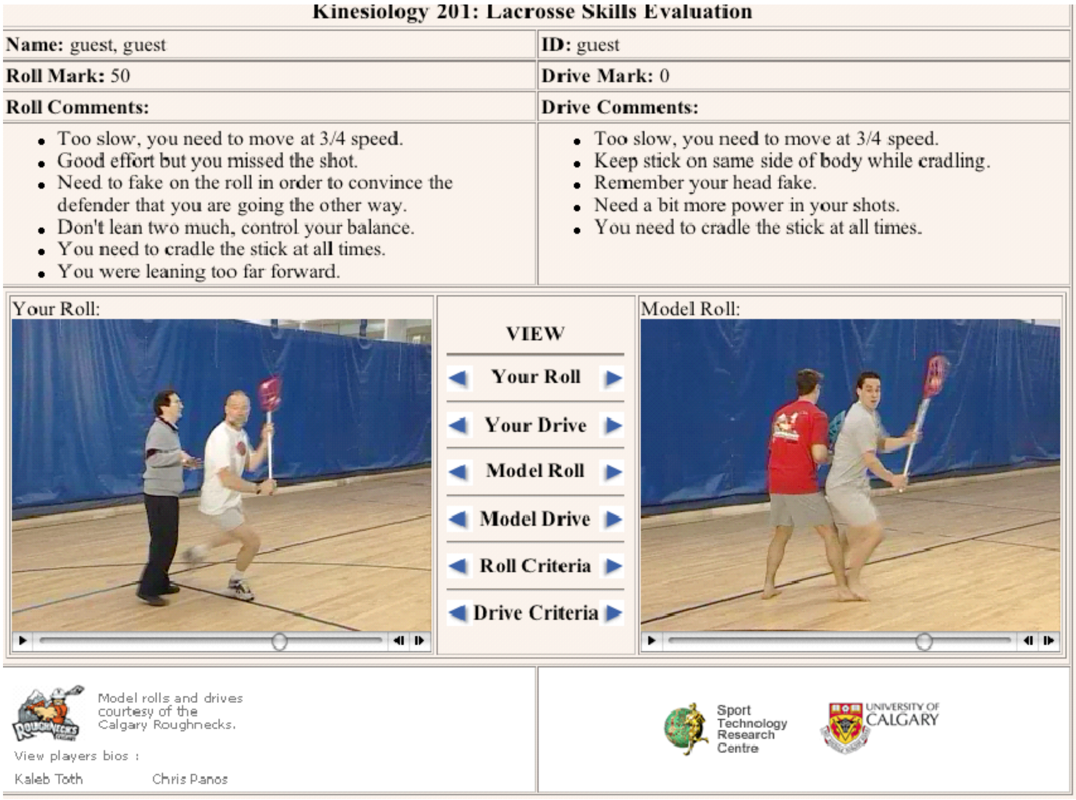


Figure 13. Online Skill evaluation Sample Guest Screen

6. What the Future Holds

The Internet provides unparalleled opportunities for coaches, athletes, officials, spectators, parents, instructors, and support personnel to access high quality, multimedia, and interactive information, resources, and learning opportunities any where in the world. People can obtain expert opinions, collaborate together at a distance, and study with the best teachers and coaches in the world.

As Internet technology evolves, it will be possible to develop more powerful models of skill and player actions represented in real time, simultaneously, and for multiple participants over distance. This means that it will also be possible for people to collaborate in shared virtual environments that are highly realistic and accurate.

With these capabilities, athletes and even spectators can practice in virtual environments with highly believable simulations without leaving their homes, while coaches can observe their performance without being physically present. Teams can practice in simulated but realistic environments without having to physically share the same facilities. Such opportunities could enhance all aspects of player development (e.g. cognitive, affective, and skill acquisition).

Training could be more scientific and precise with access to expert coaches at distances. These specialists in turn would have access to analytical tools and multimedia databases that they could use to acquire, store, and retrieve performance data for effective and efficient analysis and decision making. Athletes could provide relevant physical data from their homes for instant analysis (e.g. blood pressure and heart rate) while coaches visually monitor the training from their offices. Even more intriguing is the potential for the development of revolutionary ways to engage, learn and participate in sports and sports science.

7. Conclusion

Ideally, the appropriate design and development of Internet-based sport and technology resources and learning materials should lead to:

- Increased participation in sport and related activities
- Significant improvement in performance
- Reduction in injuries
- Improved health
- More positive attitudes to sport and wellness
- Exposure to a broader spectrum of ideas

Unfortunately, the vast majority of the world’s population does not have access to the Internet (De Moragas, 2001). However, the Internet may be a cost effective means of training athletes and coaches over distance, and allowing spectators to observe and visually interact with sporting events, especially in developing countries. As technology becomes more sophisticated, using technology should become much simpler. Through the power of the Internet, spectators, performers, coaches, trainers, and sport scientists can learn to appreciate the tools and resources that are available. More importantly, people can develop a broader sense of wellness, community, participation, and shared values that are the hoped for byproduct of associating with sport.

Acknowledgements

The author wishes to thank Dr. Ernie Chang for reviewing the paper and providing suggestions.

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Mathematics in Sport Down Under

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Abstract

The achievements by Australia and New Zealand in sport on the basis of population size are quite remarkable. Both countries invest in sports coaching and training for elite athletes with the associated expertise in many areas of sports science. This article discusses the role of the mathematical sciences in these developments and the spreading of these ideas through the six conferences held, so far, on Mathematics and Computers in Sport.

Because of my continuing participation in both mathematical research and competitive sporting activities, I have included a biographical perspective of my career in both these areas. This should indicate the long period of time needed before some goals are attained in either solving research problems or competing successfully.

1. Introduction

This article is about the development of my research interest in sport science and the interaction that followed with similarly-interested colleagues in Australia and New Zealand. It is also about the perceived progress that has been made in this part of the Southern hemisphere in aspects of many sports, through analyzing them using mathematics, statistics, operations research and computers.

I have been involved in various sports recreationally during my mathematical career. I played the generally-popular team sports of football and cricket at school, and dreamt (like most schoolboys) that I would one day play for my country in one of these sports. It did not take me long to realize that my abilities did not match my expectations in either. However at the local level, I was moderately successful in pool swimming and surf swimming, but never represented at State or National level. At university I concentrated on my mathematical studies and for sporting recreation I learnt to ride a surf board.

Upon graduation in 1960 I joined the teaching profession as a mathematics teacher in a high school and, because I could swim, I was given the school water polo team to coach. I knew nothing about the sport, but began reading the appropriate coaching manuals. This was my introduction to the scientific theory behind sport. At the same time I began to play competition baseball, a game with many strategies and, even today, some interesting unsolved problems. There have been many articles (particularly in the American Journal of Physics) on baseball, hence much of that sport has been analysed thoroughly. However one of my Australian colleagues, Chris Harman, and I are currently investigating how an outfield player knows where to run to in order to catch the ball. Chris is an applied mathematician who has played baseball for Australia against Japan, and his investigation of the literature appears to show that not much is known scientifically about this problem.

In 1962 I moved to the Royal Military College in Canberra as a lecturer in the Mathematics Department. Although I had only coached high school water polo teams, and never played the game, I soon became involved in coaching the College team, learning to play the game myself and establishing a local competition. Ten years later I was playing regularly for the Canberra team in representative matches and had just published the first Australian coaching book on water polo (de Mestre and Neesham, 1972). My co-author, David Neesham, was an Australian water polo team player at four Olympic Games, captaining the team at Montreal in 1976 and Moscow in 1980. A fascinating scientific problem in water polo, that is still not completely analysed, is the ability of a player to bounce the ball off the water's surface into the goalmouth. Initial investigations on this problem have been covered by Walker (1975), but the matter has not been completely resolved as far as I am aware.

During this early part of my lecturing career I was engaged in various research activities, mainly in the area of fluid dynamics where I wrote papers on topics as widely dispersed as shock waves and slow viscous flows. I was also developing courses on the mathematics of ballistics, and was using many sporting situations as examples of projectile motion. This collection of ideas was eventually published much later in my book on the mathematics of projectiles in sport (de Mestre, 1990).

2. Early Sports Research

At the 1976 Olympic Games in Montreal, Australia performed poorly according to our sport-crazy media and the general public. Not one gold medal was obtained (see Clarke, 2000). The Olympic ideal of just being able to compete was not considered by many sport-loving Australians to be a high enough objective. Accordingly the Australian Government established the Australian Institute of Sport in Canberra in the late 1970's with the aim of obtaining an increase in gold medals at future Olympics.

The Institute brought together athletes, coaches and scientists, and enabled me to become involved in a number of consultancies because of my interest in both sport and mathematics. I wrote a small unpublished paper on the different effects of drag on a middle-distance runner who either led the field or ran in the protected air stream behind a runner directly ahead. It indicated that up to 3% of the runner's total energy output could be saved for the final sprint by running just behind another runner. I was also fortunate to be involved with a series of experiments designed to optimize the performance of Gary Honey, an Australian long-jumper, who was an Olympic silver medallist. There was much interest in the scientific aspects of the long jump after Bob Beamon's historic jump at the 1968 Mexico City Olympics which broke both the World and Olympic records by amazing amounts. Most of these are referenced in my paper on the wind effects on long jumpers (de Mestre, 1991). It was my research on long jumping that first made me aware of another Australian sports mathematician, Maurie Brearley, and after eventually meeting him, we have established a long collaboration in sports science beginning with cricket (Brearley, Burns and de Mestre, 1990) and continuing with rowing, the long jump and golf. Many of these have appeared in the Proceedings of the Conferences on Mathematics and Computers in Sport, (see the web site www.anziam.org.au/MathSport) but some have appeared elsewhere (Brearley, de Mestre and Watson, 1998; Brearley and de Mestre, 2000). Maurie, at 82, has now retired from teaching, but his interest in sporting problems has not waned, and he has attended all six of the Australian conferences on Mathematics and Computers in Sport, delivering papers at each one. His original papers on lawn bowls (Brearley and Bolt, 1958; Brearley 1961) are still quoted as the definitive scientific analyses of this sport.

One of the outstanding sporting events in the 1980's, as far as Australia was concerned, was the arresting of the America's Cup in sailing from the United States. There was much scientific endeavour (unpublished, of course) in the development by the Australia II syndicate of the "winged" keel which added significant speed to Australia's yacht. In addition to this structural secret, the approach taken by the Australia II syndicate was to use a computer to determine the optimum possible performance standard of their yacht under different wind and sea characteristics. These standards were established by theoretical analyses and verified, in advance, by scale model testing. The yacht's skipper could then observe during a race, whether or not the yacht was performing below optimum, and consequently decide what remedial action needed to be taken, if at all. Although the U.S. was able to win the Cup back, it has now been won by New Zealand who also put considerable time and research effort into developing the scientific aspects of ocean racing (Philpott, 1993).

During the latter part of my 27 years lecturing and researching in Canberra on mainly other areas of mathematics (education, fluid dynamics and wildfire modeling) I became interested in cross-country running. I took up orienteering as a sport and eventually represented Australia in my age group. This sport has many optimization problems as it involves navigation on foot with a map from point A to point B in the minimum time. These endurance-type events developed an interest for me in the multi-discipline sport of triathlon. I wrote an article (de Mestre, 1986) on the lack of fairness in the sport because of the different emphasis in the discipline over the three sections of swimming, cycling and running.

In 1988 I visited the U.S. on study leave and made initial contact with Mont Hubbard, leader of the Biomechanical Engineering Group at the University of California, Davis. We became interested in the trade-off between angle of projection and speed of projection for a number of projectile events including the long jump and the shot put (see Hubbard, de Mestre and Scott, 2000). Further research has been accomplished on this problem in Australia by Linthorne (2001).

First Mathematics and Computers in Sport Conference, 1992

In 1989 I moved from Canberra to Australia's first private university, Bond, which was just opening on the Gold Coast, Queensland. I began conducting workshops for high school teachers in various States of Australia on how to introduce and use sporting applications in their high school courses. I believed that this would help them to maintain interest in mathematics in the classroom.

Proximity to the Australian Institute of Sport's kayaking facility, which is just across the canal from Bond University, led me to decide to concentrate my research interests in areas of sports science. Consequently I organized the first Australian conference on Mathematics and Computers in Sport at Bond University in 1992. The aim was to bring together as many Australian and New Zealand sports scientists as possible, particularly those who used mathematics, statistics, operations research and computers. The structure of this three-day conference was for long lunches, early finishes at the end of each working day, and informal gatherings for dinner each night where valuable exchanges of ideas occurred. There were 12 papers presented and 23 participants, with two coming from the Australian Institute of Sport.

The first of the keynote invited speakers was John Croucher (Macquarie University) who considered the collection and analysis of data on performances in team sports (Croucher, 1992). Jon Patrick (Deakin University) presented a paper on the role of computers in the administration of the sport, the management of athletes and the use of videos and computers in the study of athletic performances (Patrick, 1992). The third keynote speaker was David Hoffman (Australian Defence Force Academy) who endeavoured to classify the large number of sports-related articles that had appeared in Operations Research journals using a bibliography of more than fifty such articles.

Stephen Clarke (1992) and Maurice Brearley (1992) produced the first of their contributions to these conferences, while I was involved in expanding the published conference proceedings by two papers (Aldis, Fulford, Weber and de Mestre, 1992) and (de Mestre, 1992). Abstracts of all these papers can be found on the web site www.anziam.org.au/MathSport/ .

Overseas sports scientists in attendance included Lucio Geronazzo (Firenze), John Norman (Sheffield) and Ray Stefani (California State University, Long Beach).

There were also workshops on three special problems, namely a timetable for entrants in equestrian events, team ratings and the mathematical physics of body surfing.

It was decided by those present to hold a similar conference in two years' time again at Bond University in Queensland under my directorship. It was also decided to endeavour to obtain at least one of the principal keynote speakers from overseas.

Second Mathematics and Computers in Sport Conference, 1994

The second conference had 19 papers and 28 participants. The Australian Institute of Sport again sent a representative and was a co-sponsor of the conference. Three New Zealand sports scientists attended, adding to the growing interest in the conference's deliberations. The conference had a distinctive golf flavour with no fewer than six papers presented on this discipline.

The overseas keynote speaker was Mont Hubbard (University of California, Davis) who described the dynamics of a bobsled simulator that had been built in his laboratory to teach the intricacies of bobsled driving (Hubbard, 1994). The second keynote speaker was Steve Clarke (Swinburne), who discussed the stochastic aspects of sport with an emphasis on the role of the variance in consistency of outcomes (Clarke, 1994). Steve was the leader of the Swinburne Sports Statistics group to which I shall devote a whole section later in this paper because of its pioneering efforts in many fields. The final keynote speaker was Maurie Brearley who considered a multi-flash photograph of a golf drive by American golfer, Bobby Jones, to show through simple physical principles that the length of a golf drive depends very little on the force used in the swing at the time of contact of the club with the ball (Brearley, 1994).

A significant paper was delivered by Hugh Morton (Massey, New Zealand) on the functional relation between the endurance time of an athlete at specified power demands. There are 83 references listed (Morton, 1994).

Third Mathematics and Computers in Sport, 1996

In 1995 the management of the conference came under the auspices of the Australian and New Zealand Industrial and Applied Mathematics division (ANZIAM) as a special interest group known as MathSport. Sponsorship was therefore obtained through ANZIAM and the Australian Institute of Sport.

There were 20 papers presented, and 27 participants. Three papers were presented on horse-racing and two on rowing, the first time that either of these sports had been included.

The keynote speaker from overseas was Stewart Townend (Liverpool John Moores University) who considered the use of advanced mathematical techniques in the biomechanics of walking, the modeling of the female torso, the analysis of soccer matches, individual training models and yacht design (Townend, 1996). The other invited keynote speaker was Hugh Morton (Massey University) who further elaborated on the power and endurance of the human engine through various models of human bioenergetics (Morton, 1996).

Tony Lewis (University of the West of England) presented a paper on the Duckworth-Lewis method for resetting the target in rain-interrupted one-day cricket matches (Duckworth and Lewis, 1996). Steve Clarke (Swinburne) generated a simple formula to calculate home advantage in team games, and applied it to the English Soccer League (Clarke, 1996). Both these papers proved to be accepted by sports administrators as useful models for practical purposes within the respective sports that they applied to. They were the subject of a number of media interviews within Australia during the progress of the conference.

Maurie Brearley and I presented an analysis of an unsual sport, the car jump (Brearley and de Mestre, 1996). We were approached to analyse the feasibility of a motor car using a straight run-up and an inclined ramp to break the world long jump by a car. The driver was endeavouring to raise finances to have the optimum ramp built for his attempt, which he hoped would be televised.

Our backgrounds in mathematics, engineering and physics enabled us to consider the overturning moment of the car, the projectile motion of the center of mass of the car, the effect of the springs as the car reached the bottom of the ramp, the take-off linear speed, the take-off angle and the rotation of the car from take-off to landing. For safety precautions we suggested that a movable nylon mesh barrier be erected at the landing area to catch the car and reduce the impact effect on the vehicle and driver. We were dumbfounded when the driver informed us that he was not too concerned about the landing, and that he was going to jump through a “hoop of fire” at the top of the ramp. Fortunately, sponsorship money did not eventuate and the attempt was cancelled. Maurie and I enjoyed the intellectual challenge of modeling this strange sporting event, but we were definitely relieved that the model has never been tested by a real-life experiment.

Fourth Mathematics and Computers in Sport, 1998

The fourth conference was again held at Bond University, this time with 22 papers and 32 participants. Sponsorship was obtained from ANZIAM and Bond University, and no representative attended from the Australian Institute of Sport.

The keynote invited speaker from overseas was Tony Lewis (University of the West of England), who presented further details of the Duckworth/Lewis method for target-resetting in one-day cricket matches (Lewis and Duckworth, 1998). John Croucher (Macquarie) returned as another keynote speaker, because of the unavailability of a selected keynote speaker at the last moment, and gave a detailed survey paper of developments in research into tennis over the previous 24 years (Croucher, 1998). The third invited keynote speaker was Chris Harman (University of Southern Queensland) who gave a most entertaining talk on optimal base-running in baseball and softball accompanied by a film clip of an old Bud Abbot and Lou Costello comedy interchange. The results of his analysis have since been used by the Australian Softball team following some revealing experiments which verified the developed theory (Harman, 1998).

There were six papers devoted to cricket, four papers on Australian Rules football, and three on athletics. Graeme Cohen (University of Technology, Sydney) contributed a paper on analyzing various sporting problems for an undergraduate mathematics course. This paper has been expanded recently into a book which is being considered for publication as this article is being written (Cohen and de Mestre, 2002).

Fifth Mathematics and Computers in Sport, 2000

Because of the Olympic Games being awarded to Sydney in 2000, it was decided to hold the fifth conference under the directorship of Graeme Cohen at the University of Technology in the centre of Sydney combined with an organized visit by all delegates to the Olympic site. There were 25 papers and 38 participants. The increase was due to the hosting of the International Conference on Engineering in Sport in Sydney in the preceding week, which produced eight overseas participants who stayed on for the Mathematics and Computers in Sport Conference.

The first keynote invited speaker was Rod Cross (University of Sydney) who described the mathematics and physics of ball sports, emphasizing bat/ball contact and tennis ball contact with a racquet (Cross, 2000). The other invited speaker was Mel Siff (Colorado, and formerly at the University of Witwatersrand, South Africa). He considered the biomechanical analysis of weightlifting and the production of strength, resulting in improvements to the methods of strength training and injury rehabilitation (Siff, 2000).

Steve Clarke was involved with five papers including one on home advantage in the Olympic Games (Clarke, 2000). Graeme Cohen produced an annotated bibliography of 127 articles and books useful for undergraduate courses on mathematics and sports (Cohen, 2000). Chris Harman (University of Southern Queensland) extended his analysis of baseballers running in a curved path to athletes running on a curved track (Harman, 2000). Mont Hubbard (University of California, Davis) returned to the Conference series and presented a detailed paper on the computer simulation of a frisbee in flight (Hubbard and Hummel, 2000). Elliot Tonkes (Bond University) considered the sailing technique necessary to optimize downwind sailing (Tonkes, 2000). Elliot is also the web master for the MathSport web site.

Sixth Mathematics and Computers Sport Conference, 2002

The sixth conference returned to Bond with 27 papers and 29 participants. There were six participants from overseas. The papers were edited by Graeme Cohen and Tim Langtry from the University of Technology in Sydney.

Ray Stefani (University of California, Long Beach), as the first keynote speaker, spoke on the differences in performances between male and female athletes based on power output and lean body mass. He also classified three types of sporting activities and three types of rating systems (Stefani, 2002). Steve Gray (University of Queensland) gave a keynote invited talk on the Gaussian kernel non-parametric regression model used to predict the probability of winning a one-day cricket match from any point in the match

(Gray and Tuan, 2002). Graeme Cohen (University of Technology, Sydney) was the third invited speaker, and he considered two stochastic problems in one-day cricket. These were the increase in probability of dismissing the other team as the number of run-outs increased, and the geometric nature of the probability distribution of the number of scoring strokes (Cohen, 2002).

There were eight papers on tennis, and five each on cricket and football. Steve Clarke again was associated with five papers, while Graham Pollard (University of Canberra) presented three on tennis. In two papers Tony Lewis (now at Oxford Brookes University) discussed further modifications to the Duckworth/Lewis method now accepted by the International Cricket Council. David Panton (University of South Australia) discussed the use of Integer Programming optimization models to create basic pattern sets for round-robin and partial round-robin sporting schedules with constraints (Panton, Bryant and Schreuder, 2002). Emil Muresan (Catholic University, Leuven, Belgium) produced two papers on the use of videos and computers to analyse soccer matches. Katherine Hogarth (University of Queensland) presented the findings of her PhD thesis comparing computer simulations with films of a twisting dive (Hogarth, Yeardon and Stump, 2002).

Conference Statistics

Three Australian sports scientists (Brearley, Clarke and de Mestre) have attended all six conferences on mathematics and computers in sport held over the last ten years. The same three have contributed the most papers with Steve Clarke leading with 17, the author on 14 and Maurie Brearley contributing 7.

There have been 21 papers on cricket, 17 on various football topics, 11 on tennis and 10 each on golf and athletics. The absence of any papers on swimming is surprising for a country that leads the world in the application of science to this discipline with such outstanding results. One could be left with the conclusion that the mathematical sciences has very little to contribute to improvement in swimming times, or that the unsolved problems are too hard. I tried to apply Keller's theory (1974) of optimal running to a long-distance swimming race (800m or 1500m) but found the inclusion of turns after each 50m an added difficulty.

Media Coverage

The Swinburne Sports Statistics unit was developed around the research, consulting and publicity activities of Steve Clarke at Swinburne University of Technology in Melbourne. It consists of Steve, his research students, visiting academics and part-time employees through the various consultancies and interacting commercial companies. It focuses on mathematical modeling with a view to rating teams or players, measuring home advantages and optimizing strategies. These support the commercial opportunities that are evolving in sports betting. The unit uses a range of techniques. Prediction of football results is obtained using time-series forecasting methods such as linear regression and exponential smoothing, home-advantage analysis is obtained using various least squares linear models, while recent tennis research is obtained using logistic regression. Optimal strategies employ dynamic programming coupled with simulation to predict tournament outcomes. More details on the unit can be found at the website www.swin.edu.au/sport which is currently averaging over 20,000 visits per month.

The unit receives a wide variety of publicity and media attention. Steve has had more than fifty radio and television interviews on sports science research. His computer tipping predictions for the Australian Football season have been featured in major Australian newspapers for 11 years. The computer regularly beats the local "experts" and this adds further public interest to the usefulness of sports science. The prediction model has recently been extended for International events to predict the Grand Prix motor-cycle race at Phillip Island, Victoria and the Formula 1 car race in Melbourne.

Research into cricket modeling has resulted in collaboration with Synaval Pty Ltd to set up a joint Swinburne/Synaval start-up company SPORTSBET21 Pty Ltd. This company has developed a statistical model to set odds on the number of runs in an over of one-day cricket, which is being trialled by the Tasmanian Totalisator Board. Other consulting research has been undertaken for the Australian Cricket Board, the Victorian Squash Federation, Tattersals Pty Ltd, Champion Data, Ozmium Pty Ltd, the Victorian Institute of Sport and All Sports Data Services.

While Steve Clarke was grabbing media attention for sports science in Melbourne, John Croucher (Macquarie University) was doing the same in Sydney. His initial success in predicting the result and almost exactly the score in a major football match (the rugby league Grand Final of 1984) led to eight years of regular appearances on television, consultancies with betting agencies, and many articles in newspapers. John also pioneered a successful undergraduate statistics course on sport, gambling and health with lots of references to web-based material.

3. Recent Sports and Research

My involvement with sports science since I moved to Bond University thirteen years ago has blossomed more than I originally envisaged. Besides co-ordinating five of the six conferences discussed earlier in this article, I have been writing papers with various colleagues from other universities and co-authoring a book called "Figuring Sport" with Graeme Cohen. This book is aimed at the undergraduate level and has chapters on tennis, cricket, team selection, competition draws, golf, rowing, weightlifting, football, billiards, track and field athletics (Cohen and de Mestre, 2002).

Maurie Brearley and I are currently investigating a new steering mechanism for competition surf boats. Another unfinished surfing problem is to develop the mathematics and physics of body surfing, the art of using a broken wave to propel an otherwise-unassisted surfer towards the shore (no flippers, no surf craft). I have been interested in this problem for many years, particularly as I have returned to surf competition since moving back to the coast at Bond University. I am currently surf iron man champion (swim, surf board, surf ski, run) in my age group at National and World levels, and am always looking for that extra bit of assistance through the application of sports science.

This article has endeavoured to show one player's view of the evolution of the interaction between the mathematical sciences and sports research in Australia and New Zealand. It is hoped that this interaction will be carried forward by many contributions to this innovative e-journal by the scientists from this region.

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www.anziam.org.au/MathSport

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Scientific basics and commercial interests in sport information technology

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1. Introduction

If one considers the current fields of work in sport information technology under the viewpoint of scientific papers and publications in Germany, clear centres of emphasis become evident. The largest number of papers given concentrate on the multimedia area, followed by the setting up models and data bases. Here sport information technology has concentrated, fully to right, on a very topical area of education and research, even though it is apparent that the designation of concepts in the ”multimedia“, meanwhile known as “new media“, leans very clearly on the terminology of ”e-learning“. This is not only true for the international use of language, but meanwhile also for all German speaking peoples.

Faced with the large thrusts of development and the strong increased interest in e-learning, the interest in the connections between scientific basics in sport information technology and commercial interests is naturally large. There are, however, other fields in which such a connection is to be observed. For this reason this paper mainly concentrates on the topics of the setting-up of models and e-learning.

2. The Setting-up of Models

Scientific activities in the area of setting-up models could be long observed in sport information technology and in sport science and were recently summarised (Perl et al. 2002). In biomechanics as well as in physiology one has worked for many years with corresponding mathematical, chemical or physical models, in order to better understand or to make complex phenomena understandable. The proximity of a so understood setting-up models to sport information technology can turn out differently. In spite of their possible orientation to basics, the interests of the other sport scientific partial disciplines is concretely directed to questions of practical application (Arampatzis et al. 2000). In contrast classical or sport based approaches very often lead to comparable abstract or obtuse directions of work (Mester, Perl 2000).

In one’s own work group setting-up model assumptions were pursued, which because of the orientation to applicability, very quickly ran up against commercial interests.

One example is based on the modelling of the ski line in alpine racing sport, which was brought into the discussion by Seifriz (2001). In spite of the seemingly simple basic question with the physical background of a gliding movement on a sloping plane with rhythmic changes in direction, this problem revealed itself in detail to be relatively complex. The number of variables and their possible combinations together with biological regulatory events was so large, that here simple deterministic approaches were not able to contribute to possible explanations or even prognoses to any considerable degree.

On the basis of a physical-deterministic model Seifriz developed for this reason, an optimisations programme with the help of genetic algorithms, which was definitely able, to provide plausible explanations and also to optimise the choice ski lines. (Seifriz et al. 2000).

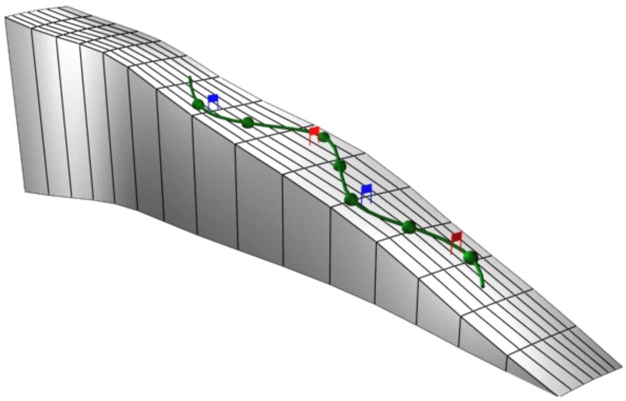
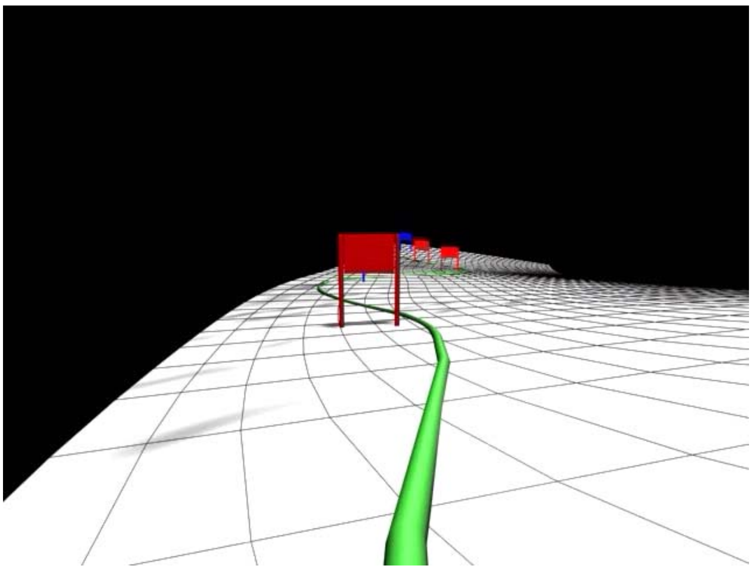


Figure 1. Model of ski slope with optimised ski line through applying genetic algorithms (Seifriz 2001)

The ski slope model illustrated in diagram 1 was determined using the GPS. The ski line was optimised using the above described technique. Powerful software (3 D-Studio Max) made it possible, to structure this ski slope model and determine the corresponding ski lines (even dynamically) and to supplement these with different 3 D simulation



(s. fig. 2).

Figure 2. Screenshot of a dynamic ski line simulation

A commercial interest in this work from the large media institutions ARD, ZDF and RTL was attributable to the fact that the differences in ski times in alpine ski sport e.g. in super G or downhill only in quite seldom cases can be assigned to definite differences in the skiing technique or other performance characteristics of the skier. An explanation of differences in performance is therefore only possible with great difficulty. With the aid of these simulations it was now possible, over and above the normal descriptive reporting, to offer explanatory statements.

It is now 10 years since the so called "blend-over technique" as a speedy further possibility of graphic coverage of differences in performance was developed, which some time ago was even taken up by commercial companies and promoted to widely distributed standard equipment in television reporting on various types of sport. With the conventional editing software, digital videos of different format can be configured without much trouble in an editing track and with differing adjustments in transparency, so that afterwards two separate videos appear superimposed in one window. In this way it is possible, for example, to let two skiers synchronous in time and place ski on one and the same ski slope.

With the advance of computer science, further possibilities are opened for the digital manipulation of videos with the aim of making differences in performance clear. Thus it is possible today, using tracking techniques, to follow moving objects in their respective trajectories and to freeze these in digital video as drawn-in paths of moment of corresponding tracks In this way, for example, flight curves in skis jumping or throwing or putting trajectories track and field events can just as well be traced, as the ski line of an alpine racing skier.

Such an example is shown in the following figure.

Figure 3: Ski line of an alpine racing skier

To summarise this section is to establish, that on account of the development of computer science and powerful and pertinent software packages, a large number of technical manipulations in the video domain are possible, which considerably benefit the medial presentation of sports events. Faced with the further increasing technology in television reporting, here are offered absolutely good working possibilities for sport information technology.

3. e-Learning in Sport Science and Sport

If one compares the different international developments in the area of e-Learning, the impression is gained that not only Germany, but also other European countries have a considerable catching-up requirement in this area. This backlog demand is not only through the comparison with the north American developments, but also clear with countries, which otherwise lie behind the central European standards in terms of development status..

In addition one compares such activities in the industry with those in schools, high schools and other public institutions, here also a larger gap in development is clear to see.

Large industrial companies, especially those, who are active world wide, have made use of e-Learning technologies for a long time. The technical advantages are clearly apparent.

The driving technology of the internet, together with the fast progress in PC techniques and multimedia developments open new possibilities for the education, advanced training further education in the form of “e-Learning“. We have to do here with a computer-aided form of learning, whereby the participants gain access to the learning material either online via Internet or offline via CDs. In addition they can use electronic services such as e-mail, chat and discussion forums to exchange questions and experiences with other participants. ”E-Learning“ distinguishes itself over the traditional transfer of knowledge through several important advantages; on the one hand journeys to a teaching locality are superfluous, on the other hand one can learn at one’s own workplace or at home with an individual schedule.

The improvement in the teaching at universities through computer based techniques, introduced under ”multimedia“ or ”new media in teaching“, experienced an especially rapid development in the recent past, which was enhanced through financial support by the state and federal government. Also in the actually agreed aims between the German Sport University Cologne (DSHS) and the Ministry for Schools, Science and Research, in NRW, the improvement in teaching due to new media played an important role.

The sponsorship of the DSHS by the state government in NRW supports two projects at this time, the so-called “University Alliance Multimedia“ and the ”Research Association Sport Information Technology“, both under the auspices of Prof. Dr. Joachim Mester.

“Trainer-Net“, a network together with the Sport Foundation NRW for schools, associations, clubs and universities for performance sport for young people in NRW should profit from this.

Sport-el has been up to now the project basis on the German Sport University Cologne in co-operation with the Ruhr University in Bochum and the Johannes Gutenberg-University in Mainz, financially supported by the Ministry for Schools, Science and Research of the NRW State. This stands for "Electronic Learning in Sport and Sport Science" and covers all multimedia forms with which the teaching at universities, schools, in associations, clubs or other institutions should be supported and improved. The Sport-el Factory, with more than 40 experts from different academic disciplines and types of sport, multimedia techniques and system administration, as well as approximately 80 students in the multimedia apprentice training, the Sport-el talent forge, are the basis for high and consistent quality of the e-Learning products, which are actualised to the state of the art in science at all times. The Sport-el team is comprised jointly of the Institutes for training and movement of sport science, bio-mechanics, individual sport, natural sport and ecology, sport journalism, physiology and psychology of the DSHS Cologne, the chair for biomechanics and movement studies of the Ruhr University in Bochum and the Institute for computer science of the Johannes Gutenberg University in Mainz.

The actual e-Learning offered by the Sport^{-eL} Factory in the DSHS consists of the following modules and services:

Web courses, or using the English CBT (Computer-Based-Training), include self compiled multimedia teaching programs, which are obtainable on CD or accessible through the internet. These teaching/ learning systems represent an extension to the traditional teaching methods and can better illustrate complex contents through the mutual use of text, picture, sound, video and animation .

Web lectures are in the form of online lectures using transparencies and accompanying materials. Web lectures allow, Power-Point presentations to be made available to an unlimited number of addressees in the internet. In order to see web lectures one requires a PC with an internet attachment, loudspeaker and a browser option.

The web collaboration centre comprises an online platform with forums for virtual class rooms and live sessions. In virtual class rooms a mutual working online is possible, i.e. participants and teacher work simultaneously with the system (synchronised learning). In addition live sessions offer much interactive material such as audio and video and are predestined for meeting and educational training in the internet. The students gain additional support on the one hand through electronic services such as e-mail, chat and discussion forums, and on the other hand through teaching groups, in which tasks can be mutually reviewed and solved.

Web written examination training provide written examinations with immediate feedback as preparation for tests and examinations. Equally the online examinations in their different forms, such as. multiple choice, open questions, are possible in the protected internet sphere.

Knowledge nuggets are short, comprising multimedia teaching units of pared down topics of not longer than 15 min duration.

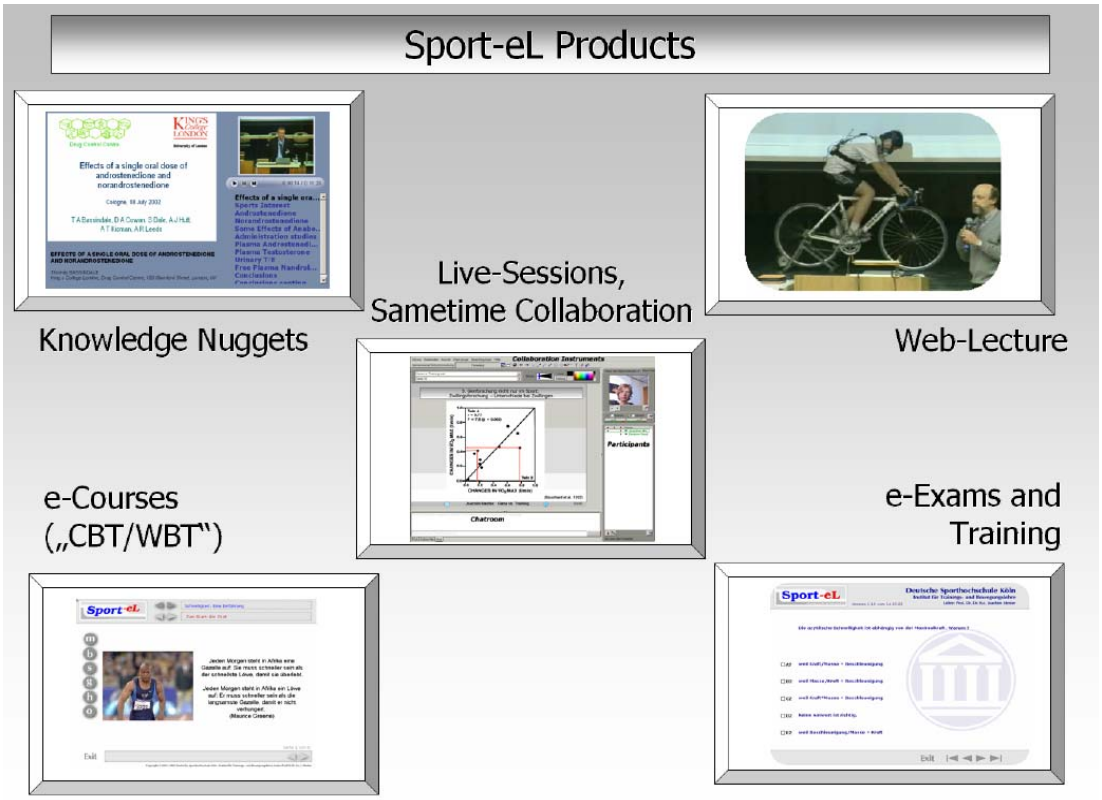


Diagram 4. e-Learning Product Assortment from Sport-eL

The hardware used at the DSHS consists of three physically present e-learning servers and 60 special e-learning training spaces. A Notebook University is being planned/ WLAN.

Picture processing programs belong to the software used (such as Photoshop), audio/video (Ulead/Premiere), graphics (Corel), presentations (PowerPoint), animations (Flash), data bases (db2), course preparation (Authorware) and interface figuration (Delphi).

The course preparation, i.e. the learning infrastructure, the different modules is controlled by the IBM/Lotus Learning Space, an excellent management program in the e-Learning range. The most important functions of the IBM/Lotus Learning Space are management of access and content, inclusion of self developed and commercial products, learning time registration, test management (times, results), written examination management, preparation of individual learning paths and –successes, documentation, setting-up if online sessions and collaboration centres with tutoring and/or publications in the intranet and internet.

The IBM company was obtained as a partner in co-operation, who in addition to their known profile in the high technology area also possess comprehensive experience in the subject ”e-Learning“.

The Sport-el team of the German Sport University Cologne compiled the presently available learn modules in the training and movement studies. The contents of the subjects strength, quickness, endurance and flexibility with implementation of the biological basics, diagnostics, adaptation and training are provided by sport scientists, trainers and active sporting men and women.

4. Summary

Scientific basics and commercial Interests about and in the sport information technology in a period of greatly increasing use of the internet in general and digital media in particular can be closely connected. Here the field of teaching and research in sport has a multiplicity of advantages vis-a-vis other university disciplines, which are restricted to a negligible visual attractiveness and minimal public interest. The impression arises, that faced with the research lead in sport information technology, definite resources are available, which could not yet be adequately exploited. These resources will further increase with the increasing number of university places and academic qualification procedures and can be located in the domain of digital techniques as well as in the scientific basics of setting up models or the development of modern methods in teaching and learning.

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Security of IT based learning systems

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Summary

IT security incidents are increasing nearly exponentially. With this increase, the importance of data accessibility, confidentiality, integrity, and authenticity grows. IT-based learning systems are especially endangered through intentional destructive actions. A basic condition to guarantee the security of personal data is the compliance with national laws and international regulations, especially the data protection laws. Furthermore, the complex standards of the BSI baseline protection manual must be fulfilled to avoid intentional destructive actions against the IT systems.

1. Current situation of IT security

The internet is not only a media were lots of information can be found and news is exchanged. It is also a media that is used for spying, sabotage, swindle and dealing in stolen goods. Using the internet for criminal offenses is an “easy and almost safe” job, since only a computer and a modem is needed and it is very difficult to detect and prove someone’s actions.

Therefore we have to reckon with an increase in white collar crime through the internet. Already now the German companies have billion-euro damages each year that must be attributed to internet spying and sabotage.

This threat does not concern, however, only the business. In the private sector one is also confronted with problems of IT-safety. An investigation by the consumer-advocate foundation *Warentest* showed that most privately used E-Mail-services are not secure. With only a few mouse clicks control over other people’s mail boxes, passwords and electronic mail could be achieved. In most cases only the knowledge of the email address was required to succeed. Therefore the owners of email accounts not only have the risk that unauthorized people can read, change or delete their emails but also that emails can be sent to other people in their name.

For example, the worm “Code Red” has gained a doubtful reputation. It took it only one week to infect about 300.000 computers worldwide. A delicate irony should be mentioned in passing: “Code Red” only infected Microsoft servers and therefore Microsoft quickly developed a security patch over the weekend. Two days after publishing the patch, the Microsoft publication server itself was infected. Besides Microsoft, many other companies were paralyzed, for instance the news agency Associated Press.

And this is no isolated case. A new study shows that US-companies lost about $250 billions through plagiarism that was made possible through the use of modern information technology in the companies. Further damages, like those caused by “Code Red”, were not taken into account by the study.

The FBI documented that 57% of the US companies they questioned stated that they had been attacked out of the internet. Furthermore it can be supposed that a significant part of those who answered “no” just were not aware that they had been attacked.

In Germany huge economic damages occur through the criminal use of modern information technologies. The agency for internal security of the German state of Baden-Württemberg estimated these at 7 billion euros per annum, the estimations of the police labor union are about 10 billion euros. Since the number of unreported cases in internet-based criminal offenses is extremely high, one can assume that the damages are worse.

The CERT/CC-statistics below give an impression of the possible future development. Figure 1 shows the number of system weak spots and the security incidents in the years 1988 to 2001.

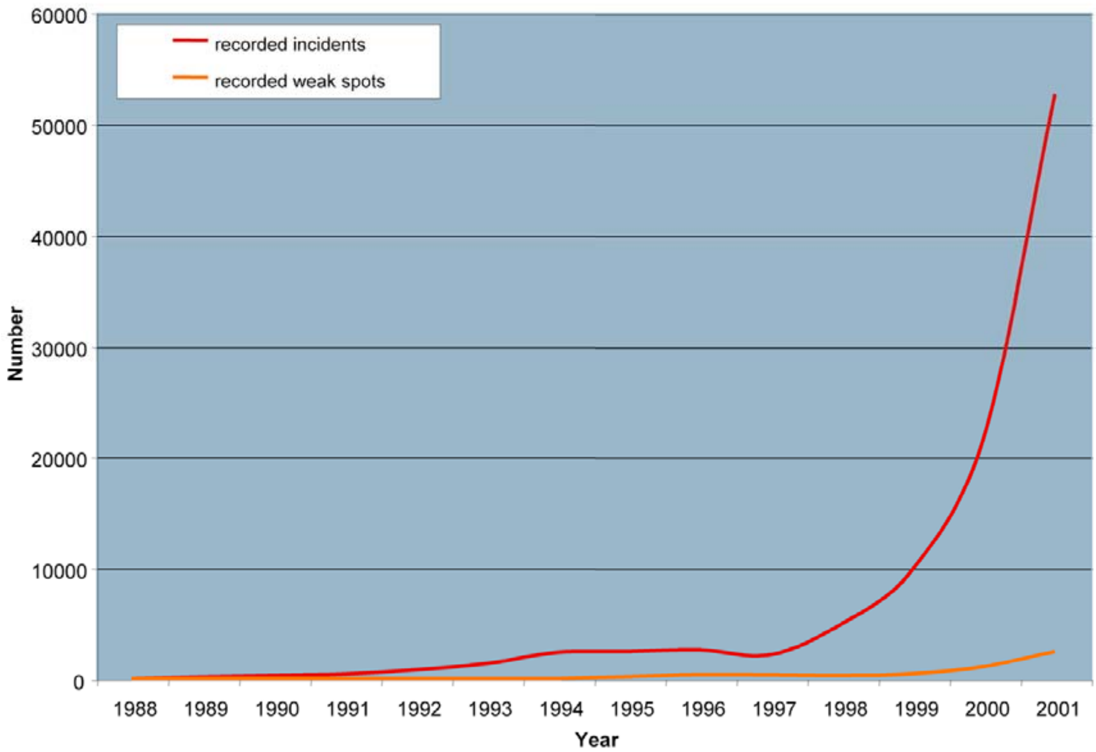

Figure 1. CERT/CC statistics 1988 - 2001

The figure shows a steady increase in the number of weak spots. One reason for this development has to be seen in the increase of IT system complexity with the consequence that process control becomes more and more complicated. Another reason is the increasing competitive pressure. Many software companies deliver products that have many errors and are not fully developed because they want to be earlier on the market than their competitors.

Even more interesting is the exponential increase of the security incidents. One major reason is the rapid development of the internet as well as the number of users. That these two factors seem to be more important than the number of system weak spots is illustrated by the increasing gap between the number of incidents and weak spots (figure 1). All the evidence seems to indicate that the development shown will continue in the future.

In contrast to this well-founded situation analysis and prediction, many companies, institutions and administrations declare that they do not have IT security problems at all. They admit that others may have problems and the trend may be consistent, but their own company is not affected.

This statement is self-contradictory, since a 100% security of IT systems will never exist. All IT systems are insecure without exception. All effort serves only one goal: to reduce the residual risks and to do this with acceptable costs. If, for example, a company states that in the last six months only two hacker attacks could not be rejected automatically, but only by manual defense, the security standard of the company is high. Is the message on the other hand that in the last year no hacker was able to overcome the security mechanisms then the presumption is obvious that some/most attacks were not noticed at all.

What are the reasons for the widespread “No-problem”-statements? Three causes can be identified.

First of all, the fear of image loss that is deeply rooted in a false security comprehension has to be mentioned. Security holes are seen as fatal errors that should never happen, instead of admitting that they will always exist and actively looking for them with the goal of minimizing the risks.

The second reason is the fear of personal consequences. The employee fears that her/his superior will judge based on the mentioned false security comprehension and therefore misjudge security holes as a slip by the responsible employee.

Wrong success criteria are the third reason. Companies, institutions and administrations have usually a small budget for IT services and projects. If the security aspect is not an integral part of the project success criteria, the risk is taken that the money will not be spent for this aspect. An e-learning project, for example, will be focused on pedagogical and didactical processes as well as the content that should be imparted. The success of the project will be measured by the learning results of the students. The relevant aspects of IT security (see below) will not be in the main focus if they are not embodied in the project planning.

The last aspect is reflected by the results of a survey taking 500 companies and institutions into account. Figure 2 illustrates the amount of money spent for IT-security relative to the total IT-budget.

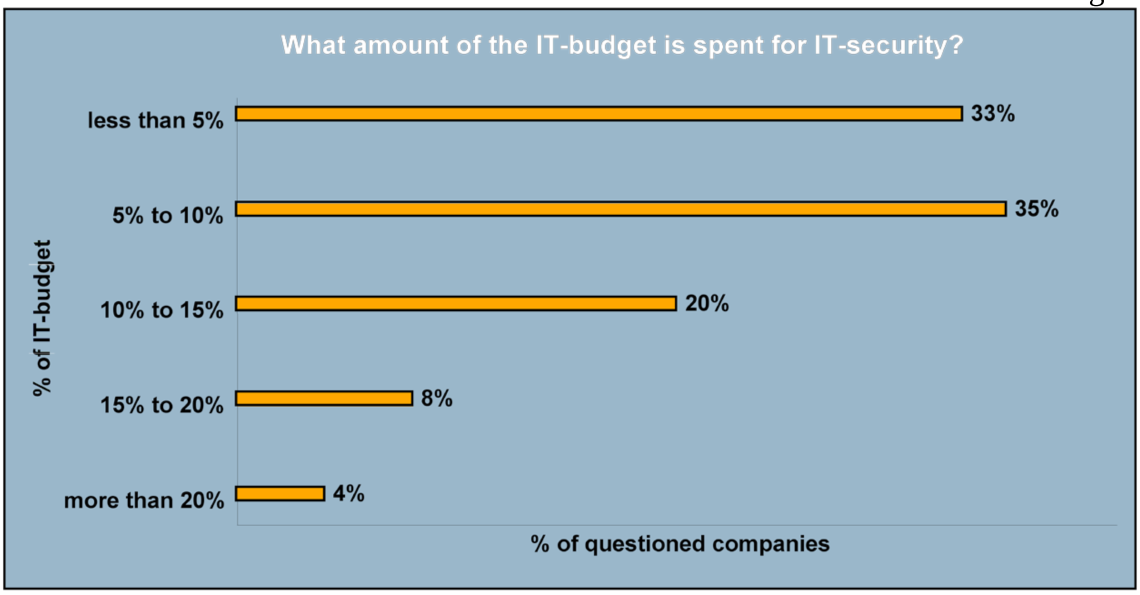

Figure 2. Security budget

One third of all companies and institutions spent less than 5% of their IT-budget for IT-security! 68% spent 10% or less! These results are alarming with regard to the tremendous economic damages resulting from IT-security breaches.

The situation is even more dramatic as the comparison of the proportion of the IT-security budget and IT-security incidents shows (see figure 3). In the period from 1999 to 2001, the attacks that became public tripled, whereas the IT-security budget stayed nearly the same.

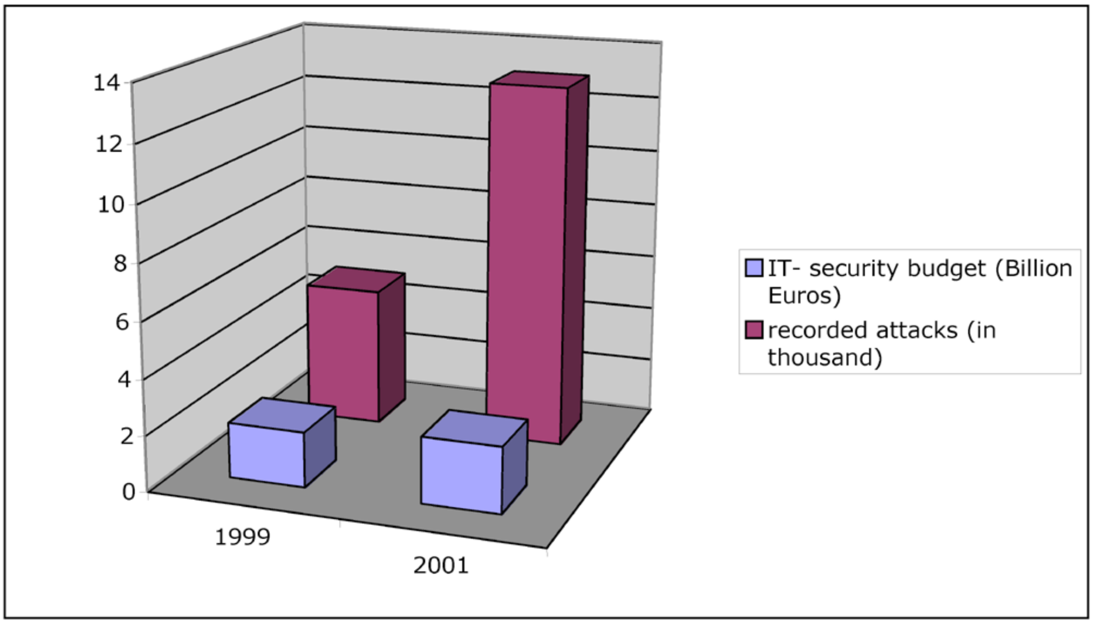

Figure 3: Recorded attacks and security budget

The consequences of the disproportion can be noticed at educational institutions as well. The author, in his rare contacts to German universities, coincidentally experienced the following security incidents:

- emails disappeared without trace
- return addresses were faked
- personal data of employers were broadcasted all over the world
- application servers were not reachable for weeks
- hackers accessed the passwords of all users at a university
- servers were used for illegal attacks on other systems

Some additional remarks on the last two incidents to show inherent problems: At the moment when the IT administration of the German university noticed that the hackers had accessed the passwords, the reaction was to send all users an email with a recommendation to select a new password. The major problem was however that unauthorized people could access strictly confidential data! And even more: The question has to be asked, how many hacker attacks had not been noticed before this one was detected by accident? Such a serious security incident has to have consequences, at least the radical analysis of the system, and probably basic changes in security. Nothing of this sort happened at this university.

Several universities did not notice that their servers were misused for hacking attacks. The hackers operated from outside the universities by remote control procedures. The IT administrators of the universities got first evidence that something is going wrong from the victims of the attacks. For days or weeks up to 90% of the university server's capacity was used for the hacker attacks and no responsible person noticed this! In summary, these incidents lead to the question, whether the IT administrators know what their systems are doing.

2. Components of IT-security

Software bugs produce wrong data, system crashes hinder the access to data, hackers attack data. Data are the starting point and the goal of all IT solutions. The security of the IT solution is therefore equivalent with the security of the data.

Data Security

Data security implies accessibility, confidentiality, integrity, and authenticity. These aspects will be discussed and illustrated through the consequences that can result in IT-based learning surroundings.

Accessibility of data means that the data are accessible during the required time and in the required quantity. If the accessibility of the data is not ensured within IT learning platforms or e-learning products then, for example,

- Results of exercises and tests are not available
- High costs for the reconstruction of missed data result
- Learning and examination programs can not be used as scheduled

Confidentiality of data is given if only authorized persons and groups of persons can access the data. Insufficient confidentiality means the possibility for unauthorized persons to access

- Examination questions before the examination starts
- Performance data of the examination
- Personal data of the students participating in the examination
- Research results and intellectual property

Integrity means that data only can be changed in an authorized way, that no unauthorized deleting, adding and modifying is possible. Violation of integrity can have following consequences

- Examination questions, results, study documents etc. are faked
- Students can not be sure that the learning results they achieved during the semester will be available unchanged at the end

Authenticity means that the origin of the data is definitely evident and provable. Violation of authenticity means that

- Dubious publications in the name of the university or their employers can be harm the reputation of the university or persons
- The semester could be disturbed through faked plans and instructions that pretend to be formulated by the administration

- Results of examinations can not be definitely assigned to the students and therefore are worthless
- Dubious emails with faked return addresses that discriminate against single persons or groups of persons damage the reputation of the alleged sender.

Endangering analysis

The security of data is endangered through natural catastrophes, organizational weakness, human errors, technical failures or intentional destruction. To construct appropriate security guidelines, processes and evaluation measures, the endangering factor in each area has to be determined. The decision matrix (figure 4) with the axes *occurrence probability* and *consequences* can support the analysis.

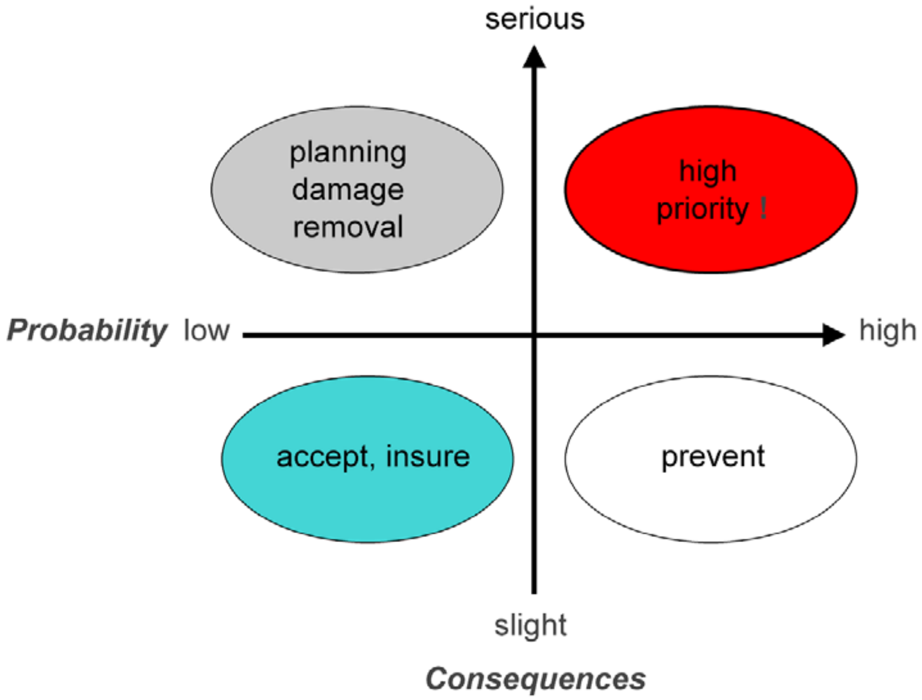

Figure 4: Decision matrix

Risk of incidents with low occurrence probability and marginal consequences can be accepted in the most cases. Sometimes it is possible to insure against these risks (figure 4, left bottom quadrant). Events with a low occurrence probability and huge consequences can be prepared for disaster recovery (figure 4, left top quadrant).

Very important is the protection from events that occur with a high probability and have mild consequences. Preventive steps should hinder the occurrence or reduce the occurrence probability (figure 4: right bottom quadrant).

Incidents with a high occurrence probability and serious consequences need a maximum of attention. Prevention and disaster recovery must be planned to guard the company against serious problems (figure 4, right top quadrant).

The result of an endangerment analysis will always depend on the type of data and the special duties and goals of the company. Whereas the probability of technical errors like the failure of hard disks can be calculated quite well, the estimation of the occurrence of intentional destruction is difficult. Similarly, the valuation of the consequences of data loss will always depend on the possibilities to reconstruct it. If, for example, data bases of a longitudinal survey lasting 10 years are lost, there is no chance to reconstruct the analysis made with these data. If only the analysis is destroyed, then the reconstruction is "only" a loss of time and money.

The ***general procedure*** of an endangerment analysis will be illustrated by an analysis of the threat to an e-learning system through intentional destructive actions. To estimate the occurrence probability several aspects have to be taken into account, for example:

Number of users: The higher the number of users the higher the probability of intentional destruction actions.

Age of users: Experience shows that a user group aged of 20 to 30 years will commit more intentional destructive actions against an e-learning system than a group at the age of 50 to 60.

Motivation: The higher the motivation for intentional action against the system, the higher the probability is. If the system is used for tests and examinations, then the motivation for illegal actions (crash the system) and swindle (achieve better grading) is very high.

Number of servers: The higher the number of servers used in an e-learning system, the higher the endangerment factor is.

Homogeneity: The higher the homogeneity of system components is, the fewer points of attack are available. If the system has a variety of hard- and software components, system security has to be ensured for each of these components.

Administration: IT security can be implemented easer if the same person(s) is(are) responsible for the administration over a long period of time. Too many administrators, with less systematic organization, enlarge the security risks.

Further aspects concerning the user are the level of education, the amount of free time, the leisure-time activities, group dynamic aspects etc. Further aspects concerning the IT surroundings are the number of connected workstations, the extent and complexity of the net, the dynamics of the net structure etc. Furthermore aspects like control of entry and architectural and technical infrastructure have to be taken into account.

Altogether these few examples show that the use of computer-based learning systems at universities, colleges, and schools will be accompanied by a high risk of intentional destructive attacks.

An ***estimate of the damages*** through successful attacks on e-learning systems has to consider several aspects:

Type of data: The damage depends on the type of data. The deleting or destroying of personal, production and research data will result in greater damage than the manipulation of data that illustrate the law of falling bodies.

Reconstruction: This aspect focuses whether or not lost data can be replaced or reconstructed as well as the consequences of a final loss. If for instance the data of a household survey from the present year are lost (where the data gathering costs 250.000 €) there is "only" a financial and a time problem. The loss of data from a learning experiment with a special group of people is irreplaceable since it is not possible to test the subjects twice. Furthermore, admitting the loss of data causes inevitable a loss of image.

Confidentiality: The question must be answered whether or not the data have to be handled as confidential. The decision has to be made in accordance with international and national laws, especially employer laws, standards (ISO) and special agreements of companies.

Because of many binding laws and regulations, confidentiality is of outstanding importance.

3. Laws and regulations

In Germany the following laws affect the IT security (incomplete list)

- the KonTraG – Gesetz zur Kontrolle und Transparenz (law for control and transparency for enterprises)
- TKG – Telekommunikationsgesetz (telecommunication law)
- SigG – Signaturgesetz (signature law)
- LDSG – Landesdatenschutzgesetze (data protection law of the states of Germany)
- BDSG – Bundesdatenschutzgesetz (data protection law of the Federal Republic of Germany)

Of special interest concerning the e-learning systems are the data protection laws since most products have to process personal data, for example

- demographical data (names, date of birth, address),
- educational data (schools visited, type of qualifications),
- psychological data (personality dispositions and profiles),
- employer data (type of job, duration of employment),
- learning results (exercise, test and examination data) and
- learning process data to serve their purpose.

Data protection laws

Some exemplary problems that arise from the viewpoint of data protection will be discussed below (see also regulations LDSG)

It is only allowed to record, save and process personal data with the agreement of the affected persons or on the basis of legal authorization.

This means that every registration, processing and saving of data within an e-learning system requires a written agreement. General agreements are not sufficient. An agreement must declare precisely which data will be saved and how it will be processed.

It is only allowed to use personal data for the purposes that were declared to the affected person at the moment of the registration.

This law is especially interesting for universities that have an understandable interest in reusing the user data for evaluation of the e-learning systems and other research projects. If they want to do so – at the moment or in the future – , they need the written agreement of the users.

It is not allowed to save personal data longer as necessary.

One problem is the exact determination of the "necessary" time. Obviously user data in e-learning systems must be saved until the goal of the course is reached, the semester is over or the examination is done. The further use for research purposes is only possible if the user agrees. In this case the data can be saved and the personal identifiers should be deleted for reasons of safety. In all other cases the data has to be deleted. One difficulty may be that the responsible persons do not know all places in the system/on the hard-disks where data is saved and therefore are not able to delete them all.

It is no allowed that a third party accesses personal data.

This law has to be considered when the user data are made accessible for tutors and are used beyond the original purpose in research projects. As mentioned above, this is only possible if the user signs an agreement.

Rules for handling personal data are not only determined by data protection laws as mentioned exemplarily above. There are a number of additional standards that have to be considered when constructing IT-based learning material.

General Standards

Standards aren't laws but they achieve a legal status through their use in laws or agreements. The following standards have relevance for IT security:

- BSI[1] Grundschutzhandbuch (IT Baseline protection manual)
- The EU Directive on the Minimum Health and Safety Requirements for Work with Display Screen Equipment (Europäische Bildschirmrichtlinie; EU 90/270/EEC)
- ISO[2] 9241: Ergonomic requirements for office work with visual display terminals (17 parts)
- ISO 13407: Human centered design processes for interactive systems
- Industrial safety rules

Further general standards concerning different IT sectors are being continuously developed. In Germany the NI-36 group at the DIN[3] institute is working on criteria for the description and evaluation of IT-based learning systems. This working group represents the German interests in the international standardization committees.

As the standards themselves are not legally binding, the compliance of software products with the ISO 9241 is per se not required. But through the reference to ISO 9241 in laws and regulations, they have to be fulfilled for instance in German public administration. Another example is the IT Baseline protection manual of the BSI. Although it is not law, it has to be carried out when it is part of a contract.

Nowadays the IT Baseline protection manual is something like an IT-security-"bible" – a de-facto-standard in the official sector and in private enterprises. Many companies want to be checked and certificated, based on this manual.

The BSI differentiates between the following protection categories:

- Low protection requirements: the system is negatively affected but the consequences are acceptable.
- Middle protection requirements: the negative effects would be small but unacceptable.

[1] BSI = Bundesamt für Sicherheit in der Informationstechnik; federal office for IT security; founded to develop IT protection standards.

[2] ISO = International Organization for Standardization

[3] DIN = Deutsches Institut für Normung e.V.; German Institute for Standardization

- High protection requirements: damages lead to a breakdown of central functions
- Very high protection requirements: damages lead to a total breakdown of the company/the institution or serious consequences for the society or economy.

The voluminous BSI-manual is only applicable to applications with ***low or middle*** protection requirements. For applications with higher protection requirements the manual is only a necessary but not a sufficient demand catalog (see figure 5).

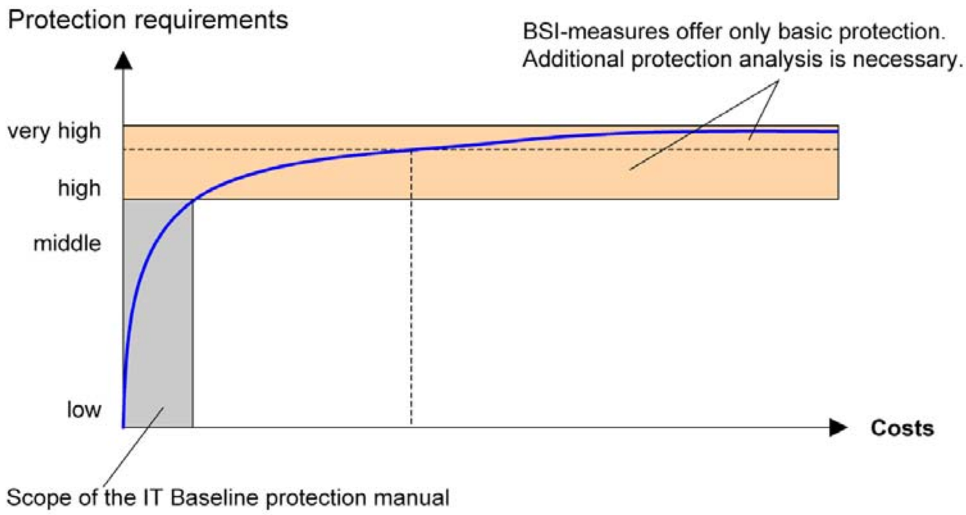

Figure 5: Protection requirements

IT-based learning systems do process personal data. From the viewpoint of the data protection law these applications have at least ***high*** protection requirements. Therefore the demanding standards of the bsi-manual have to be fulfilled. But even this is not enough. In addition, further security measures must be installed to cope with the protection requirements.

4. Attacking IT-based learning systems

As mentioned before, the security of data could be endangered by several aspects, as organizational weakness, human errors, technical failure or intentional destruction. In the following some possible intentional destruction attacks are described.

Attacks on passwords

The easiest way to get access to passwords is guessing. This procedure is successful especially when you know some details from the subject's surrounding, like first names of the family, birthdays, hobbies etc. Is guessing not possible, the passwords can be spied out. This is sometimes possible by finding notes with the passwords. Sometimes hackers succeed under false pretenses and the subjects tell them the password.

Passwords can be hacked by brute force attacks. The password-hacking applications are based on electronic dictionaries. The application tests word for word for the correct password. The dictionaries hold the words of special sciences areas, hobbies, novels, films, all the words out of books of a special author etc.

If it is known that the target person is a fan of Star Trek then the hacker will choose the Star Trek dictionary that contains all the words from Star Trek. The conclusion must be that a password should never be a word that exists in reality and that a responsible handling of passwords is indispensable for high IT security.

Provoke program crashes

Software **always** has errors. The information about newly detected errors and how they can be used to crash applications spreads like a wildfire in the hacker scene. The crashes are used to start the hacker's own programs on the foreign computer. Special target for the crash are programs that run with root rights. If the hacker succeeds, he takes over the root rights and gets access to the whole system. This type of attack can be reduced by installing the released system patches and software updates.

Sniffing

Sniffing is the action of catching and analyzing IP-packages by unauthorized persons. If the hacker is successful, all information can be accessed, especially confidential information such as passwords. The danger from sniffing is very high because it is technically very easy when the net has no encryption mechanisms. Especially endangered are the wireless LANs. The chaos computer club demonstrated this with a scan in august 2002. Driving with a motor bike and a computer in a top case though Hamburg they got access to 200 wireless LANs in the center of the city. This is alarming against the backdrop of the projected notebook universities.

When the internet was designed, secure protocols were not implemented because they were initially not needed. Therefore net solutions nowadays must consider this and create the security mechanisms needed.

Spoofing

Spoofing is the use of a false identity. IP-spoofing transmits a wrong return IP address. The wrong address is used to disguise the real hacker's identity.

Several attack variations can be carried out by DNS-spoofing. In this case the assignment of a host to an IP is changed in the cache of the DNS-server. The consequence is that an access demand to the original IP - for instance for Internet banking – will not contact the desired IP address but the cached address of computer that belongs to the hacker. If this computer has an identical web appearance the user will not notice that he is not on the right computer. The user will insert his name and password for login, the data is transmitted to the computer of the hacker and then the connection will terminate. The user will think that something is wrong with the banking computer and has no suspicion that his password was hacked.

Wrongfully, mail-spoofing is not usually a central security concern. This type of attack is based on faked email return addresses, so the recipient thinks that he got the email from somebody else. A maximum of chaos can be produced by an email that makes the recipients believe that it is send by the president of the university and includes new regulations concerning the working hours, examination regulations etc. Extraordinary costs can be caused by an email that seems to come from the IT support of a company and asks the users to delete their hard disk drive C because the support plans a new unattended setup. Further, the image of persons, institutions and enterprises can be damaged by mails with dubious content. Therefore without special checks, all identities in net applications must be seen as dubious.

Spamming

Sending emails in masses is called spamming. The goals include making an email account unusable, or a mail server or network to slow down or crash. Many methods are available for spamming. Mail bombing programs can be used. They send thousands of mails to the specified address. This method can be prevented by technical arrangements. But if an email address is spammed by emails of mailing lists that do not demand a confirmation from the user when he subscribes, the user generally has only one chance to get rid of the unwanted mails – by deleting the attacked email address.

Denial of service attacks

DoS attacks disable IT components. The effect can last for the duration of the attack or longer. The basic mechanism is the starting of more and more programs until the server breaks down.

SynFlooding enjoys great popularity among hackers. This attack works with connection enquiries. The server is flooded with a vast number of enquires until it is disenabled to answer. Since the main duty of a server is the enabling of connections there are no technical features to hinder this kind of attack.

Further denial of service attacks are based on reducing the hard disk space till it is exhausted, or the generation of a stack overflow. The overflow can be used to start destructive applications. The worm “Code Red” worked that way: a stack overflow was generated, then the destructive program was moved to a memory area were it could be started.

Many DoS attacks are based on special weak spots of the system. In the moment when these weak spots are found, immediately small applications appear that make use of these spots. The applications are so easy to handle, that every layman is able to initiate a DoS attack per mouse click. The attacks became known as Ping of Death, WinNuke, Christmas Tree and Smurf.

Destructive Applications

The best-known destructive applications are the computer viruses. The viruses are able to replicate themselves and while doing this they copy themselves into a host (operating system, applications, file). They contain a trigger mechanism that starts the application when the programmed conditions occur, for example a special date, a special action, etc. A possible consequence is the formatting of the hard disk, the deleting of files etc.

Worms function like viruses but they don’t need a host. They replicate directly be using the net. Trojan horses are applications with the main function to open a back door to the computer. Trojans in the past were for example lucrative and powerful calendar programs. The back door was used by hackers to access the foreign computer. Beside this Trojans have also destructive functions.

Modern destructive applications like “Code Red” or “Nimda” can’t be classified anymore as one of types since they have all of the described functions.

Social Engineering

Social engineering is the systematic spying on employers, students, etc. For example, the hacker calls a fellow employee in the evening at home, telling him that he is the system administrator of the company and asks for his password. In many cases the hacker will get the desired answer. Also employees working in the IT support have a "good chance" to get access to confidential data. Many companies and institutions do not like to talk about this problem, but the most cases it is easier to get the desired information by social engineering than through technical applications. It should be mentioned that there are many other possibilities for attacks. Further features that can be part of these attacks are such things as data diddling or the covering up traces (post entry).

5. Concluding Remark

Even more manifold than the dangers are the possible IT security measures. For example physical, logical or time-based access protection, applications for virus protection, firewalls, encryption applications, virtual private networks, digital signature, intrusion detection systems, backup concepts, disaster recovery etc.

These measures, mostly listed in the BSI baseline protection manual, could not be discussed in detail here. It has to be kept in mind that these have to be taken into account for the development of a secure IT-based learning system.

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ABSTRACTS of the 8th Workshop on "Computer Science in Sport"

The 8th Workshop on "Computer Science in Sport" was held in Oldenburg/Germany in June 19-21, 2002. It was organized by the section "Computer Science in Sport" of the German Society of Sport Science. More than 50 participants attended the Conference.

The main topic of this biannual workshop was "Sport and Multimedia – Prospects for education and training". Opportunities and limitations regarding the use of "new" media in sports were discussed. The fields focused on were the following:

- *University education*
- *Education for trainers and instructors*
- *Practice of training*

The contributions were arranged as follows:

- *Theoretical basics*
- *Technical developments (hardware, software, security)*
- *Empirical research*
- *Reports on multimedia experiences in sport*

The seond topic covered in the Workshop was "Modelling".

On the following pages the abstracts of the papers presented at the Workshop are given – the full papers will be published in a special volume of this e-Journal in February 2003.

CARL VON OSSIETZKY universität OLDENBURG

An internet-based information system for the sport scientific theory of selected sports disciplines[1]

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Throughout the last years sport-scientific information systems have been developed for several sports disciplines or for sub fields of sport science. Interdisciplinary approaches have been an exception, the development of multidisciplinary, comprehensive information systems shows a deficit. This deficit shall be reduced by a cooperative project between the Institutes of Sport Science of the Universities of Vienna and Salzburg.

Based on four selected sport disciplines abstract theoretical concepts of sub fields of sport science will be presented interdisciplinary.

Sports disciplines	Sub fields
• Alpine Skiing • Tennis • Athletics (in particular running and jumping disciplines) • Soccer	• Sports Biomechanics • Sports Medicine and Exercise Physiology • Sports Psychology • Kinesiology • Applied Computer Science • Exercise Science

Starting with a practical application – the sports discipline or the sports movement

- the interest should be aroused in studying theoretical concepts more intensively and an understanding for complex connections should be obtained more rapidly
- the interdisciplinary understanding in sport science should be improved both in research and education
- a more economic and effective education should be achieved

Applying a constructivist approach the critical, networked and holistic thinking should be stimulated. Based on selected practical examples the theoretical connections/overlappings of the sub fields will become transparent. Through the use of computer animations, video sequences and simulations not only high interactivity will be achieved, but also should the practical relevance of the theoretical concepts presented be underlined immediately.

The total project period is two years. Since June, 2002 a prototype of the module “Alpine Skiing” is available. The end of the project is scheduled for the end of 2003.

1) The project is funded within the framework of the Research Program “New Media in Education” by the Austrian Federal Ministry for Education, Science and Culture.

The optimisation of throwing movements with evolutionary algorithms on the basis of multi-body systems

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The motion of kinetic chains in throwing events is an object of biomechanics research. Statements about optimal movements are made on the basis of velocity-time-diagrams (OGIOLDA 1993; KOLLATH 1996; BEST/BARTLETT/MORRISS 1993; KROONENBERG 1991). However, these statements are inconsistent.

The use of evolutionary algorithms points an alternative of gaining insight into this complex object of research (PERL/LAMES/GLITSCH 2002; SPRIGINGS/NEAL 2000).

This contribution deals with the optimisation of a three chain kinetic link in a throwing movement (throw-in in soccer) on the basis of multi-body systems by using an evolution strategy (ES).

The optimisation is made by using an ES coded in Matlab (POLAND 2002) in connection with Simulink and a multi-body simulation software. The multi-body model is composed of four rigid bodies (trunk, upper arm, forearm/hand). They are connected with joints (hip, shoulder, elbow). The motion of the segments towards each other is realized with "massless motors".
The maximum tangential velocity of the distal segment (hand) is the fitness function for the ES-Code.

This contribution shows that the use of evolution strategies is one way of solving the problem of optimisation of complex sporting movements (of non-linear dynamic systems).

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About the conception and construction of multimedia applications by the example of the software "Snowboarding - Guide to Ride"

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The production of multimedia applications is shaped by various, itself partially mutually causing aspects. If application is about to carry out more to adapt than only conventional procedures of learning must been take care of all the reciprocal effects between users and program. In the center of the didactical concept has to be mankind, their learning behavior, pre-experiences and expectations with the dressing of contents equally beside the adequate illustration of the learning article.

Illustrations Further should already be defined, as clearly as possible, by the conceptioning of an application the technical facilities and requirements (on production side just like on sides of the later users). Because along with increasing comfort regarding the variety of didactical possibilities rises the technical expenditure of computer-assisted training systems and can reach fast financially and operating moderately no longer acceptable values (Friedrich/Eigler/Mandl et aluminium, 1997, 37).

To be able to conceive and to arrange multimedia projects it is accordingly necessary to understand and systematically use the integrative interaction of different components (Wand, 1998, 187).

These components, from the conception to the realization, should be discussed in the available contribution by the example of the multimedia application "Snowboarding – Guide to Ride" (Hebbel Seeger, 2001), nominated for the edut@in-price 2001.

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„WasserSportwissenschaft online“ - theoretical considerations and practical experiences on the way to a virtual learning environment

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The project "WasserSportwissenschaft online" is a virtual learning environment, which is developed as an addition to the operational readiness level teachings in the context of the theory practice meetings of water sports such as rowing, canoe, sailing and surfing at the sportscience institute at the Hamburg University

In the available contribution, on the basis of learn-theoretical acceptance and general expectations, we want to reflect our concrete experiences in the conception and realization of virtual learning environments as well as the employment and handling of the learning environment.

Beside the representation of the didactical-methodical decisions, which essentially orient themselves at the theory of constructionalism, which awards a central role for the organization of a learning process to the elements construction, kollaboration and reflection (see Hron/Hesse, /ReinhardPicard, 1997; Fischer/Bruhn/Gräsel/Mandl, 1998; Reinmann - Rothmeier/Mandl, 1999), we will deal in particular with the practical experiences in the context of the realization. In addition considerations belong regarding the program structure, contents and interaction elements just like the suitability of certain file formats to the integration of multimedia contents.

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„New media - serving the teaching and learning process in the sport-scientific education”

An empirical study about the Internet-utilization for the university sport-scientific education

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An ‘optimal ' preparation of the students for the teaching-praxis with the new media necessarily demands corresponding ‘self-awareness ' in the own university education.
The present empirical study tried to receive an actual picture of the present offers of Internet-based lectures as well as of the personal suppositions and attitudes of the students (and teachers) concerning the Internet- and Computerutilization for the university sport-scientific education.

Under this point of view at the end of the summer-term 2001 a consulting of the teachers and students at the institute of sport-science of Humboldt-University of Berlin was carried out, concerning the application of „New Media“ (multimedia, computer, internet) for the university sport-scientific education.
The aim of this consulting was to achieve a present picture of the students and teachers mind concerning their fundamentals and previous knowledge for the learning with „New Media“ – as well as to ask for their interests and attitudes concerning application of „New Media“ for the university sport-scientific education. 231 questionaires had been distributed - the return-quota runs to 39,8 % (92 questionaires)

At the winter-term 2001/02 an additional analysis of the present Internet-based teaching-offers of the german institutes of sport-science took place.
The analysis went out from the 67 institutes for sport science at the universities in Germany (february 2002, dvs-homepage, http://www.tu-darmstadt.de/dvs/). With this analysis the attemp was undertaken to classify the information concerning the sport-scientific education in the following way:

1. The kind of implementation into the learning-/teaching-process , especially regarding the coupling degree of the internet-based information to the real-lectures:

- a) Information about the study (e.g. study- and examination-arrangements)
- b) Information about the organisation of the study (e.g. Lecture-indexes)
- c) Lecture-accompanying information (e.g. terms, literature, themes)
- d) Lecture-content (e.g. scripts, exercises, collections of problems/tasks)
- e) Lectures online
- f) Virtual lectures

2. The ascribtion of the internet-based lectures (1c-f) to the different sport-scientific fields (sport-scientific theory vs. praxis, social scienctific vs. natural scientific sport science)

3. The lokalisation of the internet-based lectures in the structure of the websites (homepage, central institute-pages, departement-pages, personal or private pages)

On the long term behaviour of the performance-potential-Metamodel PerPot

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PerPot has been developed for modelling, simulating and optimising the interaction between load and performance in training processes in sport but can be used for modelling general physiological adaptation processes as well. The basic idea of PerPot is as follows (also see Mester & Perl, 2000; Perl & Mester, 2001): A time-dependent load input b(t) feeds in an identical way two buffer potentials SP (strain potential) and RP (response potential), from which a performance potential PP is fed by specifically delayed antagonistic flows – which means that the response flow from RP to PP increases the performance, where the strain flow from SP to PP reduces it. Examples of application using different interpretations of the terms "load" and "performance" are documented in Perl, 2001.

Analyses of the functional behaviour of PerPot show the following effects, which are primarily interesting under the aspect of model dynamics but also can be discussed under the aspect of similarity to physiological phenomena:

(a) Independent on time and load input, the internal load balance of PerPot has a constant value only depending on the initial values of the potentials. The reason is that load input does not effect substantial increments but only effects a re-distribution of the available amount of potential substance. In so far, load just plays the role of a pump. However, too intensive or fast pumping can cause that single potentials get overflows or run empty, which means a temporarily irreversible loss of stability.

(b) The quality of PerPot-simulation can be increased by adding atrophy components. Due to (a), two different types of atrophy have to be distinguished: Temporary atrophy, which does not affect the constant balance property, has mathematically to be modelled by a delayed re-flow from the performance potential PP to the response potential RP. So on the one hand the current performance is reduced by temporary atrophy. On the other hand, the increased response potential effects an initially delayed but then speeded up recovering of the performance value. Quite different, the life long atrophy, modelled as an output flow, reduces the amount of performance substantially. This effect changes the internal balance of the model and cannot be compensated by additional load.

(c) The delay parameters determine the behaviour of the model. In particular, changing these parameters changes the asymptotically reachable maximum value of the performance potential. However, changing model parameters, consequently means changing the model – or adapting the model to a changing system. This aspect opens a new view to the modelling of training by coupling two PerPots: An outer PerPot, which models the temporary or short term interaction between load and performance, is itself influenced by an inner PerPot, which in particular effects the delay parameter of the outer one and so can improve its long term training results substantially. For example, load input to the inner model can cause a reduction of the response delay of the outer model, which then not only increases the maximum value of performance but also speeds up the increasing process of performance – without any violation of balance. In the long run, however, speeding up the pumping process this way can cause performance reduction and serious instability of the whole system (as has been pointed out in (a)).

The presented aspects regarding atrophy and long term behaviour of PerPot show a certain analogy to that of adaptive systems like athletes. So, as already has been done with the temporary load-performance-interaction using PerPot, simulation can help to better understand and optimise long term training under the aspects of atrophy and improving parameters. Finally, aspects of life-long-training have to be discussed in order to avoid instability, break downs, or even sudden death phenomena.

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Social-scientific modelling supporting theory development: A Model of socioepidemiology of success in top-level sport

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In recent past, the connection between aspects of top level athletes' careers and success in top-level sport range was focussed by a sociological based theory of training in sports. Several studies showed, that simply structured connections between training in top level sports and success are far from being able to explain the emergence of success in sport in collectives from processes of individual top level athletes' careers. Especially the discontinuities in analysing long during ingates of sport careers (e.g. Güllich et al. 2001) have led to the development of a first draft of a "socio-epidemiology of success in sport" which – just like the tradition in examining critical life events in the socio-epidemiology of illness – tries to derive the success a top level athlete reaches at the climax of his or her career from the fact, that these athletes missed carreer-terminating critical events in other segments of life (e.g. school).

Basing on this first draft, an actor based divided intelligence-model was defined in order to explain effects in collectives from individual data. To do this, it was necessary to integrate social aspects, affecting training and careers in sport and several biological aspects of aging, affecting training and careers as well. This led to an interdisciplinary character of the model as well as to the necessity to extend instruments of social-scientific modelling. This special case shows, that a specific form of computer science like computer science in sport, which can be seen as a „Forum für metatheoretische Beiträge zur Sportwissenschaft" (Lames 1997, 229 ff.) does not only support the development of disciplinary and inter-disciplinary theories of short and of middle range in this specific field of sport sciences but does also support the advancement of instruments in other (here especially: social-scientific) areas.

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Analysis of the learning results of experts and novices using the hypermedia software RACE

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RACE is a software for learning rules and tactical aspects of regatta sailing. The investigation accessed the performance and the learning results (financial aid BISp VF 0407/13/01/2001).

23 racing experts (coaches and athletes) and 31 novices (with sailing but no racing experiences) were examined. The sailing knowledge of the subjects was tested before they started to learn with the hypermedia program (pre-test), immediately after (acquisition) and four days after the learning session(retention). Each test was made up of two parts: – a multiple-choice test (33 questions; MC-test) and a test under time pressure (TP-test), where the subjects saw 19 dynamic situations and had to decide within 5 seconds whether or not one of the two boats had to get out of the way.

The performance of the subjects during the learning session (60 minutes) was documented in a protocol file. The file contains data concerning the interaction and manipulation techniques, the time the subjects spent reading text information, the time they spent on solving questions etc. The results show that

- Experts and novices are able to learn with the hypermedia software. They used RACE in different ways and showed different learning effects.
- In the MC-test the novices showed a greater increase in learning than the experts. Experts show better results than the novices in solving MC-questions that have a high complexity level (Bloom level 2).
- In the TP-tests the experts showed greater increases in learning than the novices.
- Racing novices profit from their computer expertise only with regard to the MC-tests but not with regard to the TP-tests. Computer expertise has no advantage for the sailing experts.
- In the retention tests experts and novices answered 8% MC- and 18% TP-questions correctly that they did not solve at the end of the acquisition phase. The analysis of the novices' MC-results shows that they forgot more than the 8% of new correct answers. Experts achieve statistically equivalent results in the acquisition and retention test. The TP-results for both groups show that the reminiscence effect is greater than forgetting.
- If the experts are able to answer a given TP-question at the end of the acquisition phase, then the probability that they will be able to do so in the retention test is higher than it is for the novices.
- Experts and novices use the text, rule, animation and question pool differently. The pool usage time has no consequences on learning results.

The use of modern multibody-simulation software in biomechanical education

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Introduction

During the last years the simulation of multi body systems (MBS) has become established in the field of sports biomechanics. Different questions have been solved using this method (cp. Glitsch 2001). At the beginning only specialists used this method. But now MBS-software has been highly improved so that even non-specialists are enabled to work. The aim of the paper is to give recommendations how people should work with MBS-software in biomechanical education of sports students. Practical relevance and risks of the use will be discussed.

Mechanical notions and laws

Essentially students of sports science must be able to make use of mechanical notions and laws in sportive situations. The work with MBS-software requires fundamental understanding of modelling. Only models as easy as possible are suitable to explain mechanical laws and notions.

Push off on different surfaces (action = reaction)

Based on the modelling of two bodies which are coupled via prismatic joint and spring-damper element some possibilities of pushing off on different surfaces will be demonstrated.

Eccentric and central collisions in volleyball services

For the illustration of the collisions within volleyball services it will be used the simulation of two bodies with six DOF.

Extension to biomechanical models

The extension to biomechanical models requires the implementation of biological characteristics. The easiest characteristics are anthropometrics. Based on a three-segmental model the effect of 2 joint muscles will be demonstrated. The model is suitable to study the Lombard paradoxon.

Mathematical-physical basics of multibody simulation

The use of complex tools will lead to risks if necessary basics are unknown. The basics of scientific modelling will be discussed.

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The use of GPS for continuous measurement of kinematic data and for the validation of a model in alpine skiing

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At the Institute for Theory and Practice of Training and Movement a model was developed to calculate the running time and the optimal trajectory in alpine skiing with the use of genetic algorithms. Up to now the results of the validation of the model were promising but the evaluation (3D-kinematic, DLT) required a lot of time. A GPS-System from the Institute for Sports and Environment offers new possibilities to measure kinematic data of alpine skiers and could be used to validate the model of alpine skiing. The advantage of this GPS-System is the direct use of the results without time-consuming calculations. Further the data of the GPS-System could be used to produce virtual camera rides and to evaluate the results under aspects of competition and aspects of safety (e.g. comparison between real and optimized trajectories, analysis of the curve radius, analysis of the angle of gate entrance, analysis of the centrifugal force). The aim of the study was to prove the practical use of this GPS-System in alpine skiing.

The DGPS-System SR 530 (Leica) works with a differential phase correction and reaches an accuracy of ±1 cm. It is also possible to measure in a kinematic mode with 10 Hz. We used two antenna systems: the original antenna with differential phase correction (fixed on the helmet) and very small antenna without differential phase correction (fix on a ski). The results of the GPS measurement were compared with the data of a 3D-video-kinematic (DLT). Based on the number of used satellites the GPS-System calculates an accuracy range for each data point.

In case of the antenna with differential phase correction and 10 Hz sampling rate in kinematic mode we get data with an accuracy of 1-5 cm under normal skiing conditions. Without the differential correction the quality of the measured data get worse up to a few meters. The reasons therefore are: first the lack of the differential phase correction and second if the ski is edged also the antenna is edged and this leads to a loss of satellites which are necessary to get the right position and to increase the accuracy of the measurement. Due to the fixation on the helmet there is a difference between the GPS data and the real trajectory of the ski. The comparison with the 3D-video-kinematic clearly shows these differences depending on the curve and the body posture.

Overall the investigation showed that it is possible to record with a DGPS-System kinematic data of a skier with an accuracy of a few centimeters. Further it is necessary to develop smaller antenna with differential correction, so that it is possible to place it direct on the ski to reduce the error of measured data and real trajectory.

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Changes in motivation while working with the hypermedia learning program RACE

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In most experiments only motives like dispositions are measured (trait measurement) although the classic psychology of motivation (Atkinson, 1957; Heckhausen, 1989) assumes behavior as being the result of interaction between situational and personal factors. Rheinberg et al. (2001) developed a four factor questionnaire (FAM) to record the result of this interaction as a state of current learning motivation. The four factors are anxiety, probability of success, interest and challenge.

We report an experiment that shows that the type of media has an effect on specific motivational factor but not on learning achievement. In a group comparison design one group (N=8) worked with paper learning cards and one (N=12) worked with the hypermedia environment RACE. Before and after acquisition phase learning achievement was tested. FAM was given after subjects had been instructed but directly before acquisition phase and after a period of 30 min. No correlation between motivation and learning achievement could be detected. But we found that subjects working with RACE show higher scales values in two factors of the FAM like interest ($p < .05$) and challenge ($p < .01$) than subjects working with cards.

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Learning Styles and Learning Behaviour in the Hypermedia Environment RACE - Analysing Computer Log files and Questionnaire Data

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The following Paper describes an experiment which analyses in how far specific learner, set by questionnaire, types show congruent behaviour in a concrete learning situation. The undertaken a priori subdivision in surface- and deep-strategic learner types based on established models (Schmeck, 1988; Mandl & Friedrich, 1992; Krapp, 1993). First a group of 52 learners worked with the hypermedia program RACE (Rockmann & Thielke, 2000a; 2000b; 2001) for one hour. Then a general questionnaire about their learning behaviour in self-regulated learning situations was given. The questionnaire data (trait measurement) and the process data from the log files (state measurement) were evaluated by cluster-analysis and compared with each other. The experiment shows that both analyses result in a two-cluster solution with clear allocation of surface- and deep-strategic variables. The congruency between these solutions amounts to approx. 70%, and a significant difference could not be determined (χ^2 = 581, 1, p = 446). The comparison of the z-transformed means for the cluster variables points out that the analyses of the process data may be of a higher selectivity for determining these learning types. Interesting findings concerning the cluster composition can be shown when you include further descriptive variables (expert-novice status, state of training and computer experience).

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Integration of internet-based teaching- and learning-systems into teachership studies in sport

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Virtual university is not expected to become reality very soon. Hypermedial teaching offers likely will complete and accompany traditional teaching step by step. At present, internet-based learning- and teaching-modules are produced in the project “eBuT” (e-learning in Movement- and Training-Science) by cooperation of several universities. Formative evaluation is seated in the process of developing these multimedia-concept, among other things, about the assumptions, expectations and the using of the world-wide-wep by the target group, students in sport science. Therefore one hundret students were interrogated by questionnaire. Beyond the general data exploitation, gender differences and analysis for the grouping of basic-study and main-study students were brought into focus. Data show several differences between students in basic- and such in main-studies. In contrast to this no gender-specific estimations, expectations and using habits of the world-wide-wep for participants of sport studies were found. The findings of this study point to an increasing relevance of internet-based teaching and learning in sport science, but traditional teaching should be extended and completed and not replaced by multimedia-offers forthcoming.

An Instrument Quantifying Human Balance Skills: Attitude Reference System for an Ankle Exercise Board

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The ankle exercise board can be used as an instrument quantifying human balance skills and learning strategies. However, this requires an appropriate recording of the board movement. Using the theory of generalizing integrated navigation systems, a corresponding motion measurement system was developed and tested:

Modelling the vehicle kinematics is an essential design task of integrated navigation systems. It has to consider both the vehicle motion and the mechanical meaning of the used measurements. Up to now, a small rigid body with three translational and three rotational degrees of freedom is almost the only model applied (Farrell, & Barth, 1999). (For car navigation systems another rigid body with two translational and one rotational degree of freedom is usual.) In addition, all sensors are normally referenced to one vehicle point. However, the guidance of large vehicles (e.g. Airbus A380) having a structure which can no longer regarded as small requires generalizing the kinematics with respect to the essential degrees of freedom as well as to the spatial sensor distribution.

With the simple example of an ankle exercise board, which is in fact a hemisphere oscillating on the floor, it is possible to illustrate such a generalization: Based on a model with the unconventional combination of only three rotational degrees of freedom and on considering spatially distributed accelerometers, an attitude reference system for the board was developed. The used data fusion comprises additionally three angular rate sensors as well as a specially designed Kalman filter estimating the three Euler angles of the board and, as common, calibration values for all inertial sensors. By means of simulation and of experimental data, the performance of the system was examined.

To illustrate the application and the utility of the measurement system, some aspects of observing the rehabilitation process after ankle ligament injuries conclude the contribution.

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Concepts for the development of multimedia

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Development of multimedia products should be a structured process, particularly when science is involved. In this contribution we discuss the pros and cons of three different concepts for developing multimedia:

- Software Engineering (SE)
- New Media Engineering (NME)
- Systematic Instructional Design (SID)

The purpose of this contribution is to compare these three concepts concerning their viability and adaptability for developing multimedia products for educational goals.

Multimedia can be considered a special kind of software. The main scope of SE is to ensure high quality of software with reduced costs and time that meets the requirements of the costumer (e.g., portability, reliability, maintainability, usability, reusability and design; Balzert, 2000) by structuring the developmental process into specific phases, cascades or cycles, e.g., inception, elaboration, construction and transition with several core workflows or problem analysis, definition of requirements, sketch, specifying the interface, implementation, integration and verification, installation, validation and documentation and modification, expansion and correction.

NME aims primarily at (multi)media development (e.g., Franz & Franz, 1999). The primary objective is to keep projects on schedule and within the calculated costs. This model comprises six phases: initialisation, basic concept, fine concept, realisation, introduction and use. The first five phases result in a special milestone, respectively: disposition, treatment, screenplay, test product and final product.

SID refers to the development of educational media and multimedia (e.g., Issing, 1997). The main focus of this approach is to take into consideration the knowledge of didactics, including didactics of media application and psychology of learning and cognition. SID comprises three main phases: analysis and planning, development and production, evaluation, revision and using. These main phases are further subdivided into sub-steps.

Each of the three concepts has specific strengths and weaknesses. In order to be applied for multimedia development they have to be adapted and completed. The best way is to combine the three concepts.

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Evaluation of multimedia programs in sport science education

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When developing multimedia as an educational tool formative and summative evaluations should be applied during this process. Among other aspects, these evaluations can pertain to the extent and way of use, the learning contents and their formal presentation, the learning results, the acceptability and the usability of the multimedia tool. Furthermore effectivity and efficiency of the multimedia program can be examined.
Several qualitative and quantitative tools can be applied (Wandmacher, 2000), e.g., expert evaluation according to specific models of cognition, perception and action, discussions and interviews with users, observation of users in real-life or laboratory, heuristic evaluation, using paper or electronic prototypes or scenario techniques.
In our institute we are currently developing three multimedia tools for education:

- Program “EidS” for introduction to studying sport sciences. This program is used as a supplement for a course “introduction to the study of sport science” that is offered to freshmen of sport science.
- Program “BWS-CBT” for introduction to movement science. This program is applied as a supplement for a lecture “basics of movement science in sport”.
- Program “BioPrinz” for introduction to the principles of biomechanics. This program is applied as a supplement for a course “introduction to biomechanics of sport”.

During the development process we apply the following research methods:

- thinking aloud while using the programs: The user applies the program and all his verbal behavior is recorded by a researcher.
- qualitative interviews concerning the programs: Based on the subjective impression concerning the most salient advantages and disadvantages of the program we perform an interview in order to get more to know about the program, how it is used and which problems arise.
- two questionnaires concerning form, content and usability of the programs: the ISO norm 9241/10 questionnaire deals with seven dialogue principles (suitability for the task, self descriptiveness, controllability, conformity with user expectations, error tolerance, suitability for individualisation and suitability for learning), while the self-developed questionnaire focuses on specific aspects of form, content and use of the particular multimedia program.
- logs documenting the experiences with the actual use of the program: for each use of the program users have to document time, duration, used contents and experiences.

In the contribution parts of the programs are presented and the methods for evaluations are discussed. Selected results will be presented.

References

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