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Editorial

Arnold Baca

Department of Biomechanics, Kinesiology and Applied Computer Science,

ISW, University of Vienna

Dear readers:

Welcome to the second issue of the **International Journal of Computer Science in Sport (IJCSS)** in 2004.

At the end of the year it is possible to look back at very interesting and stimulating national and international conferences devoted to *Computer Science in Sport* in 2004 as well as on sessions and symposia on this topic within the scope of large conferences.

Moreover, it is also possible to look forward on important forthcoming events in 2005. In particular, the biennial **International Symposium** of the **International Association of Computer Science in Sport** (IACSS) will be held. Following the successful conferences in Cologne (1997), Vienna (1999), Cardiff (2001) and Barcelona (2003) the 5th International Symposium on Computer Science in Sport will take place at the beautiful island of **Hvar**, Croatia, from **May 25th to May 28th, 2005**. This event is organized by the *Croatian Association of Computer Science in Sport (CACSS)* in cooperation with *IACSS*. The symposium will provide delegates with the unique opportunity to hear international speakers reviewing their current research; to share in debates that will inform on future research and practice; and to reflect on how the future can promote and foster excellence, and engage the support of the IACSS community.

Three original papers and one extended essay have been included within this issue.

In the paper by **Arno Scharl**, **Larry Neale** and **Jamie Murphy** three main research questions are addressed. The authors analyse, (1) how prevalent sports-related terms (sports and the names of sports stars) are among the websites of leading global companies, (2) if there are industry differences in the frequency of sports-related terms on the websites of leading global companies and (3) if there are regional differences in the frequency of sports-related terms on the websites of leading global companies.

The aim of **Jürgen Perl**'s contribution is to demonstrate – by means of two exemplary approaches – how modelling can help to analyse and understand the present state as well as predict the future behaviour of a dynamic system. He concludes that due to their complex internal interactions, the time-dependent behaviour of dynamic systems cannot be predicted using static description models only, if a sufficient quality of prediction is expected. Instead, models would have to be developed that reflect the system dynamics and help to simulate its behaviour.

Nicholas Vernadakis, **Efi Tsitskari**, **George Tzetzis**, **Maria Giannousi** and **Efthimis Kioumourtzoglou** present a psychometric questionnaire, which has been developed in order to evaluate the educational web site "Youth 2004" considering the attitudes and

the perceptions of Greek Australian students. The authors assume that the scale developed might be a useful tool for the evaluation of similar websites by web developers.
Some examples showing that RoboCup Simulation League scenarios can also be interesting in the interdisciplinary cooperation between computer science and sport science are discussed in the extended essay by **Peter Dauscher**, **Felix Flentge** and **Thomas Uthmann**. One example refers to the generation of surrogate data which can be used in order to test data analysis methods, another to the use of Simulation League scenarios for testing theories of sport science.

If there are any comments, questions or points of criticism, please do not hesitate and send them to me.

Arnold Baca, Editor in Chief
University of Vienna, arnold.baca@iacss.org

Analyzing the Prevalence of Sports-Related Terms among the Web Sites of Global Corporations

Arno Scharl, Larry Neale, Jamie Murphy
{ascharl, lneale, jmurphy}@biz.uwa.edu.au

University of Western Australia, UWA Business School
35 Stirling Highway, Crawley WA 6009, Australia

Abstract

This research investigates the prevalence of sports-related terms among the Web sites of the world's leading companies, the Fortune Global 500. An automated process copied about four gigabytes of textual data, around 70 million words, from their sites. The subsequent analysis revealed regional and industry differences in the distribution of sports-related terms, the popularity of tennis stars and few references to sports stars, especially in Asia.

KEY WORDS: SPORTS MARKETING, SPONSORSHIP, TEXTUAL ANALYSIS, WEB MONITORING, FORTUNE GLOBAL 500

Introduction

Sports sponsorship seeks favorable publicity for a company and its brands with a target audience (Bennett, 1999). Increased noise in print and broadcast media along with rising global interest in sports has pushed corporate sponsorship higher in recent years (Shank, 2002; Terrian, 2002). In Australia, corporate sport sponsorship doubled from 1996 to 2000, reaching US $420 million. This figure omits an additional US $420 million from the 2000 Sydney Olympics (Lloyd, 2000). Similar to the growth in sports sponsorship, there has been a corresponding increase in using the World Wide Web for internal and external corporate communication (Leichty & Esrock, 2001).

Researchers continue to study corporate sports sponsorship, but few investigate how corporate Web sites reinforce this sponsorship or sports in general. This study uses automated software tools to measure the frequency of sports-related terms among the Web sites of the world's top companies, the Fortune Global 500. After grouping the terms into meaningful associations, an exploratory analysis compares usage of these associations. Highlighting differences among Fortune Global 500 Web sites by country and industry give practitioners insights into the online presence of sports and give academics a basis for future research.

Historical Development and Literature Review

Corporate sports sponsorship dates at least to the inaugural modern Olympic Games, Athens in 1896, when companies bought advertising space in the official Olympic program (Sandler & Shani, 1993). Regular sponsorship began in 1912, when Swedish companies acquired the permit to take photographs and sell souvenirs of the Stockholm Olympic Games

(Papandropoulos, 2002). Coca-Cola was the first corporation to buy official Olympic sampling rights, at the St Moritz 1928 Winter Games (Stotlar, 1993).
Olympic sponsorship slumbered until the International Olympic Committee (IOC) and the city of Montreal lost money on the 1976 Summer Games. The US $30 million deficit spurred the IOC to focus on sponsorship. Two factors hindered corporate sponsorship for the next summer games though, a US-led boycott and Moscow's communist environment. Sponsorship soared in 1984, helping the Los Angeles Summer Olympics earn a US $225 million profit (Shaheeh, 1999; Stotlar, 1993).
Twenty years later, as the 2004 Summer Olympics returned to Athens, sponsorship was the main source of Olympic funding. As of August 2003, sponsorship revenues approached US $500 million (www.athens2004.com). The Athens 2004 sponsorship program offers specific rights and privileges depending on the category and size of the investment, such as Shell paying about US $7 million to be the official fuel sponsor (Papandropoulos, 2002).
In addition to the Olympics, athletes across myriad sports benefit from increased corporate sponsorship. In May 2003, 18-year-old American high school basketball player LeBron James signed a seven-year Nike deal over US $90 million. This falls short though, of Nike paying US $100 million to golfer Tiger Woods. Tennis player Venus Williams has the women's sponsorship bragging rights, US $40 million with footwear and apparel maker Reebok (Teather, 2003).

Corporate Sponsorship Objectives

In exchange for sponsoring sports, corporations expect benefits. For example, one study shows a temporary boost in a company's stock price immediately after announcing stadium naming rights (Clark, Cornwell, & Pruitt, 2002). In practice, organizations use sports and sports stars in their marketing campaigns to reach some or all of the sponsorship objectives summarized in Table 1. While marketers debate the relative importance of these objectives, Sleight (1989) contends that personal objectives, such as management interest in the sport, are the least defensible reason for conducting a sport sponsorship campaign.

Table 1. Objectives of Corporate Sponsorship Campaigns (Pope, 1998)

Corporate Objectives	Marketing Objectives	Media Objectives	Personal Objectives
Public Awareness	Business Relations	Generate Visibility	Management Interest
Corporate Image	Reach Target Market	Generate Publicity	
Public Perception	Brand Positioning	Enhance Ad Campaign	
Community Involvement	Increase Sales	Avoid Clutter	
Financial Relations	Sampling	Target Specificity	
Client Entertainment			
Government Relations			
Employee Relations			
Competition			
Shareholder Wealth			

Sports researchers also differ on the benefits of corporate sponsorship (Pope, 1998). Some researchers argue that sponsorships should increase sales (Abratt, Clayton, & Pitt, 1987), while others argue for enhancing a company's image, product or brand (Armstrong, 1988; Javalgi, Traylor, Gross, & Lampman, 1994).

From a sponsorship perspective, sports and sports stars appeal to an international audience. Unlike competing entertainment such as cinema or music, international sports have standards and etiquette that transcend cultural, religious and linguistic barriers.

Modern Sports Marketing

Shank (2002) defines sports marketing as applying marketing principles to products through association with sports. Estimates on the global value of sports marketing depend upon the variables included, such as sponsorships and revenue, but Shank estimates world sports marketing at approximately US $350 billion in 2002. Thanks to the Internet, sports marketing takes an increasingly global perspective (Mullin, Hardy, & Sutton, 2000; Pope, Forrest, & Murphy, 1996; Summers, 2003).

The Atlanta Games of 1996 were the first to embrace Internet technology, and subsequent Olympics have continued this practice. As an example, the entire official Web site for the Athens Games (www.athens2004.com) is available in Greek, English and French, illustrating modern sports marketing techniques and the importance of multilingual content to reach an international audience.

The Internet gives teams, leagues, fans and consumers a two-way communication platform, independent of time and location. For example, the US-based National Basketball Association (NBA) invited online fans, regardless of their country, to select the 1996 All-Star team. In addition to English, the NBA provided French, Spanish and Italian versions of the Web site (www.nba.com). This multi-lingual initiative helps explain why one third of NBA's Web traffic during the All-Star selection originated outside the United States (Mullin et al., 2000).

While one expects large sports organizations such as the Olympics, NBA and the National Football League (www.nfl.com) to establish Web sites, research has neglected investigating the prevalence of sports-related terms on their Web sites.

Objectives

This study investigates the use of sporting related terms on the Web sites of large multinational corporations. Three research questions guide the data collection:

1. How prevalent are sports-related terms (sports and the names of sports stars) among the Web sites of leading global companies?
2. Are there industry differences in the frequency of sports-related terms on the Web sites of leading global companies?
3. Are there regional differences in the frequency of sports-related terms on the Web sites of leading global companies?

Methodology

To investigate the prevalence of sports-related terms on the Web sites of major corporations, this research studied the Web sites in the 2002 edition of the Fortune Global 500 (www.fortune.com). Researchers have used Fortune Magazine's rankings of the world's leading companies in disciplines such as business ethics (Morf, Schumacher, & Vitell, 1999; Reicher, Webb, & Thomas, 2000; Weaver, Treviño, & Cochran, 1999), health care (Montenegro-Tores, Engelhardt, Thamer, & Anderson, 2001), quality management (Baker, DeTienne, & Smart, 1998; Lawler III, Mohrman, & Ledford Jr., 1992), and international business (Gabba, Pan, & Ungson, 2002). Studies have also investigated the Web sites of Fortune-ranked companies from perspectives including content (Perry & Bodkin, 2000),

marketing (Palmer & Griffith, 1998), global usage patterns (McManis, Ryker, & Cox, 2001), customer relationship management (Romano Jr., 2002-3), and email use (Leichty & Esrock, 2001).

Sports and Sports Stars

Given the international focus of this study, the preliminary list of sports stemmed from those recognized by the IOC (www.olympic.org). Due to the preponderance of US companies in the Global 500 and English content in the remaining Web sites, popular US sports, general sports-related terms and popular sports in English-speaking countries such as cricket and rugby augmented the list of Olympic sports. Finally, given the exploratory nature of this study, the researchers added a few terms related to leisure (see Appendix).

The list of sports stars stemmed from the Laureus World Sports Awards (www.laureus.com). This annual event honors the world's best sportsmen and -women across sports and countries. This research used the names of 131 athletes nominated between 2000 and 2003 for the following six individual Laureus categories: Sportsman of the Year, Sportswoman of the Year, Newcomer of the Year, Comeback of the Year, Sportsperson of the Year with a Disability, and Alternative Sportsperson of the Year.

Gathering Web Content

Since the 1700s and across myriad media, scholars have used content analysis to deduce a medium's subject matter (Krippendorf, 1980). They have applied this technique to Web sites in general (McMillan, 2000; Scharl, 2000) and sports Web sites in particular (Pope et al., 1996). Web sites reflect industry trends and competitive strategies, but methodological problems of objectivity and reliability hinder content analysis of Web sites (McMillan, 2000) and textual data (Rourke, Anderson, Garrison, & Archer, 2001).

Human coding, common on Fortune Web site studies (Leichty & Esrock, 2001; McManis et al., 2001; Palmer & Griffith, 1998; Perry & Bodkin, 2000), is time consuming, suffers from reliability issues and usually analyzes just the home page rather than the whole Web site (McMillan, 2000). Automating the coding process (Bauer & Scharl, 2000; Scharl, 2000; Thelwall, 2002) helps address this limitation, quickly and reliably processing large samples of Web sites.

Mirroring entire sites of major corporations, however, is resource-intensive. As information towards the top of a Web site reflects common use, most content analyses use just the site's home page (McMillan, 2000). Based on experiences from past research (Bauer & Scharl, 2000; Scharl & Bauer, 2004; Scharl, Pollach, & Bauer, 2003), this study used a limit of 10 megabytes to help manage available storage space and compare sites of heterogeneous size, but is by no means limited to this parameter. A robot started at the home page and then followed a site's hierarchical structure until amassing 10 megabytes of text. A site's markup code and embedded scripts guided the mirroring process to capture documents and build a hierarchical document tree.

The robot then wrote the textual content into one single text file for further processing. The size of this file can never reach or exceed the limit of ten megabytes, as the robot removes all the tags and scripts from the original set of documents. As a rule of thumb, ten megabytes of markup code result in about three to five megabytes of plain text.

Due to changes in the Fortune Global 500 since its publication, mergers for example, this April 2003 study began with 493 of the 500 companies. The robot could not process 77 Web sites for several reasons such as little textual information, inaccessibility, and parsing difficulties for technical reasons (e.g. applets or complex scripting elements). Mirroring the

remaining 416 sites yielded almost four gigabytes of textual Web data, representing more than 270,000 documents with 70 million words.
Over two out of five (43%) of the remaining 416 sites represented US companies. Most other companies had their headquarters in Europe (31%) or Asia (24%). The predominant industry in these 416 sites was finance and insurance (24%), followed by resources (9%) and food/beverage/tobacco (8%). Each of the remaining sites belonged to one of the following industries: automotive, electronics, energy, engineering, information technology, media, pharmaceuticals, paper/freight, retail, telecommunications, travel, and wholesale.

Analyzing Web-based Corpora

Corpora are collections of recorded content used for descriptive analysis. This research investigated and visualized regularities in the mirrored text by applying and extending methods from corpus linguistics and textual statistics (Biber, Conrad, & Reppen, 1998; Lebart, Salem, & Berry, 1998; McEnery & Wilson, 2001).
Quantitative textual analysis of Web documents necessitates three steps in order to yield a machine-readable representation (Lebart et al., 1998). The first step *converts* hypertext documents into plain text. The second step *segments* the textual chain into minimal units by removing coding ambiguities such as punctuation marks, the case of letters, hyphens, or points in abbreviations. The third step, *identification*, groups identical units and counts their occurrences – i.e., creating an inventory of words. This exhaustive index uses decreasing frequency of occurrence as the primary sorting criterion and lexicographic order as the secondary criterion.
Our perception of language relies on the recognition of words as units. Aligning grammar and vocabulary, words are the primary unit of lexical meaning (Sinclair, 2004). Despite a lack of contextual information, researchers use word frequencies to analyze both traditional (Leech, Rayson, & Wilson, 2001; McEnery & Wilson, 2001) and electronic (Meyer, Grabowski, Han, Mantzouranis, & Moses, 2003; Scharl & Bauer, 2004) corpora. For Web content analyses of large document collections (Sinclair, 1991) from multiple sources (Barnbrook, 1996), word frequencies are particularly useful.
This study used a plain-text corpus, as annotated corpora are less readily updated or expanded and therefore difficult to handle when automatically analyzing dynamic Web resources. Moreover, word-based and category-based approaches such as corpus annotation and tagging address different questions and often reinforce each other. “A reluctance, on theoretical grounds, to use categories that already exist in linguistics has led to a word-based practice of corpus investigation, which in turn has led to a revised theory of what language is like” (Hunston, 2002, p93).
A sample as culturally heterogeneous as the Fortune Global 500 necessitates identifying the language(s) used. Several techniques tackle this issue, usually based on trigrams and common short words (Hull & Grefenstette, 1996). Trigrams compare a document’s frequency of three-letter sequences with a particular language’s distribution of these same three-letter sequences. Similarly, common short words such as determiners, conjunctions and prepositions help divine a language. Both methods produce similar results for chunks of text larger than ten words (Grefenstette, 1995), so this research used the computationally lighter short-word technique to classify content within each Web site.
The 416 sites’ use of English dwarfed content in four other West European languages. English content was 11 times more prevalent than French, 16 times more common than German, and used 33 times more often than Spanish or Italian. After detecting the document languages, statistical tests analyzed differences by region and by industry among the corporations' use of sports-related terms on their sites.

Results

The initial analysis revealed difficulty interpreting some terms. The ambiguous words *golf* and *marathon*, for example, also showed up as a Volkswagen car model and an oil company. Terms such as *health, swimming, climbing* or *running* also had several meanings, popular in colloquial non-sporting phrases such as 'climbing the corporate ladder'. Although the purpose of this study was to examine how corporations relate to sports on their Web sites, these ambiguities highlight the pervasive role of sports.

After eliminating ambiguous terms, the most popular term – appearing on 70% of sites – was *sport* or *sports*, hereinafter referred to as *sport(s)*. The term *olympic(s)* appeared on one third of the sites, but only 1% of the sites (five corporations) included the term *paralympics*. Selecting the most popular sport proved difficult due to ambiguous use of the terms *football* and *soccer* in different countries. *Football* was on 29% of the sites compared to *soccer* at 21%. *Baseball* (21%) and *basketball* (20%) closely followed in popularity.

Just 11 corporate sites included the term *sport(s) marketing* – most frequently mentioned by the Web site of the Massachusetts Mutual Life Insurance Company, followed by Hyundai Motor, Hyundai, Anheuser Bush, McDonalds, Samsung Electronics, United Parcel Service, Pepsi Cola, News Corporation and Bank of America.

Of those industries with at least five corporations, the automotive sector led in using the terms *sport(s)*. The results of a one-way ANOVA test showed significant differences across industries in the use of the term *sport(s)*; $F(27, 388) = 2.915$, $p<.0001$, but no differences in the use of *olympic(s)*; $F(27, 388) = 0.453$, $p=.992$.

Regional Web Coverage of Sports

To investigate sporting term usage rather than trading sports-related products, the next analysis ignored retail companies that sell sports products, such as Wal-Mart or Kmart. Similarly, Marriott featured recreational mountain biking and golfing, while Berkshire Hathaway promoted a work environment 'better than golfing or fishing'. The analysis also ignored companies with less than ten percent English content, and eight companies not based in Europe, North America or Asia.

Of the remaining 292 companies, over half (54%) were based in North America, 32% in Europe and 14% in Asia. One out of five (23%) companies was in finance and insurance, followed by companies in food, beverage, tobacco (10%) and resources (9%).

Due to difficulties in interpreting term occurrences and the low frequency of some expressions, the analysis grouped terms such as *soccer* with *football* and *rugby*, and *canoeing* with *kayaking* and *rowing*. To ensure comparability across Web sites, the analysis used term frequencies relative to the total number of words contained in the corpus. To increase the stability of results, the analysis ignored terms that appeared on less than ten Web sites. Figure 1 shows the regional distribution of sports terms, presented as a percentage of the global number of occurrences indicating a particular sport. North American companies made up over half the sample, and about one out of seven companies was Asian. Had there been no regional differences in sports, the results should have reflected this distribution. This was not the case.

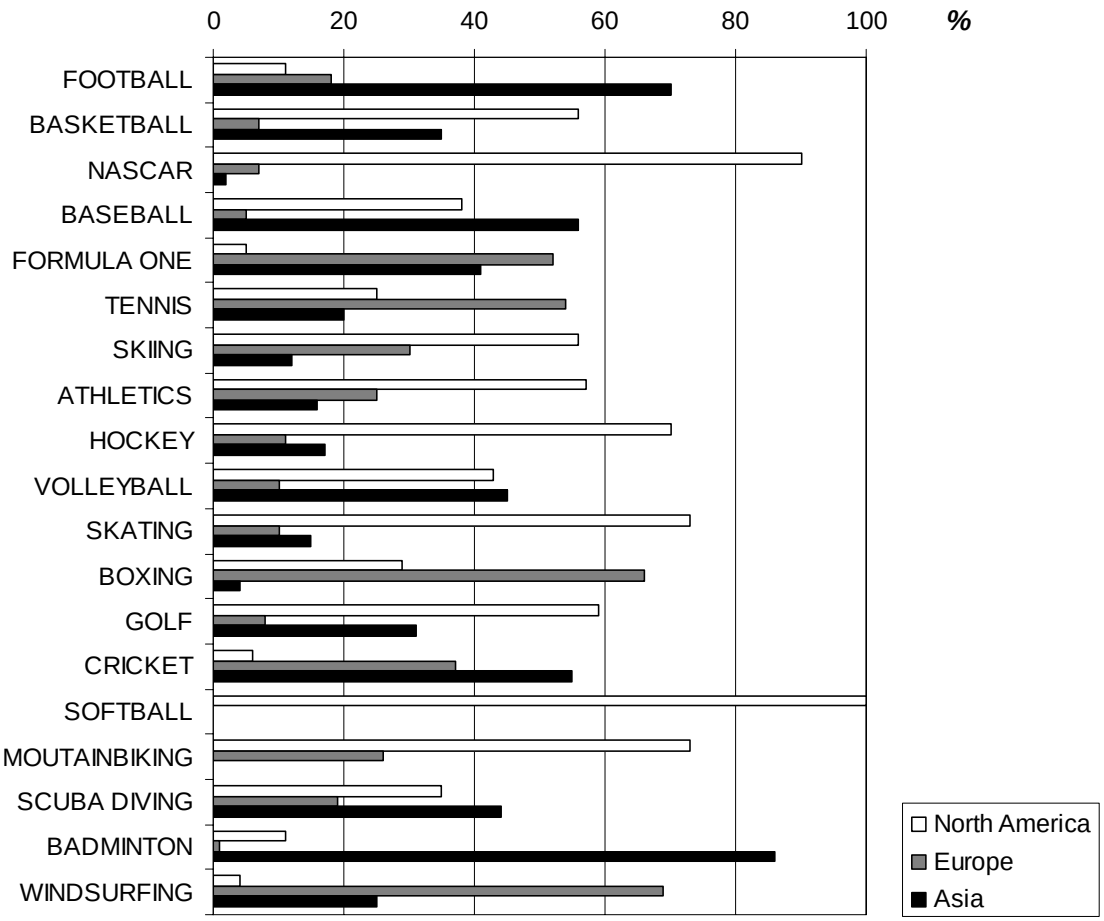

Figure 1. Regional Distribution of the Top 20 Sports

The terms *basketball, nascar, skiing, athletics, hockey, skating* (ice skating, figure skating), *golf* (pga, lpga), *softball, and mountain biking* showed a North American bias. *Formula one, tennis, boxing* and *windsurfing* had a stronger European presence. Finally, the Asian sites had a proportionally greater use of the terms *football* (rugby league, rugby union and soccer), *baseball, cricket, scuba diving* and *badminton*.

Web Coverage of Sports by Industry

Web content represents multidimensional data with so many variables that an orthogonal visual structure is often insufficient. Subdividing a problem or computationally reducing the dimensionality leads to results that are faster to interpret, convey more information, and cause fewer interpretive problems (Lebart et al., 1998). Correspondence analysis, for example, identifies lower-dimensional approximations of the original data and portrays general patterns without the need to specify a priori assumptions (Blasius, 1994; Van der Heijden, Mooijart, & Takane, 1994).

The perceptual map of Figure 2 reports the Web coverage of sports by industry, based on term frequencies relative to the total number of words contained in the corpus. It represents the rows and columns of a contingency table in a joint plot (Hair, Anderson, Tatham, & Black, 1998). The square markers represent the Top 10 sports; the round markers denote the position of a particular industry in the computationally created two-dimensional space.

The vertical axis suggests a distinction between individual sports *(formula one, nascar)* and team sports *(basketball, volleyball, baseball)*. The horizontal axis is more ambiguous. Participating sports targeting white-collar interests such as *tennis* and *skiing* dominate the

right part of the diagram and are most popular with the travel and tourism industry. Besides sponsorship, travel and tourism companies often include tennis and skiing in their offerings (e.g. holiday packages, hotel facilities, location close to well-known skiing regions), which helps explain the spatial proximity. As expected, *nascar* and *formula one* are the preferred sports of the automotive industry. Together with football, they tend to be spectator sports that often appeal to blue-collar interests.

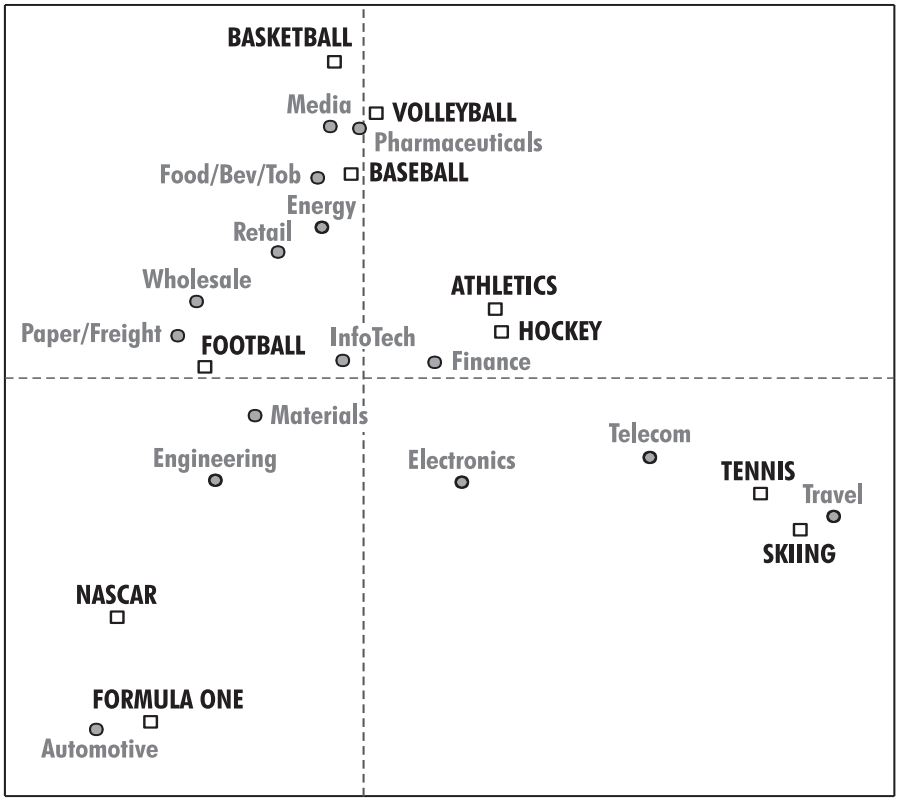

Figure 2. Perceptual Map Contrasting the Top 10 Sports with the Fortune Global 500 Industries

Web Coverage of Renowned Athletes

Of the initial list of 131 sports stars, only 28 names appeared on the 416 Global 500 Web sites. Two of the biggest sports stars in recent times, *Michael Jordan* and *Tiger Woods* topped the list, each appearing on 11 sites. *Tiger Woods* earns 10% of his annual income from tournament play and 90% from corporate endorsements (Roberts, 2002). Athletic apparel maker Nike's choice of basketballer *Michael Jordan* to lead their endorsement campaign in the mid 1980's probably saved the company (Hatfield, 2003). Jordan's sustained on-court success and public appeal ensures he remains one of the highest profile athletes in the world today, even after retirement (Anonymous, 2003).

Formula One driver *Michael Schumacher* was third with eight references, and Brazilian footballer *Ronaldo* was fourth with six references. Reflecting the regional appeal of cycling, fifth-placed American cyclist *Lance Armstrong* appeared three times on European sites and only twice on US sites. Three or more sites mentioned the following athletes: *Marion Jones, Serena Williams, Kelly Clark, Jenson Button, Janica Kostelic* and *David Hall*.

On an aggregate level, the names of athletes in only 12 sports appeared. Seven of the 28 names on corporate Web sites were tennis players, five were golfers, four were track and field stars, three were auto racers, two played basketball, and two were wheelchair athletes. The remaining sports – cycling, soccer, snowboarding, skateboarding, downhill skiing and

American football – appeared just once. Perhaps surprisingly, *Ronaldo* was the only representative of the self-labeled "World Game" soccer.
Regionally, the results showed a marked imbalance. Over a quarter of the North American and European corporate Web sites mentioned sports stars, compared to only 4% in the Asian region. This may reflect the individualism/collectivism dimension differences between Western cultures that tend to promote the achievements of the individual and Asian cultures where individuals subordinate their needs to those of the group (Hofstede, 1980). The percentages for Australian and Mid/South American sites mentioning sports stars were larger, albeit from a smaller base of corporations.

Table 2. Regional Distribution of Sites Mentioning Renowned Athletes

Regions	Corporations	Occurrences	Percentage
N. America	178	46	26%
Europe	127	33	26%
Asia	100	4	4%
Australia	5	2	40%
Mid/S. America	5	4	80%
Totals	415	89	21%

With the Soccer World Cup held in Japan and North Korea in 2002, and the surge in popularity of Chinese basketball star Yao Ming in North America, it would seem that Asian corporate Web sites reflect growing corporate sponsorship of sports. Little use of sports star names on these Web sites, however, contradicts this view. Despite a tradition of corporate-sponsored teams since the 1950s, the erosion of corporate sports sponsorship in Japan results from efforts to cut costs in light of the economic recession (Terukazu, 2001). In other Asian countries, it is often governments that push the sports agenda, not the private sector (Granitsas, 2002).

Conclusion and Future Research

Sponsorship literature is often normative, suggesting best practices in sponsorship management (Olkkonen, 2001). This paper adds a positivistic dimension by investigating the textual content on 416 Web sites. In contrast to traditional analysis with human coders, this method considers the dynamic nature of the World Wide Web by collecting the data within hours, thereby improving the comparability of results.
The method complements but does not replace qualitative approaches. This study adds an important dimension to the analysis of Web coverage by gathering and analyzing more than 270,000 documents, a text corpus impossible to analyze manually – ignoring the methodological issues of inter- and intracoder reliability.
Seventy percent of Fortune Global 500 companies mentioned *sport(s)* on their sites. As just one in three sites mentioned the Olympics, some companies may sponsor the Olympics but fail to promote their sponsorship through their Web sites. These results indicate rich sponsorship opportunities for the International Olympic Committee and suggest addressing large transnational organizations that do not yet sponsor the Olympics.
The findings also showed geographic and industry differences in the presence of sports-related terms. These results give sports marketers insights into current trends. Softball could be an untapped market outside of North America, for example, while windsurfing could be a North American opportunity. Alternatively, this lack of geographic representation could signal an unpopular sport. Marketers can add these Web-based results to their own information in order to improve the evaluation of opportunities.

While this research provides a snapshot of the online presence of sports and sports stars with the world's leading corporation, future research should add a theoretical perspective. Diffusion of Innovations (Rogers, 1995) is one possible avenue for exploring the adoption of information technology. Organizations often adopt innovations due to fashion and fad rather than for strategic purposes (Abrahamson & Rosenkopf, 1993), such as corporate Web sites that fail to reinforce sports marketing sponsorship.

Research has shown that organizational factors such as size, industry and management relate to the effective implementation of new technologies (Fichman, 2000; Fichman & Kemerer, 1999), including Web sites (Murphy, Olaru, Schegg, & Frey, 2003). Qualitative studies could analyze corporate strategy on the one hand, and marketing and sponsorship that correspond to this strategy on the other hand.

Future research would benefit from longitudinal studies of changes in Fortune Global 500 Web sites' use of sports-related terms. The analysis should coincide with events such as the Soccer World Cup or the Olympic Games to examine fluctuations during major global championships. For studies using specific US terms such as the Super Bowl, Southeastern Conference (SEC) or NCAA, the Fortune 1000 is a better database as it contains twice the number of corporations, and only those in the US.

Two limitations of this study are the 10 megabyte mirroring limit, and the reliance on term frequencies. While the limit ensures comparability, it also means ignoring content of larger sites. Statistics based on frequencies fail to consider the usage context of a particular term. Therefore, future research should (i) explore and compare alternative settings for the crawling agent and (ii) determine the semantic orientation of a site towards specific concepts.

One method to compute the semantic orientation is measuring the strength of a term's association with a set of positive words (taken from a tagged dictionary), minus the strength of its association with a set of negative words (Scharl et al., 2003), or multi-word units of meaning (Danielsson, 2004). Yet the lexis of Web content only partially determines its semantic orientation. Future extensions of the current system architecture should therefore employ shallow parsing (Hammerton, Osborne, Armstrong, & Daelemans, 2002) to process syntactic and semantic ambiguities, and capture meaning-making processes at levels beyond lexis.

Analyzing the popularity of corporate Web sites that include a large proportion of sporting terms with a positive semantic orientation may highlight the importance of sports sponsorship for successful online strategies. Does the use of sports-related terms influence a Web site? Future research should compare sports-rich Web sites and sites poor in the use of sports-related terms by studying attitudes towards corporate Web sites and consumer beliefs such as awareness, trustworthiness, aesthetic appeal, community interest and entertainment.

Appendix – List of Sports-Related Terms

Sports terms, single word: aquatics, archery, athletics, badminton, baseball, basketball, biathlon, bicycling, bmx, bobsleigh, boxing, canoe, celebrity, climbing, crew, cricket, curling, cycling, diving, dressage, epée, equestrian, fencing, fitness, football, freediving, golf, gymnastics, handball, hockey, judo, karate, kayak, kitesurfing, lacrosse, luge, marathon, motorcycling, nascar, olympic, olympics, paralympics, rowing, running, sabre, sailing, scuba, shooting, skateboarding, skating, skating, skiing, slalom, soccer, softball, spectators, sponsorship, sport, sports, stadium, surfing, swimming, taekwondo, tennis, triathlon, volleyball, walking, waterskiing, weightlifting, windsurfing, wrestling.

Sports terms, multiple word: australian rules football, beach volleyball, body boarding, collegiate football, cross country skiing, downhill skiing, field hockey, figure skating, formula 1, formula one, grand prix, grand slalom, horse racing, ice dancing, ice hockey, ice skating, indy car, modern pentathlon, motorcycle racing, mountain biking, professional football, rhythmic gymnastics, road racing, roller blading, roller skating, rugby league, rugby union, sail boarding, ski jumping, slalom skiing, snow boarding, sports marketing, street luge,

super g, super-g, synchronised swimming, synchronized swimming, table tennis, track and field, track cycling, trick skiing, wake boarding, water polo, water skiing, whitbred round the world, winston cup, world cup.

Sports stars: hank aaron, andre agassi, troy aikman, muhammed ali, heidi andreasen, lance armstrong, aaron baddely, layne beachley, david beckham, albert belle, ole einar bjoerndalen, bonnie blair, terry bradshaw, kobe bryant, bob burnquist, jenson button, jennifer capriati, anne-caroline chausson, kelly clark, kim clijsters, derrick coleman, earle connor, shea cowart, tara dakides, john daly, lindsay davenport, inge de bruijn, stacy dragila, heike dreschler, john elway, ludmila engqvist, brett favre, juan carlos ferrero, george foreman, brian frasure, cathy freeman, will gad, pierre-luc gagnon, sergio garcia, steven gerrard, steffi graf, maurice greene, wayne gretzky, ken griffey, david hall, mia hamm, daniela hantuchova, tonya harding, tony hawk, justine henin, beatrice hess, grant hill, martina hinges, mat hoffman, evander holyfield, mike horn, tara ipinski, michael irvin, goran ivanisevic, magic johnson, marion jones, michael jordan, tanja kari, davo karnicar, nancy kerrigan, janica kostelic, janica kostelic, anna kournikova, michelle kwan, bernhard langer, vinny lauwers, brett lee, mario lemieux, lennox lewis, hermann maier, dan marino, michael milton, yao ming, joe montana, juan pablo montoya, david nalbrandian, joe namath, shaquille o'neal, shaun palmer, travis pastrana, lee pearson, umberto pelizzari, chantal petitclerc, scottie pippen, dean potter, paula radcliffe, steve redgrave, elena repko, jerry rice, cal ripken, andy roddick, dennis rodman, ronaldo, wayne rooney, pete rose, marat safin, pete sampras, louise sauvage, gerd schönfelder, paul schulte, michael schumacher, beat schwarzenbach, monica seles, o.j. simpson, emmitt smith, annika sorenstam, john stamstad, daryl strawberry, picabo street, martin strel, gabriela szabo, michael teuber, ian thorpe, dara torres, mike tyson, joachim uytdehaage, franziska van almsick, pieter van den hoogenband, esther vergeer, kurt warner, karrie webb, serena williams, venus williams, tiger woods, kristi yamaguchi, steve young.

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Modelling Dynamic Systems Basic Aspects and Application to Performance Analysis

Jürgen Perl

Institute of Computer Science, FB 17

University of Mainz

D-55099 Mainz, Germany

KEY WORDS: MODELLING, DYNAMIC SYSTEMS, PREDICTION, PERFORMANCE

Introduction

The aim of the paper is to demonstrate – by means of two exemplary approaches – how modelling can help to analyse and understand the present state as well as predict the future behaviour of a dynamic system. Therefore in the following first of all some examples are discussed, focusing on basic aspects of system dynamics and prediction. Chapter 2 then deals with an application to performance analysis, which in Chapter 3 is transferred to neural network-based analysis of adaptive processes like learning.

Dynamic systems

Modelling a dynamic system means mapping not only its components and input-output-behaviour but – depending on the demand on precision – also and in particular its components interaction (see Figure 1). The reason is that dynamic interaction of system components is characterized by buffers and delays. This means that a system input – depending on the respective internal status – can cause quite different outputs, which makes it extremely difficult to predict the system behaviour by only taking static pairs of input- and output-values into consideration. Accordingly, stochastic analysis methods like correlation or trend analysis based on past values in case of dynamic systems are normally neither sufficient nor adequate for an acceptable prediction.

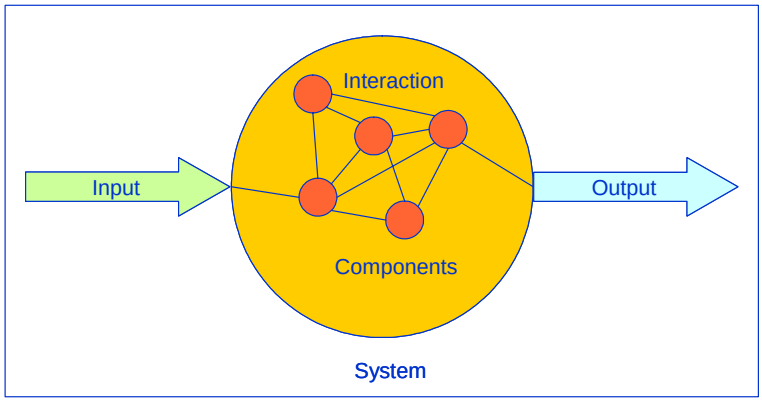

Figure 1. Dynamic system with external input and output and internal components and interaction.

Predictability of system behaviour

Four examples shall demonstrate the problems that arise even from comparably simple problem structures:

The first example is that of mathematic functions f(x), which calculate result values like $x^2+\sin(x)$ to given values of x. On the first glance the x-values seem to play the role of a system input, while f(x) is the correspondingly produced system output. In so far the system behaviour is perfectly predicted by means of the function formula. On the second glance, however, it turns out that the behaviour of such a function for all values of x is determined by the status information (i.e. the values of the derivations of the function f) for just one arbitrary x-value. This means that the value-result-behaviour of those functions is pre-determined, independent of any dynamic system-input. I.e.: The "system" f does not react on the "input" of x but just shows the related result. From the point of view of system dynamics such a system is completely static and therefore cannot be used to model dynamic input-dependent processes.

The second example deals with the problem of behaviour modelling in order to predict system behaviour: A famous case is the function called "chain line", which mathematically models the line a rope or a chain forms by hanging between two fixing points. The graph of such a function is – at least close to its minimum point – extremely similar to that of a properly parameterized parabola. This is the reason why inexperienced people swear they see parabolas when being shown hanging ropes or chains. Of course, in the area around the minimum, the difference is extremely small and therefore it really does not matter whether the original chain function is replaced by a much easier parabola function. However: Only a very small step outside this area of perfect approximation the deviations become huge immediately. This means that a black box-modelling of the values only, though it can help to easier calculate the already known behaviour, can be very dangerous if taken for predicting unknown future behaviour. Instead, knowledge of the internal structures and dynamics is necessary to understand and predict the behaviour of dynamic systems.

(The chain function used in the example is $f(x) = e^{1-x} + e^{1+x} - 2$; the best fitting parabola function is $p(x) = a \times x^2$, where $a = 2.9525548 = e^2 - 2 \times e^1 + e^0$, "e" the Eulerian constant. One can easily check the results using EXCEL.)

The third example demonstrates the problem of physical dynamic systems that not only have internal structures and interactions but also get external impacts and inputs. One well known case is that of objects like comets, satellites, or shuttles moving through the space: Reducing the examination to small pieces of their tracks, the moving behaviour can be described by rather simple functions like ellipses that roughly determine the behaviour of our planets or terrestrial satellites. The problem, however, is that all these objects interact with each other and therefore influence their behaviour in an extremely complex way. This means that the path of a shuttle started to reach a planet can be disturbed irreversibly if the gravity of an object becomes relevant, which was not known or taken into account when starting the shuttle. It should be added that already in the case of three moving objects their paths cannot be calculated deterministically.

A well known example to demonstrate the even chaotic behaviour in situations like this is that of the chaotic pendulum, which moves between the impacts of three magnetic attractors in a completely unpredictable way.

The fourth example, which then is dealt with in detail in Chapter 2, focuses all the above mentioned problems on the modelling of performance adaptation in sport: "More and better

training causes increasing performances" on the one hand seems to be a convincing approach – since it seems to meet most of our experiences from short term as well as from long term training. On the other hand, of course, it is quite clear that such an approach only can give a first orientation. Due to the fact that an athlete is a complex system with limited capacities and feasibilities, which moreover is embedded in a complex interaction of external impacts, the athlete's reaction on training can be complicated and, at least in details, unpredictable. So the problem of predictability is a central one in particular in the field of adaptation, where the proband forms a dynamic system with time-dependent dynamic states. Therefore in sport, particularly in training and motor learning in order to optimize training and learning strategies and schedules, the problem is not only to evaluate the status of an athlete but also to understand his specific dynamics.

The PerPot-concept

The *Per*formance *Pot*ential meta-model *PerPot* simulates the interaction between load and performance in adaptive physiological processes like training in sport by means of antagonistic dynamics. The term "antagonistic dynamics" means that the same load input has two contradictory effects, namely the performance increasing response flow and the performance decreasing strain flow. Depending on delays with which these flows become effective the training can cause positive or negative temporary results. Exemplarily, this dynamics can be explained by the interaction of organs or components of an organism, which produce and transfer substances with certain delays and so cause time-dependent changes of the organism's state.
Antagonistic dynamics necessarily use internal buffers, corresponding to organic components, which work like memories and therefore also can delay effects. For one example, overload can cause a fast increase of performance - but in turn can cause a delayed collapse when, after a while, the overloaded strain buffer begins to reduce the performance dramatically.
The abilities of PerPot can also be used to analyse and optimise learning behaviour on the basis of artificial neural networks. For this aim the concept of *Dy*namically *Co*ntrolled *N*etwork (DyCoN) has been developed, where each neuron of a conventional Kohonen Feature Map (KFM) additionally contains a PerPot-component, which individually controls the learning process of the neuron. By this approach, the network can adapt dynamically to different types of input-patterns and therefore, depending on the training schedule, can learn a new type additionally to an old one or replace a first type by learning a second one.
In a first approach, genetic algorithms have successfully been used to calculate such optimal learning strategies. One remarkable result was that in case of replacing learning one optimal strategy is that of "brain washing": Instead of continuously learning the replacing pattern the pattern to be replaced can better be erased by an "inverse" pattern, which helps to implement the replacing pattern as well as keep the learning effort small.
It should be emphasized that those results are not thought to be directly applicable to the phenomenon of human learning. However, they still might give ideas what dynamics and optimal strategies to look for.

Basic antagonistic structure

As has been explained above, the basic idea of PerPot is that of antagonism, which plays an important role for the control of a great number of biologic, physiologic, and also technical systems (Perl (2001 b)):

An input like the load rate feeds two internal buffers, which can be interpreted as system components that produce or transfer substances or effects with specific delays. In the case of PerPot, the strain potential together with a performance reducing flow models the negative effects of training load, while the positive effects of training load are modelled by the response potential and the performance improving flow. The pair of flow delays, DS and DR (see Figure 2), determines the characteristic behaviour of the model and so encodes the characteristics of the modelled systems, as e.g. the athlete together with his discipline (see Figure 2). Depending on the relation between DS and DR, specific standard behaviours are determined. If the response delay DR is greater than the strain delay DS, then strain works faster than response and so (as is shown in Figure 2) causes the well-known super compensation effect. If in contrast DR is smaller than DS, then the response is faster, causing a smooth balancing out.
Note, that constant delay values are only a first assumption in order to get an idea of the model behaviour. In practice, delay values can change, indicating a time-depending change of the state of the modelled system (see the jogging-example in Figure 4).

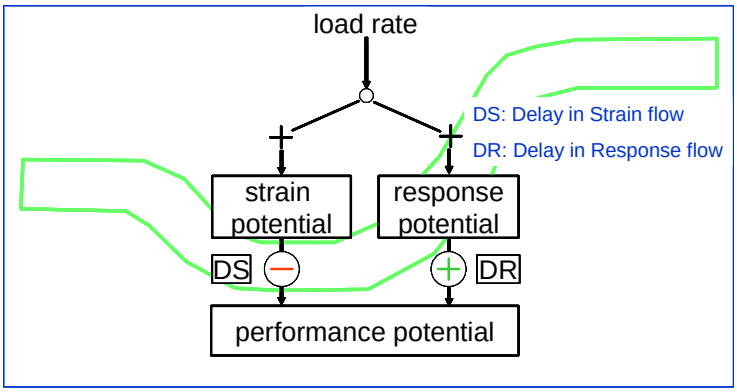

Figure 2. Basic antagonistic structure of PerPot.

For more detailed information dealing in particular with aspects like reserve, overload, and atrophy see Perl & Mester (2001), Perl (2002 a) and Perl (2004).

The role of time scale and delay parameters

The time scale of a PerPot instance is defined by abstract "time units", which can be interpreted arbitrarily with respect to the system to be modelled. If the time scale is once fixed, the time-dependent parameters of the model – e.g. the delay parameters – are fixed as well:
As has been mentioned above, the delay parameters encode the status of the athlete as well as the time scale: The absolute values of the parameters are related to the time scale. If the time units are "1 day" as in the case of haemoglobin (Figure 3, right) the delays are multiples of "1 day". If the units are "15 seconds" as in the case of jogging, the delays are multiples of "15 seconds" (Figure 3, left). The relation between the delay values reflects the athlete's reaction on load and load change.
This can be seen clearly in particular in the case of jogging (Figure 3, left), where, more or less, DR corresponds to the heart rate increasing part, while DS corresponds to the decreasing part: In the phases of speed increase, it takes about 10 units (= 150 seconds = 2.5 minutes) ≈ 3×DR to stabilize the system – which means that the performance then reaches a level of constant values. In the decreasing phases, it takes about 14 units (= 210 seconds = 3.5

minutes) ≈ 3×DS to stabilize. In both cases the stabilizing time is about 3 times the regarding delay value, which corresponds perfectly well to theoretic expectations: If decomposing the performance profile in its decreasing and increasing parts, these parts can be approximated by asymptotic exponential functions, where the delay-values are parameters that influence the asymptotic behaviour in the described way.

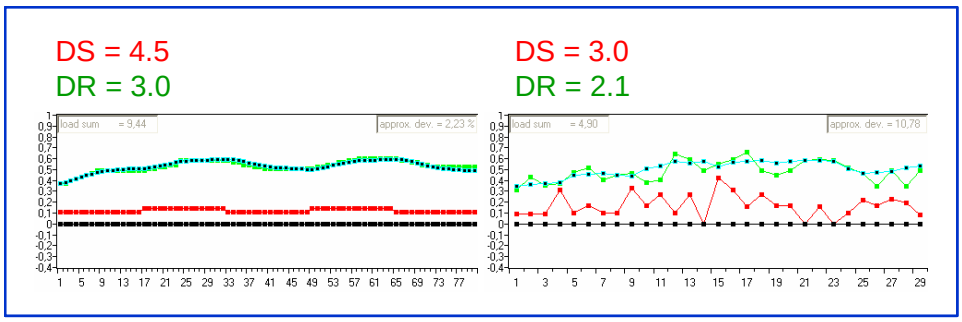

Figure 3. Delay parameters in case of jogging (left) and haemoglobin (right). Here and in the following figures "red" means load, "green" means original performance, and "blue" means simulated performance. The vertical scales mean normalized values, which the original values of load and performance are mapped to, while the horizontal scales show the respective time-steps: The space of the left graphic is 20 minutes in units of 15 seconds; the space of the right graphic is 29 days.

Approaches and applications

Performance prediction: In the phase of calibration the delay values have to be deduced from the original load and performance profiles. Consequently it can be asked how many "current" data are necessary to calculate delay parameters, which not only allow for simulating the current performance values but also for predicting the future ones.

In Figure 4 it is demonstrated that 5 data seem not to be sufficient for a proper prediction (see left graphic), while 25 data seem to fit rather well (see right graphic). The truth is that the typical dynamic changes, e.g. from low to high and/or from high to low load, are necessary to give the model enough information about the characteristic adaptation behaviour. Moreover, this method of prediction can be used for online adaptation, where every new pair of load and performance values can be used for adapting the delay values to the changing situation respectively to the changing status of the athlete.

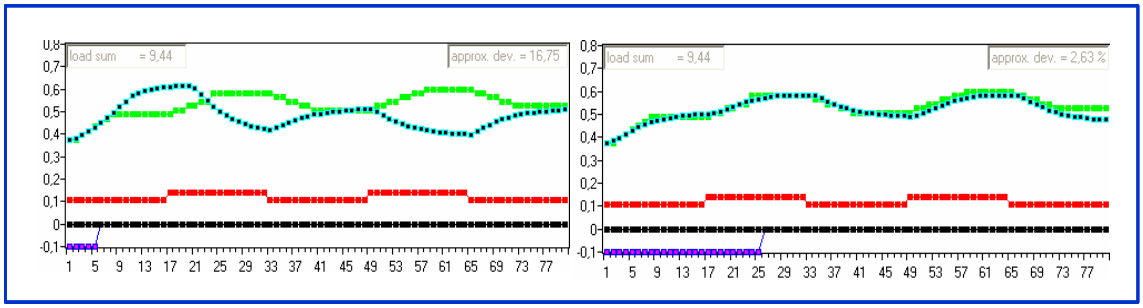

Figure 4. Precision of prediction depending on the load dynamics and/or the number of data used for delay calculation (violet dots on the bottom mark the interval of used data). The vertical scales mean normalized values, which the original values of load and performance are mapped to, while the horizontal scales show the respective time-steps: The spaces of both graphics are 20 minutes.

One reason for a changing status of the athlete can be a decrease of endurance and should influence the delay values. In turn, changing delay parameters can be indicators of effects like this. The right graphic shows such a relevant difference between original and predicted performance values in the right-most area, which is caused by a smoothing change of delay parameters. In practice, those dependencies could be used for an online adaptation of the model and a well-timed prediction of critical situations.

Load and performance scheduling: Last but not least it seems to be interesting to know how to plan the load profile in order to optimally meet a given performance profile, and how the performance output changes if the load profile is changed. Doing this by means of simulation saves the athlete's time and is careful with the athlete.

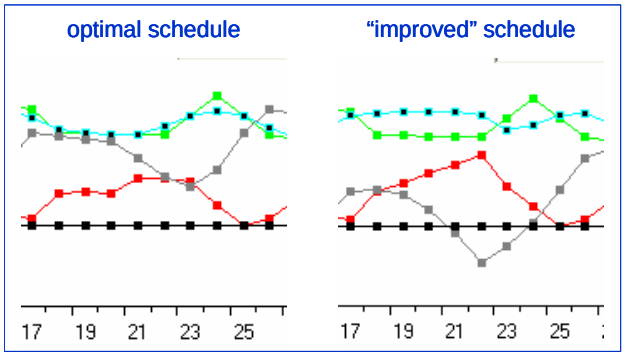

Figure 5. Detail of the effects of optimal load profile compared to that of the "improved" one.

In Figure 5, the left graphic shows (a piece of) a performance profile (green), which was designed using the PerPot scheduling component. The load values (red) then were generated correspondingly in order to optimise the load profile. As can be seen from the left graphic, the plateau (time interval 18 to 22) as well as the singular event (time 24) have been met satisfyingly well (blue). Very often coaches or athletes have the idea to even improve a proper training schedule by increasing the training load. This approach is simulated in the right graphic in Figure 5, where the red profile is the "improvement" of the left optimal one. It easily can be seen that too much load can be contra-produc-tive and can cause effects, which are in contradiction to the planned ones.

Network-based process analysis

Processes in sport can be described as time series of patterns, which can as well characterize situations (e.g. positions on the playground or angles of articulations) as activities (e.g. moving of players or angle speeds).
Patterns can be learned and recognized by means of "self organizing maps" (SOM) the most famous type of which is that of Kohonen Feature Map (KFM) (see Köhle (1990), Polani & Uthmann (1993)). Therefore SOMs like KFMs can help to analyse processes in sport, as has been done in several approaches (see Lames & Perl (1999), Schöllhorn & Perl (2002), Lippolt et al. (2004)). However, there is a type of problem that is difficult to handle with a "conventional" KFM – namely if learning itself is the process to be analysed: Due to the fact that a KFM learning process is controlled by an external algorithm using parameters that run down to final values and so eventually cause the end of the learning process, a once trained KFM cannot be reactivated. Therefore additional or continuing learning can be done only by

repetitions of the learning process using appropriate mixtures of data from the different phases of the learning process – which is uncomfortable as well as methodologically not satisfying. In order to handle this problem, the concept of Dynamically Controlled Network (DyCoN) has been developed in our working group.
(Here and in the following the term "learning" is used to describe the effect of net training, which is measured by the presence of patterns that represent training contents.)

Modelling learning processes by means of DyCoN

The DyCoN-concept is based on the KFM-concept but is different in the main point of internal organisation: The dynamics of each neurone is based on the PerPot-metamodel, which originally was developed in order to model physiologic adaptation processes. The idea was to supply every neurone with an individual internal memory and, in particular, with a PerPot-based adaptive learning algorithm. The effect of the individual neural self-control is that a DyCoN has no final state but always can adapt its internal memory to new input and therefore can learn continuously as well as in separate phases (see Perl (2001 c), Perl (2002 a), Perl (2002 b)).

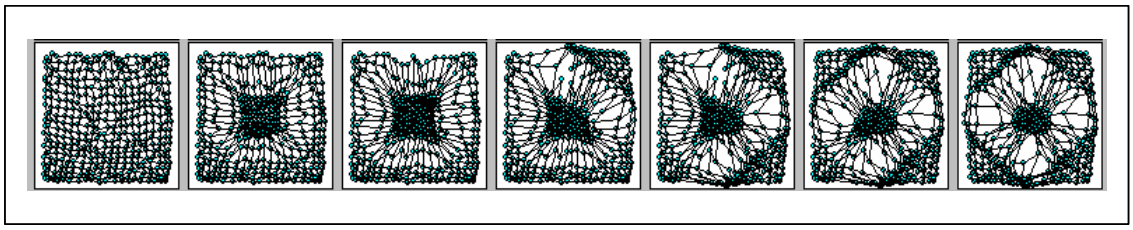

Figure 6. Visualisation of a continuous superposing learning process using geometrical patterns like squares (graphics 1, 2, 3) and triangles (graphics 4, 5, 6, 7)

One effect of the dynamic learning ability is that patterns can superpose or complete each other if learned one after the other in a continuous learning process (see Figure 6).
Moreover, DyCoN-neurones also can forget its information and so enable to replace one pattern by another one in a replacing learning process (see Figure 7).

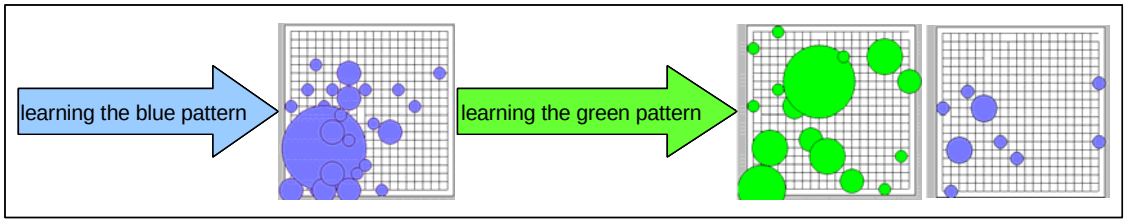

Figure 7. First learning the blue pattern results in a high degree of presence that is represented by the number and the diameters of the blue circles. A following training with the green pattern establishes the green presence and reduces the blue one.

These examples represent a typical conflict situation in learning processes: Sometimes an already learned pattern has to be completed by another one – e.g. if the backhand technique is added to an already available forehand technique – sometimes one already learned pattern has to be replaced by another one – e.g. if a less effective technique has to be improved. Obviously, appropriate learning schedules are necessary to meet the respective intentions. The questions are, whether such schedules can be found and seem to be reasonably transferable to human learning and so could help for optimizing learning and training strategies, e.g. in the areas of motor learning or tactical game analysis.

A first approach has been developed by Weber (2004), where a Genetic Algorithm calculates best fitting learning schedules to given objectives.

Optimisation of learning schedules by means of Genetic Algorithms

Due to their combinatorial structure, the number of possible schedules is enormous, and as long as there is no idea what a successful training profile could be it seems to be hopeless to find an optimal schedule. However, as is well-known from similar problems of this type, Genetic Algorithms (GA) can be helpful due to their ability of selecting, modifying, and combining parts of temporary solutions (e.g. see Dauscher (2003), p. 24). In the study of Weber, the GA had to arrange the training of two different patterns, where the one objective was superposing learning in the sense of establishing two patterns with equal degrees of presence, and the other objective was replacing learning.

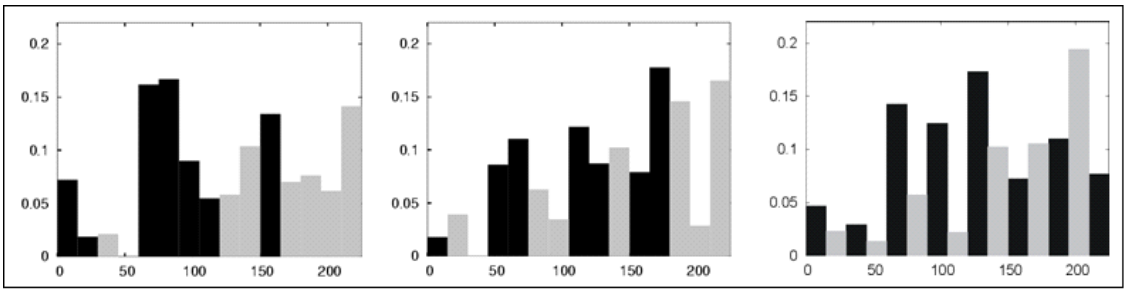

Figure 8. Three characteristic types of optimal schedules in case of superposing learning (black and grey the learning intensities of the respective patterns). In the right graphic the alternating learning rhythm was given, and only the intensities were optimised.

The structure of the schedules was given as an equidistant scheme of time-slots. The GA had to select one of the two patterns as well as the regarding learning intensity for each time-slot. Briefly spoken, the results are as follows: In the case of superposing learning the optimal schedules are of the types shown in Figure 8, meaning that alternating learning phases with moderate learning intensities fit best for a balanced presence of two patterns.

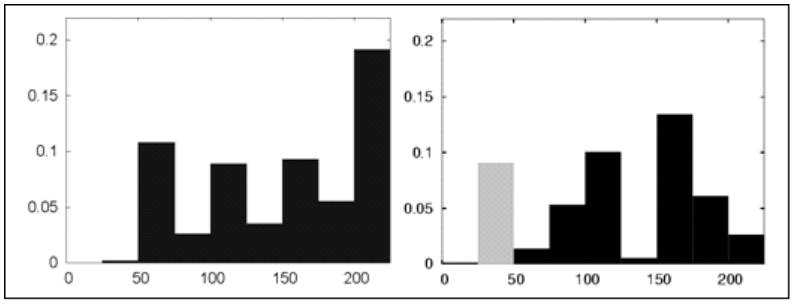

Figure 9. Left graphic: Typical learning schedule in case of replacing learning (black columns: learning intensities of replacing patterns). Right graphic: Learning with additional erasing pattern (grey column).

In the case of replacing learning the first result (Figure 9, left graphic) met the expectations: The replacing pattern had to be learned with a rather high sum of intensity. Additional tests however showed that an even better result could be reached by first "attacking" the net with an erasing third pattern (Figure 9, right graphic) – which can be interpreted as "brain washing". On the basis of those first ideas what optimal schedule structures could be, more

targeted investigation can be done in order to handle more than two patterns or get more information about details of pattern learning.

Conclusion

Because of their complex internal interactions, the time-dependent behaviour of dynamic systems cannot be predicted using static description models only, if a sufficient quality of prediction is expected. Instead, models have to be developed that reflect the system dynamics and help to simulate its behaviour. Whether such a model is sufficient and adequate has to be decided qualitatively by its convincing structure as well as quantitatively by its produced values.
Of course: Even if the model seems to be configured well it not necessarily tells the truth about the system. But at least it can help to ask the right questions and get new ideas.

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Students' Attitudes and Perceptions Toward the Web Credibility of "Youth 2004" in Greek Australian Schools: The Development of a Psychometric Questinnaire

Nicholas Vernadakis[1], Efi Tsitskari[1], George Tzetzis[2], Maria Giannousi[1] and Efthimis Kioumourtzoglou[1].

[1]Democritus University of Thrace, Department of Physical Education and Sport Science,

[2]Aristotle University of Thessaloniki, Department of Physical Education and Sport Science.

Abstract

The purpose of this study was to develop a psychometric questionnaire in order to evaluate the educational web site "Youth 2004" considering the attitudes and the perceptions of Greek Australian students. In addition, the differences among the age and sex were also investigated. Participants were 317 Greek Australian students, between the ages from 12-17 years old. Data was collected using an on-line survey. Results from the factor analysis yielded five factors accounting for 69.5% of the variance. Independent-samples *t* test analysis revealed significant differences between the two age groups, in the case of four factors: "suitable for audience", "appropriateness of information's web format", "easy to direct and be oriented" and "interaction and feedback". In the four factors above the younger children reported better results. In conclusion the student feedback from the questionnaires indicated a general level of satisfaction and contentment with this particular web site. The scale developed in the present study can be a useful tool for the evaluation of other relative web sites by web developers.

KEY WORDS: WORLD WIDE WEB; CREDIBILITY; ATTITUDE; PERCEPTION; AGE DIFFERENCES; GENDER; TECHNOLOGY.

Introduction

The Internet has, in recent years, experienced a tremendous explosion in mainstream acceptance and popularity, due, in large part, to the increased use of the electronic mail (e-mail) and the World Wide Web (WWW), two communication methods mainly supported by this medium (Caskey and Delpy, 1999).

NUA (2002), the authoritative online source for information on Internet demographics and trends, estimated that on September 2002, the total number of the online population worldwide was 605.60 million. Another survey from Pastore (2003) reported that the main reasons that teenagers go online are: to send/receive an e-mail (83%), to get information/research (68%), to play games (51%), to use chat rooms (40%), to download music/videos (38%), to send an electronic greeting card (31%), to shop (26%), to read news/sport (23%) and other (19%).
The same survey revealed what younger kids, aged from 8 to 12, prefer to do online: play games (80%), send e-mails (72%), use chat/message boards (58%), make their schoolwork (54%), download music (42%), shop (22%) and enter contests (18%).

One can understand from the above that the Internet is a powerful tool that can be used for training, research, business or amusement. The colorful and visually engaging appearance, rich resources, online audio and other interactive features, combine to make the Web an enormously valuable learning tool, enriched with numerous pedagogic possibilities (Oliva and Pollastrini, 1995; Owston, 1997; Peterson, 1997).

Unfortunately, not all demographic groups have participated in this information revolution. Worldwide, Internet users are more likely to be male, wealthier, better educated, and younger than the general population (Graphics, Visualization, and Usability Center, 1997; National Telecommunications and Information Administration, 2000; Tapscott, 1998).

According to Kraut, Scherlis, Mukhopadhyay, Manning, & Kiesler, (1996) gender and generation were strong predictors of Internet use; males and teenagers were more likely to use the Internet than females and adults. Male teenagers were by far the heaviest users, spending more than ten times the amount of time than the least frequent users.

Research in the United States has found that boys and girls do not differ in having any computer experience or using the computer at home or school, but by the age of seven, boys outscore girls in computer aptitude (National Telecommunications and Information Administration, 2000; U.S. Census Bureau, 1997). Very little differences existed between boys and girls in the level of use of school computers. Boys were more likely to play computer games than girls. However, girls used more frequently the household computer for word processing than boys did (U.S. Census Bureau, 1997).

Among adults in the United States, the pattern was similar. Males used the computer more than females when work-related word processing and bookkeeping were excluded. Males were more likely than females to own and used a computer at home, to use more computer programs, and to use computers as entertainment (U.S. Census Bureau, 1997). Compared to females, males of all ages were more adept at activities such as programming and more technologically sophisticated with computers (Tapscott, 1998; U.S. Census Bureau, 1997).

Given the impact of the World Wide Web and the possibilities that it opens as information and learning tool, there is an increasing need for quality management. However, the quality of Internet resources varies tremendously, thus criteria are needed for their evaluation (Valenti, Cucchiarelli, & Panti, 2001). Seven of the most important criteria are: graphic and multimedia design, browsability and organization, currency, content (in general), authority, workability (in general) and audience (Alastair, 1997). Web page evaluation procedure includes three (3) steps: a) identify type of page, b) use appropriate checklist and c) based on checklist criteria, determine relative quality of page. Web evaluation techniques are just beginning to get developed. Technology is outpacing the ability to create standards and guidelines. Establishing evaluation procedures will be an ongoing evolutionary process (Alexander, & Tate, 1998).

Whereas, the issue of the credibility of Web based information is extremely important when it is considered as a source of information for students in educational contexts, it is remarkable how few quantitative studies exist. Although some private companies have created proprietary knowledge about designing for maximum Web credibility, only a handful of studies in this area are public. In other words, little research has been published on why

people believe information on some Web sites but not others. The term, credibility can be defined as believablility. A resource that is credible is one which shows evidence of authenticity, reliability and believability (Harris, 1997). Basically, the key to credibility is trust; how well can one trust the information found on the Internet, as well as other resources?

Some recent researches have examined factors that affect trust in certain types of Web sites, such as e-commerce sites (Olson and Olson, 2000) or personal sites (Flanagin and Metzger, 2003). Other studies have looked into credibility but in ways too limited to draw robust conclusions (Kim and Moon, 1998). Drawing from small studies, researchers have suggested means of evaluating the quality of Web information (Wilkinson, Bennett, & Oliver, 1997), while Web site consultants have proposed ways to make Web sites more credible (Nielsen, 1999). However, no large study that investigates and outlines the factors which influence the perceived credibility of Web sites has been published yet.

Therefore, more research needs to be conducted into learners' perceptions toward this new technology, so that specific guidelines for its successful implementation can be provided (Yang, 2001).

The purpose of this study was to develop a psychometric questionnaire in order to evaluate the educational web site "Youth 2004" considering the attitudes and the perceptions of Greek Australian students. In addition, the differences among the age and sex of the participants were also investigated. More specifically, the study was conducted to explore the following three research questions:

1. Is there a single dimension or are multiple dimensions underlying the 24 attitude items toward the educational web site?
2. Does the average amount of students' attitude and perception differ between boys and girls?
3. Does the average amount of students' attitude and perception differ between kids aged from 15-17 years old and children aged from 12-14 years old?

Methods

Participants

Three hundred and seventeen (n=317) Greek Australian students of Sydney, between the ages from 12-17 years old (M=14.73, S.D. =2.91) participated in this study. The participants consisted of one hundred twenty (38%) middle school students and one hundred ninety seven (62%) high school students. One hundred sixty nine (53%) of the participants were boys and one hundred forty eight were girls (47%). Students were asked to participate in this study as part of their overall computer class instruction, but participation was optional. Students who chose to participate were given a CD-ROM of "Youth 2004" and other memorabilia of ATHENS 2004.

Instrumentation

Software Instrument

The educational web site "Youth 2004" was developed by the researchers to support the Olympic education program of the Organizing Committee for the Olympic Games ATHENS

2004. The material was programmed using a hypertext mark-up language (HTML) editor, Macromedia Dreamweaver. The site was run under Web browsers such as Microsoft Internet Explorer or Netscape Navigator and was divided into seven theme groupings:

1. the Games: their staging in 2004 and the contributing factors
2. the World: the city of Athens and the countries participating in the games
3. the Heritage: a historic review of the games, past an present
4. Willpower: the Paralympic games and their history
5. Playground: "Olympic" games for young and older friends of the Olympic games
6. Library: the Olympic education program of ATHENS 2004 and the activities of schools
7. Club 2k4: a channel of communication for the friends of "Youth 2004".

In order to cover a wide range of information on the past, present and future of the Olympic and Paralympic games, "Youth 2004" included the use of a simple language, a host of interactive applications such as audio flash movies and video, a wealth of photographic and other illustrative material and numerous high quality games.

The educational site was addressed mainly to teenagers aged 12-17 years old, consisted of 2500 pages; 12 pages were introductory, 10 were main menus, 1500 were information, 179 were practice, 764 were feedback and 35 were help. At the end of each topic and sometimes in certain sub-topics, a quiz was provided which contained 10 multiple-choice questions on the material. "Youth 2004" provided users with three types of navigation paths in addition to Internet Explorer's back and forward navigation tools. The users had the ability to navigate through the path structured by the programmer via the site map or from the menu appearing on each page.

The WAI Guidelines for Level A Conformance (priorities 1) have been used as standard for the configuration of the key activities which were performed as part of the evaluation and the construction of the content areas of "Youth 2004" considering simultaneously users with disability and generally users of internet that do not have access in specialised technologies and plug-ins. More specifically, the evaluation key activities was:

1. Visual inspection using full-featured graphic user interface (GUI) on Windows and Mac-OS (e.g. Internet Explorer version 5 and above, Netscape 6 and above, Opera).
2. Visual inspection using GUI with Java-script turned off.
3. Visual inspection using GUI with different fonts.
4. Inspection using screen readers (JAWS, HAL) in cooperation with disabled user focus groups.
5. Source code inspection of sample pages.
6. Validation of the pages using the web based accessibility validation tool Bobby.
7. Validation of the HTML code by using w3c automatic validations.
8. Validation of the CSS code by using w3c automatic validations.

Attitudes Instrument

A questionnaire was created in order to elicit relevant information on the participants' perception, and attitudes towards using the educational web site "Youth 2004". Initial drafting of questions for the instrument relied upon survey research handbooks such as those by Alreck and Settle (1995), DeVellis (1991), and Oppenheim (1992). Due to the study's

unusual context, no questions were taken directly from other studies. The dynamics of the Olympic Games milieu proved too complex to adopt items directly from other work. Nevertheless, items for the instrument were built from well-established constructs such as those in Davis's (1993) Technology Acceptance Model. Throughout development, our imperative was to build an instrument that would not be biased inadvertently or uncontrollably by a multitude of demographical and web credibility factors.

After an initial attempt to operationalize technology acceptance constructs as questionnaire items, specialised consultants were asked to evaluate the instrument. Three groups of experts were approached: English language experts, software industry professionals, and scholars in human-computer interaction.

The language experts helped eliminate unintended complexity and imprecision in wording. English experts' remarks also helped ensure cultural neutrality and detect wording that might bias responses. These experts reviewed questions in such detail that in some cases they identified individual words that 'didn't feel right'. Software industry professionals and scholars in human-computer interaction suggested ancillary constructs and operationalization techniques suitable to the goals of the study, in addition to critiquing the instrument for clarity.

All told, the several rounds of draft critiques resulted in inclusion of many items related to demographics and web credibility background, and a host of changes in wording and concept representation. Every time a set of changes was made, the questionnaire was reviewed again by the consultants, until the instrument was deemed adequate.

Throughout this process of question development, we also explored different formats for gathering information online. After various prototypes, we settled on a format that used a 5-point Likert-type scale (1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree) for each of the 24 questions on Web credibility (see Table 4). This format allowed people to select a response from "1," to "5," representing their disagreement or agreement on the particular item respectively. For the demographic questions, that gathered information on participants' age, nationality, grade and gender, we used drop-down menus.

Procedure

The researchers attended each computer class offered in fall 2002 looking for volunteers for the study. Students were asked to sign a form indicating their wish to participate or not to participate. The study took place during December 2002.

The participants were requested to access "Youth 2004" from each designated computer lab facility on their schools. The internet address, "http://www.olympiceducation.gr", of the educational web site was installed into the browser of each computer workstation. Each lab was equipped with at least ten Windows-based multimedia computer workstations. All schools used the same network system to access the internet. Whereas "Youth 2004" contained audio, a small headset was connected to the soundcard. This ensured that other participants in the room would not hear the audio from the computers.

All the participants were requested to access the web from computers with the same configuration ensuring that "Youth 2004" was viewed equally among all participants. More

specifically, this ensured smooth video-audio playback and flash movies during the browsing. If participants had been allowed to access "Youth 2004" from other locations, smooth internet movies playback could not be guaranteed. However, this request was very difficult to be verified from the researchers since the students could have browsed the Web site at their homes.

During testing days, in each school, scheduled groups of 10 participants went to the computer lab between 8am and 2pm at one-hour intervals. They were randomly assigned a computer workstation and were told the instruction would last approximately one hour. Once all participants had been seated, the instructor read a pre-written set of instructions to the group. This ensured instruction consistency throughout the testing. Once the oral instructions had been given, participants were instructed to double click on "Youth 2004" favorite icon to begin their browsing. Instruction, practice, and evaluation for this study were held on four separate and successive weeks. The groups met for 45 minutes, 2 times each week.

All participants were asked to enter their full name in the beginning of the final lesson. This information was not tracked for the experiment; it was the hope of the researcher that the participants would take the instruction more seriously if they were asked to enter their names. Each questionnaire was coded in order to track responses by participant and age group, yet maintain confidentiality of responses.

During data collection procedures, all participants were assured that the questions asked in this study were not evaluative and that their responses to the survey were only for academic purposes and would be kept confidential.

Participants answered an on-line attitude questionnaire by drawing on their cumulative experience using "Youth 2004". Upon completion of the questionnaire, the participants were prompted to submit their answers. These answers were coded and automatically e-mailed to the researcher each time the submit button was used. The code advised the researcher of the age group from which the subject participated. The data collection went faster than expected, requiring less than one week, due to the power and reach of the World Wide Web.

Design

Due to practical limitation, a field experiment, instead of a laboratory experiment was conducted to test the hypotheses. The experiment is a factorial design with sex groups (boys and girls) and age groups (15-17 years old and 12-14 years old) as independent variables, and attitude - perception performance as dependent variable.

Factor analysis was conducted to identify underlying clusters or relationships concerning the learners' perception towards the educational web site "Youth 2004". Independent-samples *t* test analyses were conducted to investigate the differences of this perception among the age and sex of the participants.

The hypotheses of this study were:

H_1: There are multiple dimensions underlying the 24 attitude items toward the educational web site
H_2: The boys will have more positive attitudes than girls toward the educational web site

H_3: The children aged from 12-14 years old will have more positive attitudes than kids aged from 15-17 years old toward the educational web site

Results

Means and standard deviations for each factor in this study are presented on Table 1, while the means and standard deviations for the sex and for the age groups are presented on Table 3 and 4 respectively. The results of each analysis are given separately below.

Table 1. Means 1 and standard deviations for each factor.

Factors	N	Mean	S.D.
Suitable for audience	317	4.60	.39
Appropriateness of information' s web format	317	3.95	.44
Easy to direct and to be oriented	317	4.50	.36
Interaction and feedback	317	4.24	.40
Graphic and multimedia design	317	4.89	.25

[1] Scale: 1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree

Factor Analysis

A principal component analysis of the 24-item scale was performed in order to investigate the underlying dimensions of the educational web site's evaluation, using the SPSS Factor Analysis program. Prior to performing principal component analysis the suitability of data for factor analysis was assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Oklin values was .787, exceeding the recommended value of .6 and the Bartlett's Test of Sphericity =5406.535, reached statistical significance (p<.001), supporting the factorability of the correlation matrix (Tabachnick, & Fidell, 2001).

Results indicated that our initial hypothesis of multidimensionality was correct. The principal components analysis revealed the presence of five components with eigenvalue exceeding 1, explaining 30.2 per cent, 16.7 per cent, 9.7 per cent, 8 per cent and 4.9 per cent of the variance respectively. An inspection of the screeplot revealed a clear break after the fifth component. Based on screeplot and the eigenvalues, it was decided to retain five components for further investigation. To aid in the interpretation of these five components, Varimax rotation was performed (Stevens, 1996). The rotated solution (presented in Table 4) revealed the presence of simple structure, with five components showing a number of strong loadings, and all variables loading substantially on only one component. The five factors solution explained a total of 69.5 per cent of the variance, with component 1 contributing 17.6 per cent, component 2 contributing 16.1 per cent, component 3 contributing 14.5 per cent, component 4 contributing 11.4 per cent and component 5 contributing 9.8 per cent. The interpretation of the five components was defined as follows:

(1) Suitable for audience, (5 items)
(2) Appropriateness of information's web format (6 items)
(3) Easy to direct and to be oriented (6 items)
(4) Interaction and feedback (4 items) and
(5) Graphic and multimedia design (3 items).

Table 2. The rotated loading matrix from the factor analysis [1].

Items	1	2	3	4	5	H^2
There is a paragraph on the page explaining what it is about	.855					.874
It is clear how to navigate through the resource's pages	.847					.769
The site is well-organized along logical lines	.711					.751
The site presents some information I disagree with	.871					.852
The site presents some information I think is wrong	.649					.855
The up-to-date information makes a difference for my level		.832				.822
The site is very quickly loaded		.571				.577
The site would be difficult for users with disabilities or special needs to use.		.550				.602
The authors often use some absolute words (like "always" or "never")		.680				.572
The website games were very easy for me		.649				.775
The games were rather boring		.646				.779
The frames, which are used in the site, are applied in a meaningful manner that aids navigating			.622			.598
The information is presented clearly and logically in a format useful to me			.633			.793
The graphics are used wisely to enhance and supplement the text			.704			.605
The page leads me to some other good information (links)			.645			.570
When I first entered the tour, I could choose from different options or paths to take			.553			.487
The tour allowed me to visit a place that I would never be able to visit in real life			.479			.544
There is a high percentage of dead or inactive links either internally or externally				.701		.602
I have gotten more information from an encyclopaedia				.622		.743
Throughout the tour, I could always get back to the beginning				.648		.795
The tour did not encourage me to learn more about the topic				.790		.750
The site's design is appropriate to its subject matter.					.819	.674
The site looks professionally designed					.749	.605
The resource is a collection of data in special formats such as images, audio or video data					.638	.500
% of variance	17.63	16.13	14.54	11.40	9.82	
Total variance						69.53
Eigenvalue	4.232	3.872	3.490	2.737	2.356	

[1] H^2 = communalities

Reliability Analysis

Coefficient alpha is the statistic mostly used to assess the internal consistency. The Cronbach-alpha coefficient was calculated for each of the sub-scales. The *"suitable for the audience"* factor had an a =.87, the *"appropriateness of information's web format"* had an a =.83, the *"easy to direct and to be oriented"* factor had an α =.79, the *"interaction and feedback"* factor had an α =.76 and the *"graphic and multimedia design"* factor had an a =.68. Although statistical texts (DeVellis, 1991) suggest that scale with reliabilities more than 0.70 should normally be considered as acceptable, in practice lower limits have been set up as acceptable by researchers.

Independent-Samples t Test Analysis

An independent-samples *t* test was conducted to evaluate the hypothesis that boys have more positive attitudes than girls toward the educational web site. The test revealed no significant difference among the two sex groups, in any case of the factor analysis, counter to the research hypothesis. As shown in Table 2, the boys reported similar scores with the girls.

Table 3. Means [1] and standard deviations for the sex groups in each factor.

Factors	Sex	N	Mean	S.D.
Suitable for audience	boys	148	4.58	.40
	girls	169	4.61	.38
Appropriateness of information' s web format	boys	148	3.99	.42
	girls	169	3.93	.46
Easy to direct and to be oriented	boys	148	4.51	.36
	girls	169	4.48	.36
Interaction and feedback	boys	148	4.23	.43
	girls	169	4.25	.38
Graphic and multimedia design	boys	148	4.87	.28
	girls	169	4.90	.22

1 Scale: 1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree

Another independent-samples *t* test was conducted to evaluate the hypothesis that children aged from 12-14 years old have more positive attitudes than kids aged from 15-17 years old toward "Youth 2004". There was significant difference in scores for children (M=4.66, SD=.32) and kids (M=4.49, SD=.47) in the factor "*suitable for audience*" $t(315)=3.816$, $p<.01$. Similar, there was significant difference in scores for children (M=4.33, SD=.32) and kids (M=3.72, SD=.33) in the factor "*appropriateness of information's web format*" $t(315)=16.072$, $p<.01$. Also, significant difference was revealed in the factor "*easy to direct and be oriented*" $t(315)=13.420$, $p<.01$, between children (M=4.78, SD=.18) and kids (M=4.33, SD=.34). Finally, there was significant difference in scores for children (M=4.65, SD=.23) and kids (M=3.99, SD=.24) in the factor "*interaction and feedback*" $t(315)=23.990$, $p<.01$. As shown in Table 3, the children aged from 12-14 years old scored significantly higher in the above four factors, according to the hypothesis. No significant difference was found between the two groups on the "*graphic and multimedia design"* of the site.

Discussion

Within the context of arguing that the credibility of Web based information is extremely important when it is considered as a source of information, this study developed a psychometric questionnaire in order to evaluate the educational web site "Youth 2004" considering the attitudes and the perceptions of Greek Australian students. The study also sought to investigate differences among the age and the sex of participants.

Table 4. Means [1] and standard deviations for the age groups in each factor.

Factors	Age	N	Mean	S.D.
Suitable for audience	12-14	120	4.66	.32
	15-17	197	4.49	.47

Appropriateness of information' s web format	12-14	120	4.33	.32
	15-17	197	3.72	.33
Easy to direct and to be oriented	12-14	120	4.78	.18
	15-17	197	4.33	.34
Interaction and feedback	12-14	120	4.65	.23
	15-17	197	3.99	.24
Graphic and multimedia design	12-14	120	4.87	.30
	15-17	197	4.90	.22

[1] Scale: 1=strongly disagree, 2=disagree, 3=neither disagree nor agree, 4=agree, 5=strongly agree

Results indicated that the evaluation on a pedagogic website was a multidimensional concept. This fact has been proved from other studies that have examined the role of the World Wide Web as an educational tool (Alastair, 1997; Yang, 2001). The reaction of students to the educational web site "Youth 2004" was encouraging. Analysis of the survey revealed a generally strong positive attitude and perception towards this particular web site. Participants found the materials and interactive learning experiences worthwhile, valued the "Youth 2004" features and believed web resources, as a meaningful educational tool. They were typically agreeable to various statements about navigation, satisfaction, interface design, useful information, additional use and improved learning.

This finding was quite a surprise, given the amount of students' positive attitude toward the educational site. The explanation in this phenomenon could be that participants in this study had already increased interest in Olympic issues. Factors that could have contributed in this were the web experience of the participants with Olympic Sites, their Greek origin and their previous experience of hosting successfully the Olympic Games of Sydney 2000. If this were the cases, it was also likely that some other group of students were less favourable toward the educational web site of Athens 2004. Also, the use of volunteers clearly had predisposed the students towards more positive attitudes.

Further analysis of the survey showed that the first factor of the questionnaire *"suitable for audience"* had positive ranging from "agree" to "strongly agree". This reveals that participants found the site easy to use, all necessary special commands were clear and the user interface issues such as menu design and readability of screens had been addressed. The factor *"appropriateness of information's web format"* had the smallest positive impact on perception of the web site "Youth 2004". The explanation to this phenomenon could be that students between the ages from 12-17 years old may need more sophisticated and complicated applications to have their work done. The third factor *"easy to direct and to be oriented"* had positive ranging from "agree" to "strongly agree". This indicates that the resource is organized in a logical manner to facilitate the location of information without navigation problem. Also, students found the interactive learning experiences worthwhile since the respondents rated the *"interaction and feedback"* questions by answering, from "agree" to "strongly agree". Finally, the strong positive responses on the last factor "*graphic and multimedia design"* made it the most dominant in increasing "Youth 2004" perception. This shows that the educational web site looked professionally designed and appeared visually appropriate to the subject matter.

According to James (2001), web experience of the respondents clearly had an influence on the web site evaluation. Inexperienced users found simple web site to be more useful from complex web site. Other researchers report that prior computer experience positively

influences attitudes toward the computer (Shashaani, 1997; Williams, Olgetree, Woodburn, & Raffeld, 1993). Eastmond and Ziegahn's (1995) concluded that adult students must be technologically proficient or have someone in their immediate support system who is competent in using technology, in order to be successful in Web-based courses. The students who were less proficient and did not seek assistance with the learning environment expressed either no opinion or dissatisfaction with the course. The Web-based learning environment did not motivate these students. Participants of this study had regular access to computer technology in their classrooms over several years. Perhaps, this prior computer experience positively influences their attitudes toward the educational web site. Therefore, these results are addressed to students that are familiar to the web, aged 12 – 17 years old.

The research on how sex changes perceptions of the web site "Youth 2004" showed no significant differences. Boys and girls answered the questions of the survey the same way, indicating similar perception. This suggests that using the educational web site has a positive effect for both sexes. Similar results have been reported by Comber, Colley, Hargreaves & Dorn, (1997) and Mumtaz (2001), who found that girls and boys equally enjoy using World Wide Web. Other researchers report that males have more positive attitudes than females (Sensales and Greenfield, 1995; Shashaani, 1997; Williams et al., 1993). However, most of these studies were conducted with small, local populations of college students. Besides, recent research literacy has showed that, overall boys were no more likely than girls to have a computer at home, or to use it. Whereas, little differences existed between boys and girls in the level of use school computers (National Telecommunications and Information Administration, 2000; U.S. Census Bureau, 1997).

The research on how age changed perceptions of the web site "Youth 2004" showed significant differences. The older respondents (15-17 years old) tended to be more critical of amateurism on a site, compared to the younger children (12-14 years old). This means the older kids were harsher on sites that had glitches like a single typo or a broken link. The younger children showed a higher level of contentment with the web site, especially in the four following factors: "*Suitable for audience"*, "*Appropriateness of information's web format*", "*Easy to direct and be oriented*" and "*Interaction and feedback*". However, using the educational web site has a positive effect for both age groups and these differences were typically small. On the one hand, this is in agreement with McKenna, (1997) and Tapscott, (1998), who reports that, teens and young adults generally have more favorable attitudes towards technology than older adults. On the other hand it is in disagreement with Fredericksen, Pelz, Shea, & Swan, (2000) and Swan, Shea, Fredericksen, Pickett, Pelz, & Maher, (2000), who report that, younger students were the least satisfied with Web-based learning than older students.

In conclusion the student's feedback from the questionnaires indicated a general level of satisfaction and contentment with this particular web site. Yet, in order to have the learners make constructive and flexible use of the educational network technologies, the "suitability for the audience", the "appropriateness of information's web format", the "easiness to direct and to be oriented", the "interaction and feedback" and the "graphic and multimedia design" seem to be crucial considerations. Perhaps, adherence to these basic principles will not only improve overall site impressions, but also will increase visit frequency to the Web site concerned. The scale developed in the present study can be a useful tool for the evaluation of other relative web sites by web developers.

Research and development in this area will be continued with the view to refining any kind of web-based educational environment so that it meets and fullfills all expectations for supporting and enhancing pupils and students learning process. More studies should be conducted to investigate the effect of web experience on student's attitudes toward the World Wide Web, especially when its effect is linked to age. Also, one can reasonably assume that most people – regardless of gender, age, or other demographic factors – access web site credibility in similar ways. Although real differences do exist, it's more striking to see how many things were not different, suggesting that the various demographic groups shared similar approaches to evaluating web sites.

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Connecting Computer Science and Sport: The RoboCup Simulation League

Peter Dauscher, Felix Flentge, Thomas Uthmann
{dauscher, flentge, uthmann}@informatik.uni-mainz.de

Institute of Computer Science
Johannes-Gutenberg Universität Mainz

Abstract

RoboCup is a most challenging project in the field of Artificial Intelligence and Multi-Agent Technology research. In this article, we will discuss some examples showing that RoboCup Simulation League scenarios can also be interesting in the interdisciplinary cooperation between computer science and sport science. One part of the paper concentrates on the generation of surrogate data which can be used in order to test data analysis methods. Furthermore, we will discuss RoboCup scenarios as testbed for sport theory as a future perspective.

KEY WORDS: ROBOCUP, SIMULATION LEAGUE, DATA ANALYSIS, SELF-ORGANIZING MAPS, TESTBED

General

"RoboCup is an international joint project to promote AI, robotics, and related field" that provides "a standard problem where wide range of technologies can be integrated and examined" (www.robocup.org).

The main focus of the RoboCup competitions is playing soccer with a number of autonomous acting players (agents). This scenario – stemming from the world of team sports – implies a number of different challenging information processing problems.
On the one hand, several problems have to be solved if the agents play in a real environment. E.g., sophisticated computer vision techniques are used to recognize objects like other agents, the goals, field boundaries and the ball. This has to be done in real time, of course, and the methods have to be robust against a number of disturbances as, e.g., changes in the light intensity or events outside the playground.
These abilities are crucial especially in the Middle Size League and the Sony Legged League. In the Humanoid league, the main challenge is bipedal locomotion, yet (Figure 1).

In the Simulation League, in contrast, these kinds of problems can be largely neglected: All the physics of a game is simulated on the so-called *soccer server* (see Figure 2). Instead of perceiving real situations by means of cameras, the agents (i.e. the 22 players and the coaches) receive numerical information (like distance and angle to ball or other players) generated by the soccer server and transmitted via a well-defined communication protocol. Similarly, actions chosen by the agents' "brains" are sent to the soccer server instead of controlling real motors.
It is to be emphasized, however, that also in the Simulation League the agents act autonomously, i.e., there is not one "holistic" control mechanism that coordinates all 11

players of a team simultaneously (as in tabletop football) but 11 separate programs interacting only via sensor inputs and actor outputs.

a) b) c)

Figure 1. Some RoboCup Leagues: a) Middle Size League, b) Sony Legged League, c) Humanoid League

In order to make things more realistic, position data are perturbed by simulated noise or even not accessible – depending, e.g., on the distance to an object. The agents must cope with this incomplete or vague information and build up a world model enabling them to act "reasonably" .

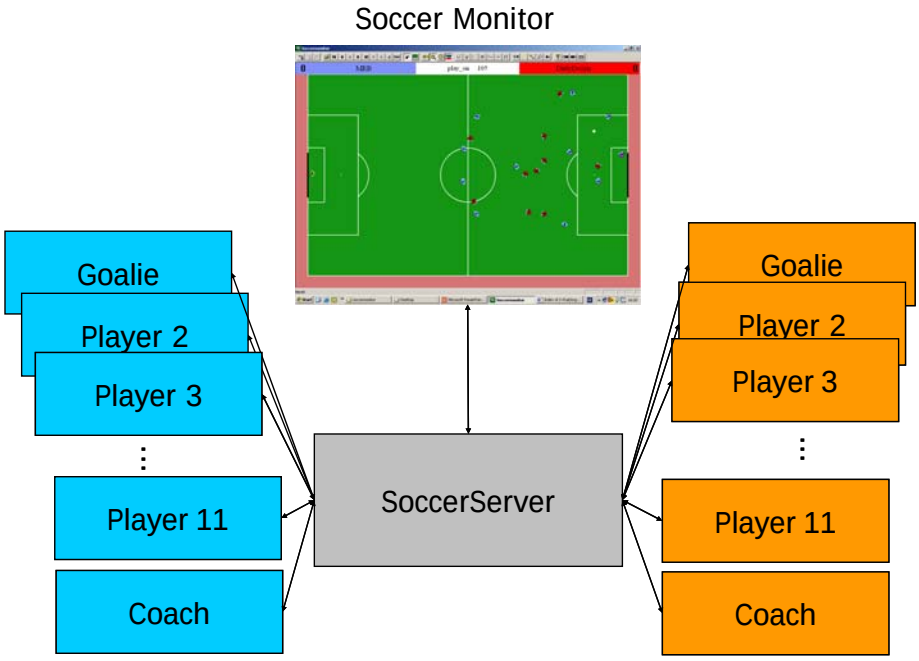


Figure 2. Agents and the soccer server in the Simulation League.

In the beginning of the RoboCup competitions, the scenarios in the Simulation League were 2-dimensional for the sake of simplicity. Since 2004, however, also a 3D soccer server is in use and will, probably, replace the 2D version within a few years. The server and the agents can either be run on the same computer or on different computers in order to enhance performance.

The simplifications of the Simulation League w. r. t. technical aspects allow to concentrate on other questions dealing, e.g., with world modeling from input data, multi-agent collaboration and competition as well as adapting behavior (or even complex learning) and forming strategies.

Rather than the technical challenges in the hardware leagues (intimately connected with specific robot hardware), these more abstract questions can be interesting also within the interdisciplinary field of Computer Science and Sport. In the following, two aspects are discussed: the first one refers to the possibility to use Simulation League data to test analysis methods developed for data analysis in real sport. In this field some research work has been already done at the University of Mainz. The second aspect, namely using Simulation League scenarios for testing theories of sport science describes rather a promising research perspective than current research activities.

Testing Data Analysis Methods for "Real Sport"

Measurements in real sport (especially team sport like soccer) are mostly rather intricate and expensive and may be interfering. E.g., motion tracking systems have to be set up, calibrated and tested which requires personnel and is time-consuming.

Therefore, it is most desirable to know beforehand, which analysis method can be used in order to answer a given question (because the method determines the data that must be collected). However, without any data, it is hard to test and to compare different analysis methods.

One way to circumvent this dilemma is to use surrogate data, i.e. data which are structurally similar to the original data but do not require the performance of real measurements. The problem, however, is how to obtain such surrogate data which show a sufficient similarity to such complex data as obtained by observing team sport processes. Here, the RoboCup Simulation League can be an option for a number of reasons:

- In RoboCup Simulation League scenarios the agents face similar challenges as human soccer players do in real soccer matches – at least on a basic level. Therefore, it is most likely that similar spatio-temporal structures organize.
- Within a RoboCup simulation run a number of different data (e.g., the positions of all players and the ball) are logged by the soccer server. These data can be used directly to perform analyses.
- Since, no exhaustion occurs in simulated agents, matches can be repeated arbitrarily to generate a huge amount of data, which can be extremely important in order to obtain statistically significant test results.
- The implemented behavior of the RoboCup agents can be changed in various ways. It is easy to test whether (and in which way) a given analysis method is able to detect such a change.

In the following, we will present an example from the Institute of Computer Science at the Johannes Gutenberg University of Mainz. Here, Self-Organizing Maps (SOMs), a special kind of Artificial Neural Networks, have frequently and successfully been applied for several

years as a data analysis tool. The most important ability of these Neural Networks is the mapping of high-dimensional data-points to lower-dimensional structures, mostly a two-dimensional grid consisting of so-called "neurons" [Kohonen, 1982; Ritter et al., 1992; Kohonen, 1995], which is sketched in Figure 3.

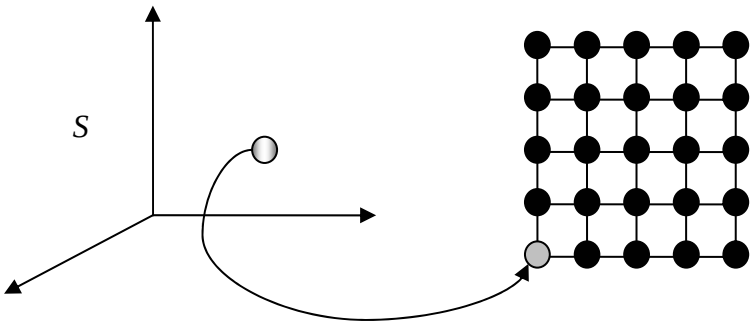
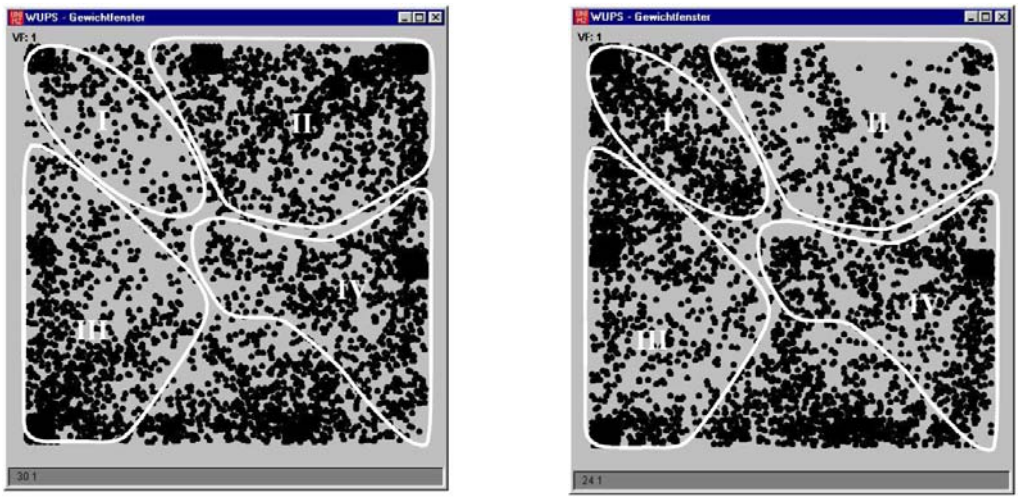


Figure 3. Mapping from a high-dimensional data space *S* onto a two-dimensional grid of "neurons". *S* is illustrated here as 3-dimensional, for convenience; in most applications, its dimensionality is quite higher.

This map is not static (as, e.g., a simple projection) but adapts to the distribution of the data-points during a learning process. SOMs can be used either for a direct visualization or for a further automatized processing of the data. The best-known SOM is the Kohonen Feature Map. An extension to algorithm is the DyCoN model developed in Mainz [Perl, 2001; Hawlitzky, 2001]. In this approach, the way in which network structure adapts to the data-point distribution, is controlled by dynamical systems implemented in the "neurons". On the one hand, this approach is an object of fundamental research aiming at modelling strain-dependent learning behavior. On the other hand, it has also applied successfully to various data analysis tasks, especially within the interdisciplinary field of Computer Science and Sports.

One interesting application of SOMs is to investigate the complex structure of player movements. [Wünstel et al, 2001] have shown that a SOM-based analysis can reveal typical motion patterns in space and time. The data that were used came from a RoboCup Simulation League match (Carnegie Mellon University vs. Mainz Rolling Brains). In order to cover temporal aspects, the data-points processed by the SOMs were generated by combining data from a series of several timesteps (similar to time delay embedding methods in nonlinear data analysis methods [Kantz & Schreiber, 2004]). The method provides a visual representation of the average team behavior. Different kinds of motion patterns correspond to "clusters", i.e. groups of adjacent neurons. The frequency distribution of the data-points over these clusters can reveal, e.g., superiority of a team or the not-implemented dribbling-skill of another team. In Figure 4, e.g., one can see that the cluster (I) is remarkably more populated for the MRB team than for the CMU team. A further investigation identified this cluster as associated with a backward movement of the player; the density difference in this cluster is likely to occur due to the superiority of the CMU team in this match.

A more detailed overview about Self-Organizing Maps and the methods used by [Wünstel et al, 2001] can also be found in [Uthmann & Dauscher, 2004].



a) b)

Figure 4. Visualization of the behaviors of two players of different teams in a RoboCup Simulation League match (adapted from [Wünstel, 1999]) a) Carnegie Mellon University (CMU) team player b) Mainz Rolling Brains (MRB) team player.

One of the current goals is to enhance usability and flexibility of such analysis programs in order to make these methods more accessible, especially for sport scientists and practitioners. One approach is to combine the Self-Organizing Map with database techniques [Boll, 1999; Jouraai, 2003].

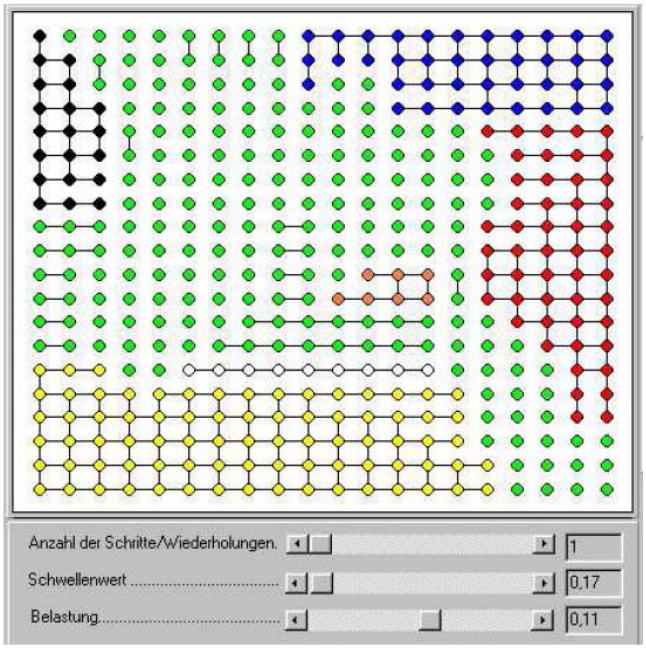


Figure 5. a) Colored cluster structure in a Self-Organizing Map (adapted from [Jouraai, 2003]).

Such techniques enable the user to store data from measurements or from RoboCup simulations in one or more database tables and then to choose a set of observables interactively which are used then for the adaptation of Self-Organizing Map. Clusters

representing a given situation or movement can be identified, colored and labeled appropriately; this cluster structure can be stored in a database again (c.f. Figure 5).

Emotion exorcised – well controllable agent behavior as a future perspective

Considering a real soccer match, it is obvious that it is influenced by a variety of different factors forming the overall behavior in an extremely complex way: On the one hand, there are some strategic decisions that can be put in words more or less easily. On the other hand, there are a huge number of skills and techniques of the individual players, including intuition and emotions that lead to the decisions the players take. These aspects are hardly accessible for science, although they are most important for the game dynamics.

In the medium-term future, however, RoboCup might offer an interesting testbed for sport theory. At present, we have already well-controllable synthetic matches: All basic skills of the players (like passing, dribbling etc.) as well as their information processing mechanisms from perception to decision are completely determined by a human-made controlling program. Furthermore, it is possible here to log the perceptions and decision processes on computer files that can be analyzed afterwards. This way, it can be traced exactly, how the controlling program has taken its decision based on the data it received from the soccer server.

Figure 6. Screenshot of the analysis and visualization tool FUNSSEL.

Of course, logfiles are hardly interpretable in a direct way. Appropriate analysis and visualization tools must be used to evaluate such data and to display it in a well-understandable form. Figure 6 shows the visualization tool FUNSSEL [Arnold et al., 2002]. In addition to the players' positions, information about their internal states can be displayed directly.

However, there is at least one crucial problem which makes it difficult to use RoboCup Simulation League scenarios at their present state in sport science: Things and concepts that are rather easy to learn for typical human beings are quite hard to program. Whereas it is somewhat clear for a human player what is meant by, e.g. "passing to open space", it is hard to objectify such concepts mathematically and to code them into a computer program.

Therefore, one will have to wait until such abstract concepts stemming from real sport will either will be learnt by the agents by means of adaptive algorithms from Artificial Intelligence or be transferred directly to hard-coded computer programs. Indeed, there are attempts in the RoboCup community to formalize and incorporate soccer theory aspects from sport science literature (as [Lucchesi, 2001]) into RoboCup scenarios [Dylla et al., 2004]. Higher-level description languages like the text-based *Extensible Agent Behavior Specification Language*, XABSL [Lötzsch et al., 2004] or the graphical *UML statecharts* will most probably turn out to be important tools to proceed in this direction.

Of course, like in most interdisciplinary projects, cooperation between sport scientists on the one hand and RoboCup specialists on the other hand might be difficult in the beginning due to differences in terminology and the basic concepts. However, it is to be expected that an exchange of ideas and methods can be fruitful for both computer science and sport science.

If such a cooperation results in RoboCup scenarios where the agents are controlled by mechanisms which explicitly incorporate high-level concepts from sport science, these scenarios might be a useful tool to test theories from sport science under "laboratory conditions", i.e. under well controllable conditions which – in contrast to real soccer scenarios – can be arbitrarily tuned, reproduced and the events of which can be recorded in a meticulous way and easily evaluated and visualized.

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