TacTowers: An Interactive Training Equipment for Elite Athletes

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ABSTRACT
The interactive training equipment, TacTower, is aimed at supporting multiple elite athletes, such as handball players in training their micro-tactical skills in close-contact situations. It focuses on psychomotor abilities and trains the skills involved in reading the opponents' actions and anticipating the outcome while reacting accordingly. The TacTower prototype will be demonstrated live, and here we summarize the main design issues, to give the reader a sense of how the elite sports context stands out from other interaction design domains. There is much potential for interaction design for the elite athletic community, as this domain holds interesting challenges while also inspiring relevant, new forms of interaction design for other domains.

Author Keywords
Kinesthetic Interaction, Kinesthetic Empathy Interaction, elite sports, team sports, competition, motivation, social interaction, playing field, interaction space

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Merging the context of elite sport with the knowledge and experiences from HCI and interaction design is a promising domain for interaction design research. The high expectations for precision and relevance within this context call for new technologies and interaction techniques that can meet the demands for motivation, skill training, transferability etc. Working with elite athletes can drive research to new insights, while at the same time give the athletic community technologically supported ways of training especially so-called 'open skills'[4, 10] – improvisational skills used in response to e.g. the unpredictability of a human opponent. This general intention is exemplified in the concrete design of the TacTowers prototype from the research project iSport, at Center for Interactive Spaces. The project explores the possibilities and challenges for utilizing interactive technologies within a competitive elite environment as means to improve the athletes' psychomotor abilities. Psychomotor abilities are the cognitive part of motor learning which is otherwise difficult to engage in training sessions. TacTower prototype (figure 1) is developed for Team Handball players, based on the notion of kinesthetic empathy interaction [7] and partly inspired by [2]. It is an interactive sports equipment that can train the athletes' skills in reading opponents' offensive and defensive actions while in active play. Kinesthetic Empathy Interaction is utilized to bring the kinesthetic aspect of the social interaction into focus. By using this type of interaction, in the development of the installation, the goal is for the players' movement actions generated through the system to continuously change according to the person they are training with and for the system to be able to accommodate and push this change.

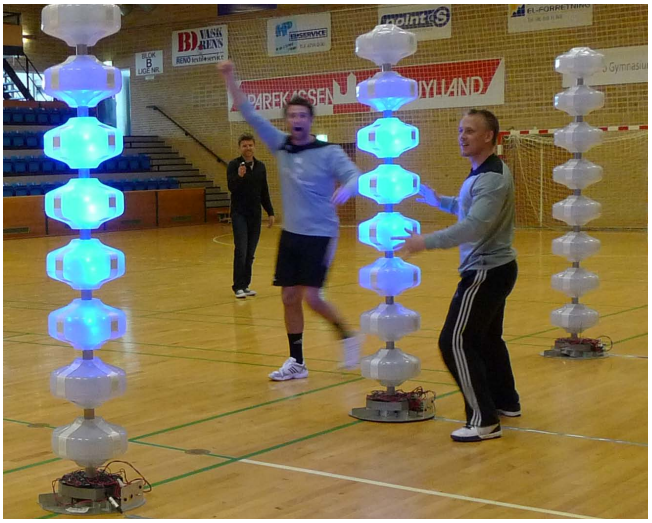

Figure 1: TacTowers for elite athletes – a competitive way to train micro-tactical skills one-on-one.

By working with a sports context as our research domain we aim to go beyond using kinesthetic interaction for purely pleasurable, entertaining or children-oriented purposes. This domains have sofar been the main focus of much kinesthetic interaction research, including our own, since engaging the body easily is extended into these do-

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mains. However, we believe that designing for bodily intelligence can be applied and explored in many different domains and the elite sports domain sets alternative demands for the designs we are able to develop. In order to unfold the potentials of the design space without being elite athletes our selves, the project has been developed with a research-through-design [19] process, going through a range of designs leading to the final design of the TacTower prototype. The process has gone through a number of workshops and prototypes[3] at various levels of complexity.

RELATED WORK

Technology is already widely present within competitive sports, and has played an important role in advancing sports for example in the design of new sports equipment, developing laboratory tests, as motivation for play and game, improving training exercises and in the training of closed skills. In relation to interaction design the focus has mainly been on developing laboratory tests, video aide e.g. [15], virtual reality [1] or training equipment that focus on improving close skills of athletes. Close skills take place in predictable environment where the performer knows exactly what to do and when to do it e.g. a free-throw in basketball.

In the gaming industry, games are becoming more physical and the competitive aspects of sports are used for entertainment. With the Nintendo Wii™[18], the players control the action on the screen by applying different movements. Sports is used to frame fun, engaging experiences for the users by using the body as a tool for interaction. Though tempting, the problem with directly using the principles of the Wii™ in an elite sporting context is that the computer interprets and translates the interaction between the players. The players' moves are abstracted into a limited set of options and converted into on-screen actions. Furthermore, the players are only peripherally able to pick up on the opponent's intentions visible in his movements, since the two players are placed sideways from each other. As in the Wii™, the objective of the research prototype Table Tennis for Three [13] is social interaction. The difference is that in Table Tennis for Three the opponents have direct visual contact via one another via a video link. Through the video link the players are able to see the intent in movements made by the other players much in the same way as in a "real" interactive sport. Still this is very far from playing the actual game of table tennis since the ball is hit against a wall instead of another player. Some aspects of the game could possibly be transferred into a training situation as target practice and the other players' existence would function as a motivating factor.

The Octopus Trainer [17] is an example of an interactive sport equipment used to train reaction time and speed primarily for handball goalkeepers and badminton players. The movements facilitated by the Octopus Trainer are the same as the ones executed when playing the actual sport. Since the indication of the "ball" comes from lights turning on and off there is no relation to other players, which creates an artificial environment far from how the situation would look in a real match. In a match, the goalkeeper would have the shooter's movements and statistical information to rely on.

Whereas the other examples mentioned all focus on improving closed skills, the IntelliGym™ [16] is a screen-based training system designed to improve the tactical aspects of basketball and hockey. The cognitive training consists of a variety of brain exercises designed to improve performance of real-time decision making, anticipation, concentration, attention-span, team-play, fast response time and 'court sense'. The IntelliGym™ allows the users to train game perception individually in an isolated context by replaying scenarios on the screen with simple mouse-clicks.

ELITE SPORTS – THE DESIGN CHALLENGE

When designing interactive sports equipment targeted at elite athletes a range of design challenges emerge. The designer is faced with the clear-cut and non-negotiable goal that the users have to become better athletes from using the equipment. We have defined the 'elite' as top-division teams and players at national level. In our case we have worked with team handball players from both junior teams as well as senior players from the Danish championship league. If it is not apparent to these world-class professionals why the training will prove fruitful or if the kinesthetic development fails to appear, the athletes will quickly loose interest in using the equipment. Within other domains where the body is used as a tool for interaction we do not see the same demands because the goal of the interaction is not necessarily bodily development. In these types of domains the body is more often used as mean for reaching a higher goal [8], like creating a giving learning experience [9], doing a collaborative search [6] or creating a playful game [12,18]. In the following we characterize the most important challenges we have faced and uncovered for designers entering this domain.

Measurable skills vs. non-measurable skills

For top athletes to try out new types of training methods the positive effects have to be sufficiently documented and tested to convince the athletes that this training will give them something extra. In interactive sports there is more to being a successful athlete than being able to perform one isolated skill perfectly like a javelin throw or a Fosbury Flop. These athletes know they can learn new skills through a playful training approach. The predicament is that open skills concerning Kinesthetic Empathy Interaction are dependent on another person and thus non-measurable to any objective scale and normally these types of skills are trained while playing the actual sport. By singling out the close combat situation, it is possible to focus the training on improving open skills without the athletes having to concentrate on all the other aspects of the game. In this type of interaction the computer should fall into the background and solely functions as a facilitator[10] of a dynamic interaction - not only as the measuring timer.

Motivation

Top-athletes' uncompromising commitment stems from their love of the game and the satisfaction they get from setting and achieving goals[4]. Yet, continuously keeping athletes highly motivated is a key challenge in any sport, for any coach. One key observation we were surprised to make is how playful the training approach is, even at the highest elite level. We had expected to see more drills dedicated towards the training of specific skills. Instead discovery learning [5] is used to encourage athletes to find and assemble their own unique solutions to given tasks. Through this learning process the athletes are able to concentrate on exploring potentially important new sources of input and solutions to ever changing tasks, as opposed to merely satisfying demands prescribed by the coach. The design of the TacTowers and its games allows athletes to freely explore new movements, micro-tactics, timing and feints and find their own solutions to the continues number of task presented to them.

Transferability

Another key element to the success of the design is whether or not the interaction style transfers into the sport in terms of physical performance and in how movement choices are made. If a single skill, e.g. reaction time is isolated, the design run a risk of creating an artificial environment where the interactive element inherently present in the sport is removed. Instead it becomes one person *re*-acting to a computer. In our vision the movements performed, while interacting with the equipment, resemble the ones executed in the sport under as close as possible similar conditions.

Scaling and adaptability

Evaluating the TacTower prototype also identified a design challenge concerning scale. In order to cater to different types of elite players we had to support a flexible configuration of the interaction space, where the coach can define the size, scale and difficulty of the training setup. This, in return, affects the measurability and reproducibility of the results from playing and using the training equipment, as mentioned earlier. However having a flexible setup is important in order to allow coaches to adjust exercises to the individual players or new challenges, and it makes the TacTowers usable to a range of elite athletes from the 2.10 meters tall male players to 1.65 female junior players.

TACTOWERS

The TacTower prototype, being demonstrated, creates and facilitates a playing field of interaction where the user has to focus on the opponent and his movements while playing the game. In all games one player's moves and planned actions are closely depending on what the opponents does; how he chooses to jump, where he hits a tower etc. In the interaction with the towers both fine and gross motor control is used which ensures that feints can be made by pretending to hit the ball in one direction and then in a split-second change direction by a swift turn of the wrist. The elite athlete needs to observe the position, direction and speed of the ball while using his split-vision skills to constantly monitor the opponent. This closely resembles the interactive play of the close-contact situations in e.g. handball and other similar sports.

The TacTower prototype consists of four towers with eight plastic balls, stacked on top of each other and held together by a steel structure inside. Each ball is a little larger than an actual handball to accommodate this structure, and it is both an interaction surface and a display. Twelve touch sensors are placed in four bands set perpendicular to each other, as seen from the top and each ball contains 8 RGB diodes and is used as the display surface for the game. The interaction style is as hard and tough as one would play on the handball field. The ball is hit to make the "ball"-signal move sideways and up and down the TacTowers. Hitting a lit ball horizontally can send the light signal in the direction of the hit onto another tower. A hard slap sends the light signal two or three towers down the line, depending on force and the game.

Figure 2: TacTowers with a game of 'Extinguish'. The challenge is for red player to turn on as many red signals and to turn off the opponent's blue light signals. The first to reach 7 wins.

We have developed a range of games and are currently running tests with two elite teams to get feedback for making new games and refine the ones we have. One example of a game is already mentioned briefly under figure 2. Another game is "Blocker" (figure 2) where one player controls the "ball" as a blue light signal and his objective is to get the ball into a goal zone (red light signal). The opposing player uses two "blockers" (yellow lights) to defend the goal zone and corner his or her opponent.

In most games the towers are lined up to form an interaction surface, inscribing a linear interaction space where sideways movements are trained along with split-vision. The TacTowers are 2,25 meters tall, with touch sensors at the lowest 0,25 meters above the floor. This affords both jumping and bending movements executed at high speeds and continually during the game, pushing the athletes physical abilities to the edge. In order for the athlete to hone psychomotor abillities to new levels, it is necessary to apply

open skills during intense physical training [14]. As the TacTowers can be positioned with varying distance they can be used at different levels of elite training.

In other games the TacTowers may be positioned in a rectangular playing field. These games are basically about defending one or two towers and changing positions or roles according the flow of the game. Here the interaction and movements are more focused on close physical interaction as guarding a tower requires tackling and holding, and from the offensive position requires feinting and using physical strength and surprise to get passed the defense.

DISCUSSION AND FUTURE WORK

By including the empathic aspect in the kinesthetic interaction, we have developed the notion of the playing field as an interaction space. This connotes how the computational elements is defining a field or background for the human interaction, and as such facilitating a space for interaction rather than prescribing it.

The TacTowers utilize Kinesthetic Empathy Interaction in creating a piece of training equipment for elite athletes exercising their interaction skills in relation interactive sports. TacTowers have been tested with two national league teams. Results from these tests have preliminarily given us an understanding of how the TacTowers fit into the training cycle of the elite athletes and how well each of our designed exercises worked out. The expert elite athletes gave us feedback on both the physical and interactive design of the TacTowers and our current games, as well as ideas for developing games to fit needs we have not yet seen. On the basis these tests we will be able to redesign and improve games, as well as establish how well we have managed to design a system that can train the athletes' interactive, in-game abilities. After this we hope to do prolonged testing and integrating the TacTowers into the fabric of daily training over a period of weeks. One aspect of this we have already seen is that the TacTowers can be used outside the normal team training in the same way as the weight-lifting facilities, which means that the motivational aspect of the games becomes even more important.

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