Tactile feedback in real life sports: a pilot study from cross-country skiing

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ABSTRACT

We describe the research challenges of bringing HCI into the domain of sports, and what research in this domain can add to the general questions multi-modality and sensor-based interaction. To illustrate this, we present results from a pilot study on providing tactile feedback to cross-country skiers. Our results show how real-time feedback can be provided for a variety of purposes without disrupting or disturbing the actual sporting experience

ACM Classification Keywords

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

Keywords

Multi-modality, sports interaction, tactile feedback, skiing.

1. INTRODUCTION

At her keynote speech at CHI 2010, Genevieve Bell pointed to sports as one of the domains that have been largely forgotten in Human-Computer Interaction (HCI) research, even though work is starting to emerge. We argue that HCI research in sports could contribute to the general problems involved in how to develop interaction models for a range of complex and variable settings where traditional hand-eye interaction is not sufficient., as well as to current concerns in exploring ways of designing for various kinds of bodily experiences [5,10,11] Sports and physical activity provide challenging examples of such settings, and design principles and interaction techniques are potentially transferrable to other mobile domains, such as social and leisure activities in nature.

Most readily available sports technologies, such as sports watches and GPS-devices, rely on the use of physical and physiological data as indications of measures of *individual performance* and not so much for other dimensions such *personal or social experiences*. We argue that a research on HCI in sports should align with current strands of experientially oriented research [6] by addressing performance in concert with aspects such as flow, rhythm, joy, sociality, and context. This involves a strive to gather and portray physiological and biomechanical measures in a way that opens up the possibilities for interaction by incorporating *user interpretation*, rather than attempting to exactly model people's performances and communicate objective information about the activity. This will allow users to connect performance measures to the particular social and physical context and to the individual's subjective perception of the whole activity.

We claim that an interpretative approach allows us to design interactive technology that users perceive as more robust and trustworthy in the fast paced and dynamically changing situations that sports usually involves. Thereby it reduces the risk of breakdowns in the interaction due to limitations in underlying computational models and provides resources for users to construct a subjective experience that allows them to improve their athletic performance.

To achieve this we need to address three important research areas:

- *multi-modal forms of interface representation* that augments the performance and experience of sports and physical exercise. Critical elements is to allow for interpretative representations, account for combinations of modalities, and how they map to the temporal, spatial, bodily, perceptual, and social aspects of the activity.
- *multi-modal interaction mechanisms* that allow users to interact with technology while still being fully engaged in the experience of the activity in real-life settings, thus leveraging on the sporting activity as an integral part of the interaction, taking advantage of the possibilities offered by light-weight sensors, actuators and mobile devices.
- *data modeling techniques* of physical and physiological data, exploring how data sets from individuals can be meaningfully analyzed in order to be integrated with interaction mechanisms and representations, as well as shared and used in social and collaborative activity.

Here, we will relate this research agenda to the existing literature, and describe preliminary work on interaction mechanisms for sports activities illustrated by results from a pilot study on vibration feedback for cross country skiers. This is the first step for in exploring design for movement and physical activity in sports, as well as how to design for dimensions of optimale performance and personal user experience in concert.

2. RELATED WORK

2.1 Sports Technology

Interactive technology has been used for a long time to enhance athletes' performances in sports. Success in sports at the highest level is a matter of millimeters and milliseconds. Until recently this development has focused on how to optimize performances in sports, while we now start to see approaches that bring in social and leisure oriented perspectives on body metrics and other forms of physical and bodily data. We argue that there is a need to further widen this towards experiential perspectives in the design of light-weight technologies for sports and physical exercise, since these activities involve more than giving feedback to people based on physical and physiological measures. There is a range of different technologies that have successfully taken advantage of the possibilities offered by novel sensor, actuator, and recording technologies. These have contributed to pushing athletes' performance to higher levels as well deeper understandings of how to design for such settings. These technologies range from video analysis tools and advanced motion capture systems for experimental studies of athletes' movement pattern, to pulse-bands (Garmin, etc), mobile applications (Runkeeper), and light-weight sensors worn in shoes or clothing (Nike+) available on the commercial market. Research has developed technologies to support detailed aspects of sports techniques such as running mechanics [2], and balance and weight-transfer in snowboarding [6]. However, most of these have focused on how to improve specific details of the performance and many have been designed for testing and experimentation in laboratory settings. There is still a limited set of technologies that can easily be used in the field. To further expand on this research there is need to design technologies that embrace a larger perspective on performances in sports and physical activity. This is in line with some previous studies of recreational athletes [8,10] that show that the experiential (social, intellectual, emotional, and bodily) side of the performance is a key aspect as to people's engagement in the activity. These are also aspects that are emphasized in sports psychology [4] and flow-theory [1] regarding what creates optimal performance. The notion of flow has also been one of the fundamental dimensions explored in experience oriented design approaches. In most sports technology research performance and flow have been separated, even though athletes and coaches often emphasize exactly this connection [4]. Central research challenges thus include how to design technology that combines performance measures, emphasized in sports technology, with experiential aspects, emphasized in sports psychology.

2.2 Interaction

With the development of inexpensive and accessible sensor-technology we have seen a growing interest in designing interaction based on users' movement. Interaction along this line of research range from gesture-based interaction around stationary devices, multi-touch interaction for mobile screen based interaction, to more open-ended forms of interaction for dance and music making [5,3]. Furthermore, numerous explorations of technology illustrate novel multi-modal approaches for interaction, such as the eMoto pen [9] for bodily emotional expression, or BodyBeats [12] for dance-based music creation. A critical aspect in designing for body and movement is to expand the modalities used for input and output. To design working interaction for people engaged in physical activities such as walking, running, or swimming, we cannot rely on visual or screen based forms of interaction, but need modalities that also engage non-visual senses such as haptics, tactility and audio. Research along these lines have for instance investigated how to provide audio-based feedback to people in movement [2], and the use of tactile feedback in sports and recreational activities such as tactical guidance for soccer players, body posture feedback for speed skaters and cyclists [11], and performance of specific movements in snowboarding [7]. However, much research along these lines has focused on how to design for interaction based on one specific modality such as sound or tactility. To expand this line of work, we need to address challenges on how different modalities could be combined in terms of the temporal, spatial, bodily, perceptual, and social aspects of the activity. Critical aspects that need to be explored include where the feedback should be presented, how to present it, in which modality, and at what time. The combination of these is crucial for the unfolding of the interaction and for the integration in an activity as a whole.

3. PILOT STUDY

As a starting point for exploring how to design interaction for sports activity we conducted a pilot study on vibration feedback with cross country skiers. The aim of this work is to design technology that gives skiers real-time feedback on their skiing technique out in the field.

3.1 Study Setup

The study was carried out at the Swedish Winter Sports Research Centre in Östersund, Sweden. Four Swedish elite skiers participated, recruited by test leaders at the research centre.

The purpose was to explore how vibrational feedback is perceived *during* a sport activity, to what extent it integrates with or disrupt the experience, and how the perception of vibrations are affected by physical activity, and vice versa.

The skiers were equipped with a cell phone strapped around the chest, and skied on a treadmill using different skating techniques at various speeds and inclinations for approximately 30 minutes each.

Different vibration signals were remotely triggered in the phone attached to the skiers' chest. Signals varied in length and repetition. They were all were of the same strength (internal to the phone). Skiers were instructed to acknowledge and comment on the vibrations when they felt them. A post interview was carried out after the skiing session. The whole session was video and audio recorded.

3.2 Preliminary Results

Overall, the skiers were very positive to the idea of vibrational feedback on their skiing technique. They all said they clearly perceived the vibration, and did not describe the experience as intrusive or distracting. Several of them would have preferred a stronger more distinct vibration to make it easier to perceive while focusing on the skiing at higher level of fatigue.

As stated above, the vibration strength did not vary during the session, but the skiers expressed that they had experienced variations in strength. Possible reasons for this could be variations in tension in the upper body as well as variations in focus and concentration in different speeds and techniques, and different levels of fatigue. For instance, one of them said that *you need to be really focused to ski fast, so you block out a lot of stuff.* This suggest that the strength should possibly be increased as skiing intensity increases, but also, that the feedback should not attempt

to involve to much information as it may disturb the focus of the skier, thus, potentially being contra-productive.

The skiers believed that vibration feedback on their skiing technique would be helpful during training sessions. In particular, they foresaw using it during high-intensity sessions where they would be especially focused on maintaining a correct technique despite a high-level of fatigue. Moreover, they reported that the skiing technique in general is more in focus at higher workloads since that is when loss of technique is most costly. Consequently, it would be in these situations that skier would benefit mostly from interactive training support. During slower skiing, the technique is usually less critical so feedback would not be as valuable.

Examples in which they mostly themselves saw the usefulness of real-time feedback were technical details such as the transferring of weight from side to side, keeping the appropriate angles in hips or knees, to help keep specific technique training details in mind, and to be reminded of thinking about technical improvements that they could be working on.

The skiers also saw connections to video analysis, motion capture and other interactive tools that they use to analyze skiing technique. Such tools could be used to reveal important details that need improvement. Combined with real-time feedback mechanisms in the field, these could then be used to prompt skiers to think about those details and keep them constantly in mind during training sessions.

4. FINAL REMARKS

We have presented initial results from a pilot study on the design of real time vibrational feedback in sport activities. Overall, this works targets design of services for movement based and bodily engaging settings in the wild. Our overall conclusion is that well designed real-time feedback can be provided for a variety of purposes without disrupting or disturbing the actual sporting experience. Moreover, even though the feedback we provided were relatively basic, the athletes saw usages that went beyond what we had foreseen when designing the study. This points to the possibility of using simple, easy to use devices when designing for a complex settings and activities.

We are currently expanding this work by designing a series of prototypes in domains with various characteristics (cross-country skiing, golf, horseback riding). This work will entail explorations of real-time feedback based on data modeling and analysis techniques for sports and physical activities, by drawing on sensor-based data as well as data generated from social media and data sharing techniques. This will allow us to build more complex services while relying on the computational and interactive possibilities of smart phones and cloud computing.

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