Putting the Coach in the Loop: Improving Practice in Outdoor Activities Through Technology

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Abstract
Outdoor activities provide many benefits, including physical and mental health, skill acquisition and social development. Wearable devices that measure activity data, such as GPS position, speed or heart rate, can potentially help users improve their performance. For this purpose, current systems either present data to the user, or have an expert system evaluate it and provide recommendations. But both these approaches leave out a key player: the expert coach. Expert mentoring has an important and irreplaceable role when it comes to making decisions to improve performance. We argue that in order to effectively improve performance, systems that use wearables to capture data during outdoor activities should provide useful visualizations to experts when these are available.

Author Keywords
Outdoors; Sports; Sports Tracking; Wearables; Expert Feedback; Coaching; Performance Coaching

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

Introduction
It goes without saying that outdoor activities have a myriad of benefits for physical and mental health. Physical inac-

tivity, defined as less than 30 minutes of brisk walking per day, increases several causes of mortality: cardiovascular diseases including hypertension or stroke; metabolic diseases including diabetes or obesity; several types of cancer including breast, prostate and pancreatic; pulmonary diseases such as asthma; immune dysfunction; musculoskeletal and neurological disorders (see [1] for a review).

One of the goals of performing outdoor activities, e.g. running, hiking, cycling, skating, skiing or open-water swimming, is training to improve performance. For this purpose, wearable devices that can measure a wide variety of data bring new opportunities. Current systems though, follow one of two approaches: they either burden the user, making him interpret data on his own and take action, or use an algorithm to make decision for the user. But these approaches leave out a key player for improving performance: the expert coach.

Imagine having to interpret the results of a medical test, such as an electrocardiogram, to make recommendations for improving your own health. Or having to interpret the results of a personality test to determine the changes you should make to reach your goals. When we are left to interpret our own data, and we do not have the necessary knowledge to do so, we might make inaccurate decisions or have a biased perspective, falling for confirmation bias [11]. Expertise becomes crucial when making not only a decision, but the right decision. So why is it then that research and commercial system haven't given experts a center role when it comes to improving performance in outdoor activities? We argue that systems that use data from wearable devices and aim at improving performance should include experts that can access and interpret activity information.

Coaching and Its Benefits

Lyle [4] distinguishes between two types of coaching: participation and performance. Participation coaching is less intensive, usually not systematic, and not all of the performance elements (e.g. strength training or technique) are attended to. Performance coaching has competition goals, longer-term horizons, significant athlete commitment and an attempted control of contributory variables. In this position paper we refer to performance coaching, although the ideas could be applied to less intensive coaching for amateur athletes, as long as their goal is improving performance.

McPherson and colleagues have long studied expert and novices in sports, mainly through tennis [9, 6, 8]. They find that experts learn to solve problems in a more sophisticated manner, having developed cognitive structures for this purpose. Experts generate more plans for action than novices, which are more varied and with more sophisticated goals. In contrast, novices show minimal planning strategies and poor interpretations of events, focusing on the moment and developing weak solutions to current problems [7].

Performance coaches develop and improve the individuals' performance. Their expertise is domain-specific, they recognize patterns faster than novices, their knowledge is structured and easy to recall, they are more flexible, more able to adapt to situations and take deeper meanings from cues than novices [10]. They have both procedural and tacit knowledge that allows them to make correct decisions.

Supporting Outdoor Activities with Technology

Wearable devices that can measure outdoor activity data are becoming more available and affordable. They include sensor such as pedometer, accelerometer/gyroscope, GPS, heart rate monitor and temperature [3]. Research has

looked into using the data from these devices to improve performance mainly in two ways: by having the user make decisions based on his own data, or by having a system provide recommendations based on automatic analysis.

Some systems record user data during outdoor activities and show it to them in real time. *RunRight* [12] shows a live visualization of a runner's body movement so that they can correct their posture. Stienstra et al. [16] propose a system for professional speed skaters that measures speed-skating strokes and provides auditory feedback, as a way to present complex information that the skater can use to improve his technique. The *sonic golf club*[1] is a system that provides auditory feedback to improve the swing during golf. These systems rely on the user having the sufficient knowledge for decision making, which is not always the case.

The second use of the data is to have it analyzed by a system that acts as a virtual mentor and provides recommendations for improvement. *FootStriker* [20] senses the contact point of the feet during running and gives feedback as electrical muscle stimulation, so that runners avoid striking with their heels. *Around Me* [17] is a robot that follows a person while it jogs (from the front), and provides a real-time visualization of the ideal jogging posture so users can adapt their posture. Spelmezan & Borchers [14] proposed a system that measures forces applied by the feet during snowboard and provides feedback on the posture.

Sensor data can also be used by a coach as part of the decision process for improving performance [3]. But this has only been recently introduced in HCI. Wakefield et al. [18] interviewed coaches to determine which data they collect from athletes and how they use it. They identify that recording data is tedious for athletes, and that it can be difficult for coaches to read, parse and understand it. Sharing data is cumbersome as many times this happens face-to-face. Athletes sometimes forget to present some of the relevant information, and even if they use a journal, they may forget to record data or do not know exactly what data are relevant to record in the first place. This qualitative study shows that there is a need for data to be exchanged between athletes and coaches. Nevertheless, specific data needs for coaches to provide useful feedback towards improving athletes' performance remain unstudied, as well as how can technology support this process.

The only published work in HCI, to my knowledge, of a system that aims at coaches providing feedback to athletes, is in the context of snowboarding practice. Spelmezan et al. [15] designed a system for improving snowboarding, where a trainer can provide live feedback to a novice by giving him electric stimulation. This study though, aimed at determining how accurately athletes can interpret feedback, and did not study how coaches could visualize and analyze data during decision making. Their prototype was one-way as the expert could provide feedback, but there was no sensory data that an expert could see.

Some companies in industry are starting to produce hardware for professional rugby and american football teams, that can measure in real time fatigue index, collision load and distance covered, as recently reported in the news[2]. Decrease in injury and improved performance are reported, but research that can validate these claims is still missing.

Discussion

With the increased availability of wearable devices, various types of data can be recorded automatically. This opens the possibility for both live and offline coaching. Live coaching

[1] www.sonicgolf.com

[2] http://www.bbc.com/news/business-36036742

is a challenge for outdoor activities as these usually involve moving through long distances. Following every athlete is physically demanding, thus systems could take advantage of real-time data from wearable devices and enable remote live coach feedback to improve athletes' performance.

In running, coaches could provide real-time feedback on stepping (as *FootStriker* [20]) or posture (as *Around Me* [17]). During swimming, feedback could include breathing, arm movement errors and upper and lower body coordination, which are some of the problems in the crawl technique [5]. Data logging though, does not need to be restricted to an automatic process, as technology can assist manual logging. For instance, smart glasses could be used to log data such as Rated Perceived Exertion (RPE) [19].

Outside of training sessions, other important data can also be automatically recorded such as average heart rate, step count and sleeping time. These data can later be used along with that of the activity when developing long-term training plans. Data sharing with current technologies can happen transparently for both the athlete and the coach. But in order for coaches to make correct choices, systems need to present all the gathered information in a way that is easy to understand. Systems need to create useful data visualizations that satisfy coaching goals.

Lastly, besides improving practice, having data to support decisions can bring additional benefits for coaches, for instance in understanding the rationale behind their decisions. Coaches are many times seen as "masters of the instantaneous response" [2], making decisions based on intuition. Research has recognized that there is value in studying the *why* and *how* of coach behavior, and not only the *what* [13]. Many existing courses for coaching however develop "parrots" that mimic the instructor, and evaluate candidates on their ability to do so. But a pedagogic approach based on data that makes transparent the rationale behind decision making would be more successful than the current approach that relies largely on luck [10].

Conclusion

Digital devices that collect data during outdoor activities have a great potential for improving performance. But so far, systems have largely neglected performance coaches. Research has focused on providing the user with visualizations for making decisions on how to improve, or on automatic systems that make these decisions for the user. We argue that we should aim for systems that provide useful visualizations of athletes' data to coaches. Experts of outdoor activities can provide valuable and useful feedback to athletes that want to improve their practice if they have access to their data. This feedback can be in real-time while the activity is being performed, or after the activity in a retrospective analysis.

Because outdoor activities, such as running, cycling or skiing involve traveling, technology can help to bring the expert closer to the person performing the activity. Video feeds, position data, speed, heart rate and other measures can all be sent to the coach in real time for live feedback, or be recorded for later analysis.

Given the findings presented in this paper and the open design space, we plan to pursue qualitative studies to identify the data needs of performance coaches for improving performance. Then, we plan to explore the design space of future systems that gather and present this data to coaches, with the goal of prototyping and testing one or more prototypes. Ultimately, we plan to create technology that helps people become better athletes. we look forward to the possibility of discussing these topics with others as part of workshop activities.

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