Recording and Sharing Non-Visible Information on Body Movement while Skateboarding

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ABSTRACT
Knowing your own body movement is an essential element of sports. Recently, the popularization of smartphones has enabled people to easily record their performance in most situations. However, these observations have limited applicability in assisting with a clear understanding of body movement. In this paper, we propose the Motion Log Skateboard, which records and shares non-visible information about body movement that is difficult to obtain through current observation methods in skateboarding. A pressure-sensor matrix on a skateboard deck is used to record the pressure distribution data, which are then played using the video function of a smartphone camera. With this logged data, a user can access the feet positions, pressure intensity, and timing of the foot movements. To verify the proposed concept and determine the specific context of its use, an experimental session and interviews were conducted with skateboarders of various skill levels. Based on the results of this research, the shared experiences of non-visible information, which is perceived differently depending on the individual, are expected to become a standard for exploring and training body movement.

Author Keywords
Sports interaction; representation; body movement; body perception; skateboarding; sports learning;

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

INTRODUCTION
In sports training or learning, proper logging and analysis of movement are considered useful. Understanding one's own body movement can affect performance, safety, and even motivation for an activity [8, 21]. People review and modify their body movement through various sensory information, such as hearing, vision, and the proprioceptive senses. Recently, the popularization of smartphones has enabled people to review their sport activities with various sensors high-quality video cameras, not just their own senses. Smartphone cameras are used to record and analyze movement in sports, not only by professional athletes but also ordinary people who enjoy sports in their everyday lives [12]. By playing back the recorded video at various speeds, people can carefully review how they moved. They can also upload logs of their movement to the Internet to discuss their body movement with others and consequently improve their performance. Despite these advantages, however, existing video recording has clear limitations in terms of obtaining information. Information from video recording is limited to observation of the external appearance of the body. However, the information the user actually desires is non-visible in nature and difficult to perceive through external observations, such as video recording. In this study, we focused on this non-visible information about body movement as our research domain. In addition, most of this non-visible information is directly related to performance of the movement. For example, information on the force transition at the impact point or the direction and intensity of the power a user applies cannot clearly be perceived from a video recording or observation by a colleague.

In this research, we studied non-visible information on body movement during skateboarding, which is hard to collect with existing video recording. By developing the Motion Log Skateboard system, pressure distribution on a skateboard deck, the primary element in skateboarding, was logged and provided along with recorded video. Based on this additional information, we expected skateboarders to be able to enhance understanding of their body movements and establish a standard for exploring body movement through skateboarding trials. Five skateboarders of various skill levels were recruited to try a Motion Log Skateboard prototype. The system was evaluated and discussed with a focus on sharing non-visible information. In this study, we examined the design possibilities of sharing and comparing non-visible information on a sports experience that is visualized by an interactive system.

RELATED WORKS

Providing information on body movement during a sports experience
Various studies on human–computer interaction (HCI) have focused on providing body movement information through

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modality transfer. In the case of golf, many studies and a product have focused on capturing the foot pressure or swing traction via pressure and gyro sensors to modify the swing form of a golfer [7, 13]. Pijnappel proposed four design themes for skateboarding trick training by projecting traces of skateboarding on the wall. They explored various approaches for providing feedback on skateboarding [16]. Holleczek tested pressure insoles and accelerometers to define the needs for non-visible information in snowboard training [5]. Park developed a snowboard deck that can provide real-time visual feedback on weight distribution. It has the limitation of being a visual distraction; however, this feedback may be a hint for exploring body movement while snowboarding [6]. By sonifying a golf swing and visualizing the balance of each foot during jogging, Nylander presented advantages in mirrored feedback for sports [17]. In the exergame area, which is the integration of game and sport (or exercise), providing information on body movement is considered to enhance immersion and interest in the desired system [1, 2, 4].

Thus, providing information on body movement through modality transfer can be beneficial in sports. In this research, we focused on non-visible information that cannot be perceived by conventional observation methods.

Sharing information on body movement

Sharing information on body movement is already a casual part of everyday life. In the above cases of golfing and snowboarding, sharing information on body movement can be useful in lessons. The instructors and students can communicate by sharing visualized body movement [6, 7, 13]. In addition, many other sports use social networking services (SNSs) not only for real-time feedback but also as a system for sharing body movements. Strava provides an SNS for cyclists to share and compare various information about their cycling activity (e.g., heartbeat, speed, and cadence) [18, 20]. Nike SB is a mobile application for skateboarders who want to compete with other skateboarders by recording videos of tricks [11]. In addition, several tracking devices such as Syrmo [19], Tilt'n Roll [14], and Rideblock [15] enable skateboarders to record their tricks and share them with other skateboarders by using small sensors attached to the board.

From this literature review, we confirmed that people have a clear desire to share and analyze their body movement through comparisons with other people. At the end of this paper, we discuss the influences of sharing and comparing non-visible information in sports.

MOTION LOG SKATEBOARD

Skateboarding

Skateboarding is a typical extreme sport in which a person rides a wooden deck with four wheels. A skateboarder performs various tricks by controlling the feet and weight balance in short time intervals. Thus, the movement of the feet is an essential element in skateboarding. However, even if the skateboarder knows the mechanism of controlling the feet, a long period of time and many attempts are necessary to learn a desired trick. In addition, the time of performance is relatively short, approximately 1 or 2 seconds, and the movement should be very precise; thus, it is hard to gain information from ordinary observation. We expected that providing non-visible information on body movement in a dynamic situation such as skateboarding could help a performer perceive and explore his or her body movement.

Choosing non-visible information on movement in skateboarding

To understand the essential information on body movement in skateboarding and existing methods for learning tricks, an online survey was conducted (15 males, 3 females; average age: 26.7; SD: 3.5; various levels of experience; various types of boards). According to the survey results, participants considered balancing the body to be the most important element of skateboarding (72.2%). Participants answered that the positions and movement of the feet on the board could be information that is essential to achieving a balanced body. With regard to the video recording experience, most participants had captured or watched video clips to study skateboarding. We collected the 22 most-viewed video clips on YouTube with the keyword "skateboard tutorial" and reviewed the camera angles of each video clip. Our results confirmed that 20 out of 22 tutorial videos emphasized the movement and positions of the feet on the skateboard deck. Additionally, in the previous research on biomechanics, they implied the need for investigation of the cushioning and pressure distribution in skateboarding [3].

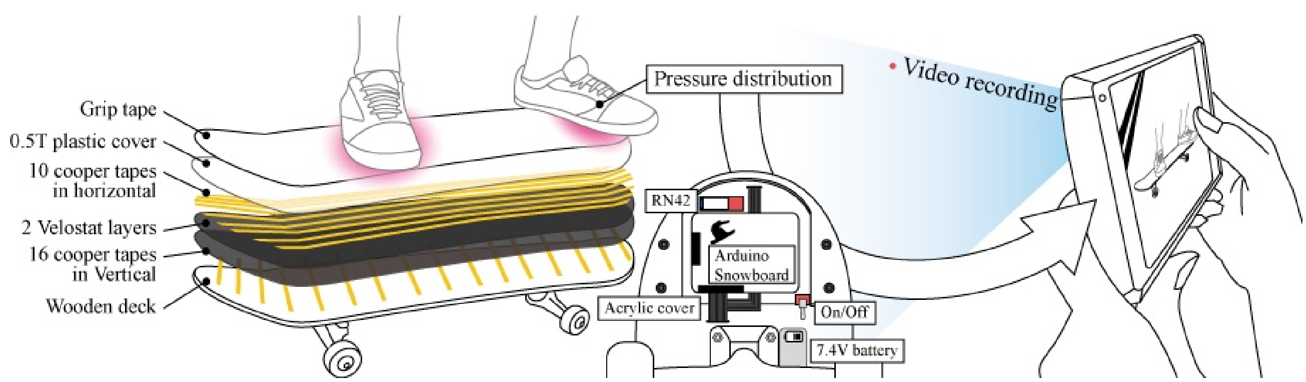

Figure 1. System structure and hardware settings

For the Motion Log Skateboard, we chose to provide the pressure and force distributions on the skateboard deck synced with smartphone video recording. With this, the user can get information on the positions, pressure, and timing of the movement for the feet.

Hardware

Figure 1 shows the hardware of the Motion Log Skateboard. A snowboard (Arduino kit from Kytronix) that had been optimized for a sensing pressure matrix was used to calculate the sensor data [10]. An RN42 Bluetooth module was selected to send the data to a mobile device. Two sheets of Velostat and 5 mm of copper tape were used to make the pressure sensor matrix [9]. In the current prototype, 10 horizontal nodes in 15-mm intervals and 16 vertical nodes in 50-mm intervals were used to collect pressure data from 160 points. This pressure sensor matrix has the advantages of thinness (less than 1.5 mm), ease of installation on an existing skateboard deck, and no effect on the safety or performance of the board. Moreover, this sensor matrix can be applied to various types and shapes of skateboards, such as longboards or cruiser boards.

Software

Visualization

The pressure distribution was visualized in heat-map style and overlaid on the skateboard image, as shown in Figure 2. Higher pressure appears in red, and lower pressure appears in blue so that the user can confirm the distribution intuitively. Based on the sensor data of 10 × 16 points, the pressure distribution image is visualized as 20 × 64 cells. Higher resolution can provide understandable foot shapes. We tested various resolution of data and explored several styles to represent it, and then, we chose this format.

Single review mode

Figure 2 shows the single review mode, in which logged data can be reviewed as recorded video and pressure distribution. The left side of the video displays an image of a skateboard deck and the pressure distribution data. We decided that the orientation of pressure data should be aligned with a boarder's first-person point of view. Sensor data and recorded video are synced and controlled by a timeline interface so that the user can analyze his or her body movement at various playback speeds.

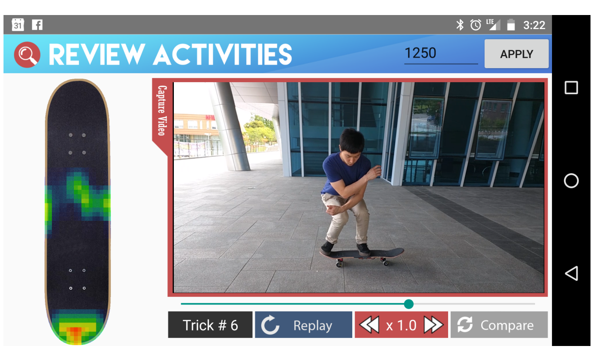

Figure 2. Single review mode of Motion Log Skateboard app

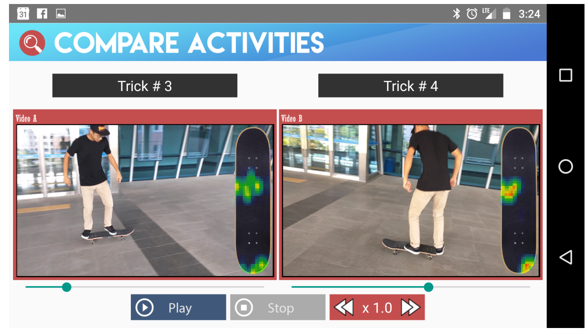

Figure 3. Comparative review mode of Motion Log Skateboard app

Comparative review mode

Figure 3 shows the comparative review mode, in which two sets of logged data are played at the same time so that they can be compared. The user can play his or her logged data for the movement of a trick along with another person's movement, such as a coach, colleague, or even his or her own past trials. The two sets of logged data can be controlled simultaneously. In addition, the timeline of each set of logged data can be controlled individually to help users compare their movements by matching the starting points of the performed trick.

USER STUDY

Study settings

A user study was planned to evaluate the concept and explore the scenario of using the Motion Log Skateboard. A total of five skateboarders (three males, two females; average age: 28.6 years; SD: 6.1; two beginners, one intermediate, two professionals) were recruited with skill levels from beginners to professional athletes.

The user study consisted of an experience session and an interview session. During the 30-40-minute experience session, participants performed given tasks with ordinary recording by a smartphone camera. Directly following that, they used the proposed Motion Log Skateboard system so that they could compare the two methods. To recall the various riding experiences, three tasks were given: "Push off and turn," "an easy trick for participant," and "a challenging trick for a participant." The tasks were decided based on the various expertise of the participants. Moderators recorded the participants' movement at the angles requested by the participants. After the session, the skateboarders were interviewed for approximately 30 minutes. The main discussion evaluated the prototype and specific contexts of its use.

Study Result

Utilizing the provided movement information

Most participants seemed satisfied with obtaining information from the proposed system. They answered that the provided information was perceived differently from their own perception. Additionally, it was useful in helping them to perform the desired movement of a trick. Due to the short time of the session, they could not accumulate enough information on what was correct or wrong. However, they could find differences between the perceived and actual movements. This led the participants to attempt more variations or modifications of movement in their next trials. Participants also compared the logged data of their trials in the comparative review mode. Participant 5 noted that comparing logged data can help with focusing on certain body parts in a self-training context. From these findings, we expect that the Motion Log Skateboard can provide users with "homework" to practice their body movements.

"After watching logged data of Motion Log Skateboard, I could try to focus on the movement of my feet rather than other body parts." – Participant 5, beginner

Comparing body movements in the context of lessons
The participants were most satisfied with the function of comparing two sets of logged data. Participants wanted to compare their own progress to practice a trick over the long term. In addition, all of the participants answered that they wanted to see the logged data of professional athletes who had already mastered the trick. Participants expected that this kind of objective comparison of information would be useful in a lesson context. In sports training or lessons, content is focused on delivering knowledge of moving and feeling body parts. In general, some essential information is perceived differently, depending on the individual. Occasionally, this difference in perceiving information may lead to miscommunication between the instructor and students. However, with the Motion Log Skateboard, this non-visible information can be transferred to a shareable format for both the instructor and student. For example, the instructors can have objective evidence of a student's incorrect movements and can thus make more reliable comments.

"Some students don't understand the instructor's comments about their incorrect movements. In that situation, this would be clear evidence." – Participant 1, advanced

Intuitiveness of visualization and amount of information
The Motion Log Skateboard provides pressure distribution to skateboarders to obtain non-visible information, such as positions of the feet, pressure, and timing. Some participants Do you mean "wanted to obtain more or other types of information, such as the axis of the shoulder or angle of the knees. Interestingly, in the latter part of the interview, they had conflicting opinions on the questionnaire about visualization methods. They said that simplifying the pressure distribution to foot-shaped images could make it easier to understand. They also wanted to focus on just one or two types of information at a time depending on the purpose and needs. This implies that the non-visible information on essential body movement was considered very useful, so they wanted to try to obtain more or other types of information. However, due to the cognitive workload, a simple and intuitive visualization makes it less of a burden to utilize provided information. Depending on the purpose or context of use, the designer should compromise between these two aspects: amount of information and intuitiveness of representation.

DISCUSSION
Despite the small number of participants, all agreed on the need for standardizing logged information on movement with large samples. There is no certain movement that can be called the "right answer" in skateboarding because positions of the feet and movements have different details depending on the individual and situation, even for the same trick. However, with this system, we can analyze the average pattern of pressure distribution based on a library constructed from plenty of trials. Comparing their own trials with these patterns, we expect that users can study the technical variations of their tricks, such as height or spinning timing. Through the process of comparing and exploring their own body movement, users can enhance their fundamental perception and interest of their body movement.

In this research, we confirmed that users want non-visible information about their sports activities, and with proper technological support, users can access this information to enhance their sports experience. We expected that the format of visualization and sharing information could be applied in other areas of sports. For example, in fitness activity, users might be able to identify the weight distribution or the muscle activeness of the desired part using visualized images to perform effective exercise and prevent injury. In racket sports such as badminton and tennis, it would be helpful when learning new techniques and modifying stroke form if the trace of racket movement or impact point was visualized and shared with the coach. Likewise, we will be able to explore the non-visible information needed for each sport or its specific purpose and define the design requirements for delivering this information properly.

CONCLUSION
We developed a novel system that can record and share the movement of a skateboarder's feet on a deck. This non-visible information about body movement, which is hard to perceive by one's self, is visualized in an objective manner so that the performer and observer can easily share the information about the performer's body movement. For further research, a long-term user study in an actual lesson context could help define a standard for qualitative body movement and develop improved visualization methods for sharing non-visible information on body movement. Also, the knowledge obtained from this could be extended to other sports areas. Through this approach, we expect that interactive technology could induce people to explore their body movement in sports experiences.

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REFERENCES

1. Daniel R. Mestre, Virginie Dagonneau, and CharlesSymphorien Mercier. 2011. Does Virtual Reality Enhance Exercise Performance, Enjoyment, and Dissociation? An Exploratory Study on a Stationary Bike Apparatus. Presence: Teleoperators and Virtual Environments 20, 1: 1–14. http://doi.org/10.1162/pres_a_00031
2. Florian "Floyd" Mueller, Darren Edge, Frank Vetere, et al. 2011. Designing sports: a framework for exertion games. Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11: 2651–2660. http://doi.org/10.1145/1978942.1979330
3. Frederick, E. C., Determan, J. J., Whittlesey, S. N., & Hamill, J. 2006. Biomechanics of skateboarding: Kinetics of the Ollie. Journal of applied biomechanics, 22(1), 33. https://doi.org/10.1123/jab.22.1.33
4. Hamilton a. Hernandez, Zi Ye, T.C. Nicholas Graham, Darcy Fehlings, and Lauren Switzer. 2013. Designing action-based exergames for children with cerebral palsy. Human Factors in Computing Systems: Proceedings of the SIGCHI Conference, (CHI 2013): 1261–1270. http://doi.org/10.1145/2470654.2466164
5. Holleczek, T., Zysset, C., Arnrich, B., Roggen, D., & Troster, G. 2009. Towards an interactive snowboarding assistance system. Proceedings of 2009 International Symposium on Wearable Computers – IEEE' 09: 147-148. https://doi.org/10.1109/iswc.2009.30
6. HyungKun Park and Woohun Lee (2016, June). Motion Echo Snowboard: Enhancing Body Movement Perception in Sport via Visually Augmented Feedback. In Proceedings of the 2016 ACM Conference on Designing Interactive Systems – DIS '16: 192-203. http://doi/10.1145/2901790.2901797
7. IOFIT http://iofitshoes.com/
8. J. R. Roberts, R. Jones, N. J. Mansfield, and S. J. Rothberg. 2005. Evaluation of impact sound on the "feel" of a golf shot. Journal of Sound and Vibration 287, 4-5: 651–666. http://doi.org/10.1016/j.jsv.2004.11.026
9. Jon Moeller, DIY Pressure Sensitive Floors for Expressive Interaction
10. Kitronix, Arduino Embedded Force & Touch Development Kit (TDK), http://www.kitronyx.com/snowboard.html
11. NIKE SB, iOS application, http://www.nike.com/us/en_us/c/skateboarding/sb-app
12. Ojala, J., & Saarela, J. (2010). Understanding social needs and motivations to share data in online sports communities. Proceedings of the 14th International Academic MindTrek Conference – MindTrek 10: 95-102. https://doi.org/10.1145/1930488.1930508
13. Philip Kelly, Aoife Healy, Kieran Moran, and Noel E. O'Connor (October, 2010). A virtual coaching environment for improving golf swing technique. In Proceedings of the 2010 ACM workshop on Surreal media and virtual cloning, SMVC '10, 51-56, http://doi.org/10.1145/1878083.1878098
14. Reynell, E., & Thinyane, H. (2012, October). Hardware and software for skateboard trick visualisation on a mobile phone. In Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference, SAICSIT '12: 253-261https://doi.org/10.1145/2389836.2389866
15. Rideblock http://www.rideblock.com/
16. Sebastiaan Pijnappel and Florian "Floyd" Mueller. 2013. Designing interactive technology for skateboarding. Proceeadings of the 8th International Conference on Tangible, Embedded and Embodied Interaction - TEI '14: 141–148. http://doi.org/10.1145/2540930.2540950
17. Stina Nylander and Jakob Tholander. 2014. Designing for Movement: the Case of Sports. Proceedings of the 2014 International Workshop on Movement and Computing - MOCO '14: 130–135. http://doi.org/10.1145/2617995.2618018
18. Strava, http://strava.com/
19. Syrmo http://syrmo.com/
20. Williams, Alison M. "King of the Mountain: A Rapid Ethnography of Strava Cycling."
21. W. F. Helsen and J. L. Starkes. 1999. A multidimensional approach to skilled perception and performance in sport. Applied Cognitive Psychology 13, 1: 1–27. http://doi.org/10.1002/(SICI)1099-0720(199902)13:13.0.CO;2-T