XR Golf Putt Trainer: User Opinions on an Innovative Real-time Feedback Tool

Mai Geisen [1], Khaleel Asyraaf Mat Sanusi [2], Tobias Baumgartner [1] and Stefanie Klatt [1,3]

[1] *German Sport University Cologne, Am Sportpark Müngersdorf 6 50933, Cologne, Germany*
[2] *TH Köln, Ubierring 40 50678, Cologne, Germany*
[3] *University of Brighton, 58-67 Grand Parade, Brighton BN2 0JY, United Kingdom*

Abstract

In impact sports such as golf, a specific stance and motion of the club can make decisive differences in the performance of players. The provision of feedback to learners in order to improve such a motion execution is crucial for their own performance development. Video recordings have been used to provide visual feedback to promote motor learning, but usually are shown with a time lag from the learner's own motion execution. With the help of new technologies such as Extended Reality (XR), learners are able to receive visual feedback during motion execution for real-time analyses via head-mounted displays. Consequently, a new real-time feedback method using XR to optimize the golf putt was developed and subsequently tested by participants of the 16th EATEL Summer School on Technology Enhanced Learning 2022. Feedback was obtained from users on the XR golf putt trainer, which will be addressed and analyzed in this article for further adaptations of the system to strengthen it for future application. The training method was developed and implemented, particularly under the aspect of improving psychomotor learning within the framework of the MILKI-PSY project.

Keywords

Direct feedback, technology-enhanced learning, JTELLSS 2022

1. Introduction

Interest in the use of predominantly visual feedback in golf has increased significantly in recent years. For instance, research suggests that the use of videos can help golfers to improve their performance [7]. Many golf facilities already use high-speed cameras, which record swing sequences and provide visual feedback for performance analyses after the motion execution [1, 2, 9]. Especially with regard to the temporal component of feedback, innovative technologies such as XR enable the provision of visual feedback to learners in real-time, i.e., during the motion execution. Whereas delayed feedback makes it difficult to translate the visual information provided into optimized motion execution directly, immediate and accurate feedback on a learner's performance may be crucial to improving sports performance [8]. Researchers also mention that in previous video-based studies, the lack of three-dimensionality prevented learners from reacting as realistically as possible to certain motions [10]. Technological developments in recent years have created beneficial opportunities for optimizing motion performances, especially considering the application of real-time feedback: (a) by providing specific, accurate and objective feedback, (b) by enabling a direct actual/target value comparison, and (c) by improving self-awareness of one's own motion [3]. Unlike original training methods, XR technologies offer the possibility for learners to directly capture and repeatedly review movements in immersive training environments and not necessarily have to rely on an outsider's perspective. Thus, the use of XR technologies for training optimization in the field of competitive sports is becoming more and more widespread [6].

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EMAIL: m.geisen@dshs-koeln.de (A. 1); ks@colognegamelab.de (A. 2); t.baumgartner@dshs-koeln.de (A. 3); s.klatt@dshs-koeln.de (A. 4)

The use of XR in golf is already being considered as researchers proposed a system for applying multimodal XR feedback to perceive differences in golf swing performances between oneself and an expert in multiple dimensions and in real time. Learners are thus able to imitate motion sequences registered by an expert which is aimed to help them improve their performance [4]. In view of this, our research addressed the extended use of XR as a supportive training tool for golf-specific motion tasks, focusing on the golf putt. As a result, an XR golf putt trainer was developed that provides learners, specifically beginners, with feedback during their putting performance by visually contrasting their own golf club motion with that of a previously computed optimized virtual golf club. Following a brief presentation of the immersive training tool hereafter, this paper will focus on user feedback of the tool from participants of this year's Joint Summer School on Technology Enhanced Learning (JTELSS 2022; 16th EATEL Summer School on Technology Enhanced Learning 2022). For this purpose, the written feedback of the participants was evaluated as well as divided into different categories, which will allow the project team to make further systematic adjustments to user needs.

2. Proposed feedback tool

With the help of the XR golf putt trainer visual feedback is provided using an XR device in the form of Microsoft HoloLens 2 glasses. Wearing XR-glasses is intended to allow subjects to receive visual feedback in real time without being restricted in their own motion execution of the putt. Specifically, the user is presented with a visual comparison of the desired, optimized club motion (a pre-programmed virtual golf club that serves as a role model) with his/her own club motion (a real golf club) via the XR-glasses. The comparison refers to temporal aspects (speed of the club) as well as spatial factors (club posture and guidance). The same visualization provided by the glasses is shown to the experimenter, i.e., to the coach in real-life training settings, for verification and observation via a screen connected to the glasses. This shall additionally give coaches the opportunity to receive precise visual feedback during the learner's motion executions, as well, which may help for further analyses. However, this does not affect the aspect that the feedback tool can be used without outside help.

To match the velocity of the virtual golf club to the real world, the necessary calculation of the coefficient of surface friction was calculated as follows: Several putts were executed for which pairs of the club swing speed and resulting distance were recorded. The friction of the surface could then be derived from these pairs and thus the correct club speed for the target distance (three meters), could be set. Spatially, the virtual club swing was based on the direct path from the ball to the target, further marked by a virtual red line, displayed in the XR-glasses. Figure 1 represents the feedback tool.

Figure 1: Illustration of the XR golf putt training. The upper left image shows the user's view through the XR-glasses, including the visible deviation of the user's own club guidance (on the righthand side) from the virtual golf club (on the left next to it) as well as the virtual red line guiding the direction from

the starting point (marked by a white X) to the hole. The other two images, i.e., the middle image and the image on the bottom right, present the situation at the same time from an observer's perspective, i.e. the view of the user wearing the XR-glasses

The general aim of the proposed XR golf putt trainer is to provide learners with an improved intuition of how the pre-calculated and pre-programmed optimized execution of the putt should look, both in terms of time and space, and how far they themselves deviate from this at the respective time of training and need to adjust their motion execution accordingly.

3. User application and feedback procedure (at the JTELSS 2022)

The XR golf putt trainer was presented during the workshop 'Visual feedback using XR: A real-time feedback training on performance optimization of the golf putt' at JTELSS 2022. After a presentation of the feedback tool and having been given user instructions, participants of the event were able to test the XR golf putt trainer themselves in the position of a learner. Thus, a total of 22 people (participants of the event, i.e., mainly PhD students in the field of technology-enhanced learning) each performed about 5-10 putts with the feedback tool as support. Each person tested the XR golf putt trainer individually and received a questionnaire immediately after their own execution with the XR golf putt trainer. The questionnaire could be filled out voluntarily and was intended to give feedback to the researchers and developers of the XR golf putt trainer in order to give them an impression of the use of the tool and obtain critical opinions from young researchers in the field of technology-enhanced learning. On the one hand, the questionnaire included the System Usability Scale (SUS) [5] to query the participants' assessment of system use. For this purpose, 10 questions were to be answered, each with a five-point Likert-scale (1 for 'strongly disagree' to 5 for 'strongly agree'). On the other hand, the questionnaire also contained free space to add more open feedback, i.e., comments and ideas, on the tool. In total, 19 persons filled out the SUS and general, open feedback in form of one or more key points was gained from 21 persons.

4. Summary and Categorization of user feedback

Based on the SUS rating, i.e., evaluation by a scoring system associated with the test with a possible score from 0 to 100, we report a score of 80.7 (± 17.9). This above-average result highlights that the tool received majority positive feedback which can, according to the questions included, be allocated to efficiency, effectiveness, and satisfaction [11]. Since the SUS questionnaire is intended to serve as a measurement tool to investigate usability, it can be assumed from these results that the innovative and specially developed tool proves to be user-friendly and conceivable as a new methodology for technology-based learning.

After reviewing the open written feedback of the users, the individual comments could be divided into different comprehensive categories, which on the one hand refer to personal evaluations and impressions (listed first). On the other hand, trying out the new tool in practice seemed to have inspired users to come up with ideas for providing the tool with further features adapted to specific needs (listed second). These comments and ideas grouped into categories are presented in the following.

Evaluations and impressions of users regarding the first use of the novel tool were:

- Widely referred to as a useful guide: users described the tool to be user-friendly and well adapted, however, one user stated that it was not quite easy for him/her to adapt to the virtual golf club;
- Appealing animation: learners had a positive attitude towards the innovative tool in regards to the animations being shown that aroused interest and motivation in them;
- Application of the tool as a dry training/preliminary training: practicing with the tool without actually hitting a ball might be useful to initially concentrating exclusively on the perception and sensation of the correct motion;

- Conceivable integration of the tool into the usual golf training in the form of alternating training: training alternately with and without tool for supporting the internalization process;
- Possible differences in using the tool as an advanced golf player and as a beginner: putting the focus on researching this and eventually adapting the system to specific needs.

Furthermore, the following ideas were mentioned for the possible enhancement of the tool, particularly with regard to preferences from the learner's perspective:

- Further specific real-time visual feedback: learners felt that additional information such as angular differences could help them see errors more clearly;
- Expansion into a holistic training tool, i.e., having instructions for familiarization of the new training method (e.g., via a voice guide) and summaries of individual results (delayed summative data-based feedback) directly integrated into the training tool;
- Use of multimodal feedback: addition of tactile feedback in the form of vibration motors integrated into the user's own real golf club as well as auditory feedback in the form of sounds adapted to the visualized optimal course of motion of the virtual golf club;
- Detailed customizations: making the virtual elements more transparent to avoid being distracted by them and to prevent the real objects from not being recognized correctly, presenting a more precise starting point (the X was quite big), considering to integrate even more virtual elements in the training environment for an innovative immersive set-up.

5. Conclusion

Here, we presented a XR golf putt trainer as an innovative tool that aims to provide visual feedback to learners during their own execution of the golf putt. Subsequently, we evaluated the tool by conducting a mixed-method approach with participants of the JTELSS 2022, i.e., young scientists working in the field of technology-enhanced learning. In summary, the paper offers some theoretical and practical contributions for further elaborating the tool. Regarding the theoretical contributions, multimodal feedback could potentially be a long-term solution in which different feedback modalities, i.e., tactile and auditory feedback, should be further tested in combination with this tool to develop an overall practicable system. Moreover, the tool could offer a holistic training system on the one hand, and might be used as an additional training tool by alternating the novel method with traditional training methods on the other hand. In terms of practical contribution, the tool might be more suitable for some users and less suitable for others, depending on how well they get used to the tool and their ability to internalize such real-time feedback. Accordingly, it would be conceivable to adapt the tool to specific needs in the future. Overall, the XR golf putt trainer represents an innovative tool that users, especially experts in the field of technology-enhanced learning, can envision for general use by learners and see potential for further development.

6. References

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