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A Feedback System for the Motor Learning of Skills in Golf

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Abstract

This paper presents a feedback GUI to improve the motor skills of a subject performing a golf putt. In this paper inertial sensors (gyroscopes) and video were used to capture the swing. Feedback was provided by a graphical user interface created in Matlab and displayed the video of the putt and quantitative values such as the putt tempo (ratio Backswing duration : Downswing duration) and score which gives an indication of how close the putt tempo is to the ideal rato of (2:1) . A zero-crossing method was used to determine the swing phases and durations from the rotational velocity.

The effectiveness of the feedback GUI was tested using 10 participants (4 experienced and 6 inexperienced). Each participant executed two sets of 15 putts over distances of 3m, 6m and 9m on an artificial turf putting surface with feedback provided by the GUI between the two sets of putts. The results indicated that overall tempo ratio of experienced and inexperienced participants became closer to 2:1 after the feedback. The standard deviation also decreased which meant that participants also improved their putting consistency. The results indicate that the participants were able to improve their skill in terms of putting performance indicators after using the feedback GUI.

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1. Introduction

The putt is a very important part of the golf game as it accounts for up to 40% of all shots in a professional tournament [1]. The golf putt occurs when the ball has landed on the golf “green” at the last stage of each hole, with the aim to putt the ball into the cup. This means that if one could improve their putting game significantly, the total number of shots in a round of golf would drop and the player’s performance will improve. Some of the factors identified as affecting the golf putt are the timing of the putt and the concistnecy of the putting. The timing can be described by the tempo of the putt which is a

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ratio of two swing phases (backswing:foreswing) in a single putt and the consistency which can be identified between different putts.

The putting motion can be broken down into four distinct phases, the backswing (BS), downswing (DS), contact (CT) and follow through (FT) [2]. BS occurs when the player addresses the golf ball and moves the club head backwards to the desired position. DS occurs when the backswing ends and the reverses the direction of motion of the club head to the hit the ball. CT occurs at impact and lasts ~30ms. FT occurs after the ball is hit.

The putting tempo is defined as the BS:DS ratio and should remain the same regardless of what putt length is required [3]. It has been found in elite golfers that the ideal tempo is 2:1 as it gives the golfer precision in distance control and accuracy [4]. Maintaining the value of the ratio close to the ideal is important in maintaining the consistency of the putt.

Inertial sensors have been used to measure and monitor the swing phases of many different sports [5,6]. Gyroscopes measure the rotational velocity and therefore are suited to monitoring the putting motion. Jensen [7] & Lai [3] have applied a gyroscope to the putting motion and have been able to identify the different phases of the putt by finding the zero-crossing points of the rotational velocity. The duration of the phases is the time between the zero crossing point of the rotational velocity. These durations can be used to calculate the Tempo.

The literature reports that the learning of motor skills is dependent upon the type of activity, feedback and practice [8]. The golf putt is an appropriate skill most suitable for the application of feedback due to the clearly defined swing phases and the precision and consistency required for a good putt. This makes it an ideal task for motor learning. Inertial sensors can used to provide objective measures of the swing and are ideal for extrinsic feedback.

This paper presents a feedback GUI using inertial sensors and video to aid in the learning and improvement of the motor skills involved in the golf putt. Experienced and inexperienced players were used to verify the feedback GUI's operation. This work conformed to Griffith University ethical standards (GU ethics code: ENG/06/012/HREC).

2. Methodology

2.1. Data Collection and Analysis

An inertial sensor unit was placed on the base of the putter to monitor the swing characteristics. The inertial sensor unit contained a triaxial gyroscope (300^0/sec) which was sampled at 100Hz. The sensor had an RF unit which sent the data in real time to a laptop to capture and store for later analysis. All data recorded was filtered with a Butterworth low pass filter with a cut-off of 8Hz to remove noise and impact artifacts [9]. An algorithm was designed to detect the zero crossing points on the gyroscope channel perpendicular to the putter head. The zero crossing points were used to delineate the phases and determine the duration of each phase. The duration of the BS and the DS were used to calculate a value for the tempo.

In order to provide feedback about the putt, a metric was developed called "score" that scored how close the player's putting tempo was to the ideal tempo of 2:1. It was decided to implement a system which was based on the International Golf Handicap system since this system is familiar to all players and it is well understood that a lower number is desired and that a number closer to 20 is not desired. A low score (1-5) is given when the tempo was in the range 1.8-2.3. A bad score (16-18) is given when the tempo was < 1.5 and >2.9 and an average score (6-15) is given to the range in between.

2.2. Feedback GUI

A Matlab GUI was developed to provide video and quantitative feedback to the player. The quantitative feedback included the putting tempo calculated for a series of putts and a player score based upon the feedback. The GUI allowed the user to select any putt from a series of putts, control the playback of the video of the putt, receive quantitative feedback through the tempo and score, and receive quick visual feedback with a colour bar representing the tempo. The design was aimed to give an intuitive and learning environment which encouraged players to improve their putting tempo and scores.

Figure 1 shows the integration of putting tempo, player score, colour bar and video footage all synchronized together for each putt. Visual Feedback (Colour Bar with arrow, Tempo Value, Putt Score) was implemented to allow participants to easily understand their putt.

A list box allowed the user to select the putts to review. However, the user could choose to play the current selected putt, play all the putts, play only the successful putts, or play only the unsuccessful putts. The video controls allowed the video to be played at different speeds. The tempo for the putt and the score are displayed on the top of the video. The colour box behind these values indicates how close the tempo was to the ideal ratio of 2:1. The colour bar and arrow on the right hand side allows a quick visualisation of how close the putt was to the ideal ratio of 2:1. A tempo close to 2:1 is green, a poor putt with a tempo <1.5 or >3 is red, and a tempo in between these ranges are the colours shown between the green and the red. The colour of the boxes underneath the score and the tempo match the colours of the colour bar.

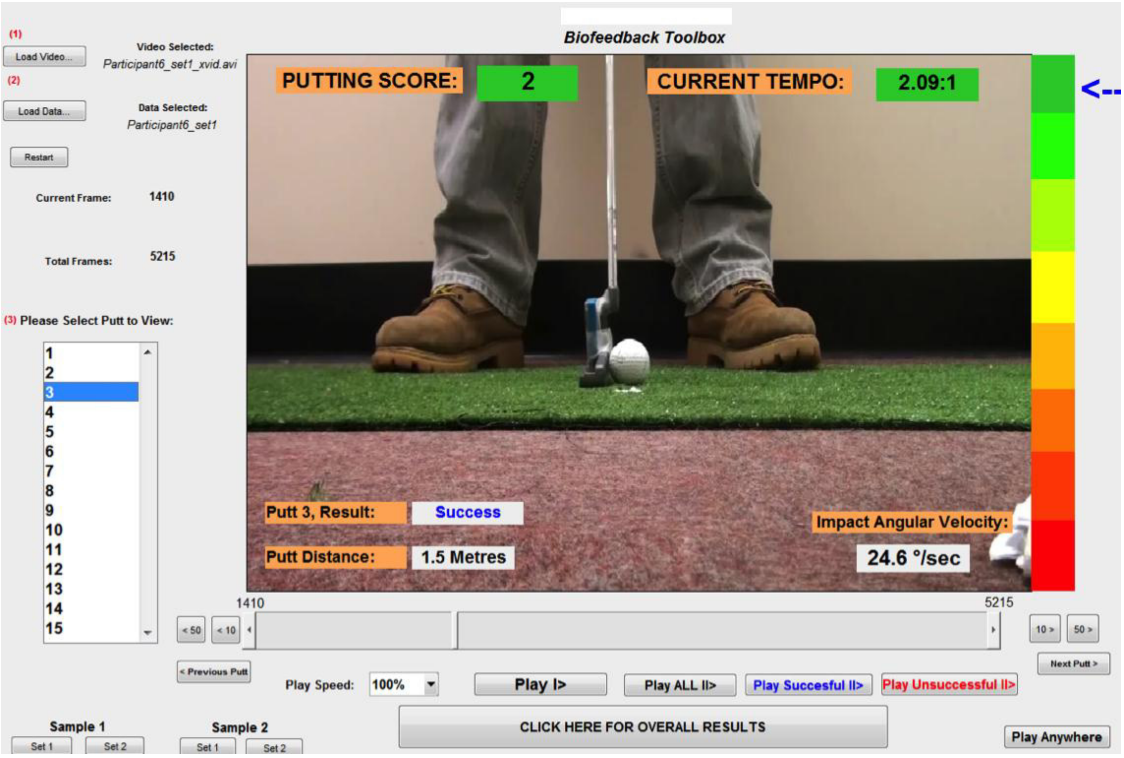

Fig 1. The feedback GUI showing the video of the putt and associated tempo and score.

2.3. Study Design

The aim of the study was to test the effectiveness of the feedback GUI. The experimental setup can be seen in figure 2. The putting surface was flat artificial turf in an indoor environment to minimise outside distractions and variables. A mix of six (n=5) inexperienced golfers and four (n=4) experienced golfers were used in the study. Experienced golfers were those who have played competitively before and/or/were members of a golf club. Each participant completed two sets of 15 putts, at distances of 1.5m, 3m and 6m from the target marked out on the golf turf. The objective for each player was to stop the ball in the target area, a circle with a diameter proportional to the distance away from the hole. Between the two sets of 15 putts, the participants were shown the feedback. This coaching "intervention" was to allow the participant to learn from their performance indicator results and video footage and then use this feedback to improve their results. Therefore the aim of this intervention technique is to promote the motor learning of the putting skill. The participants performed a second set of 15 putts after the intervention to determine if there was an improvement in the participant's putting skill due to the feedback given by the system.

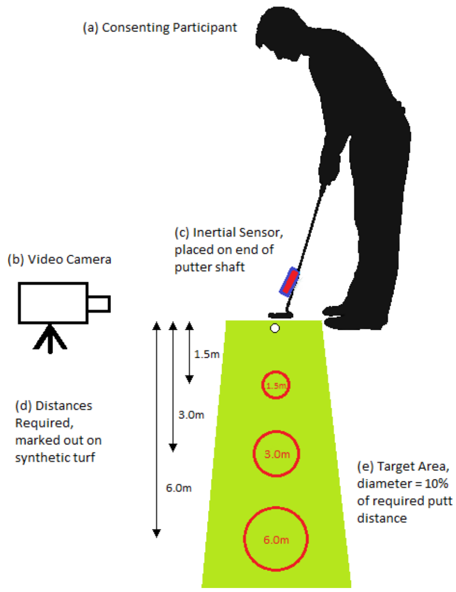

Fig 2. Design of the golf putting experiment

3. Results and Discussion

3.1. Phase Determination

Figure 3 shows the golf putt rotational velocity in a direction perpendicular to the head of the putter. The algorithm was able to clearly determine the phase transitions and the peaks as indicated by the markers. This matched the results seen in the literature [3].

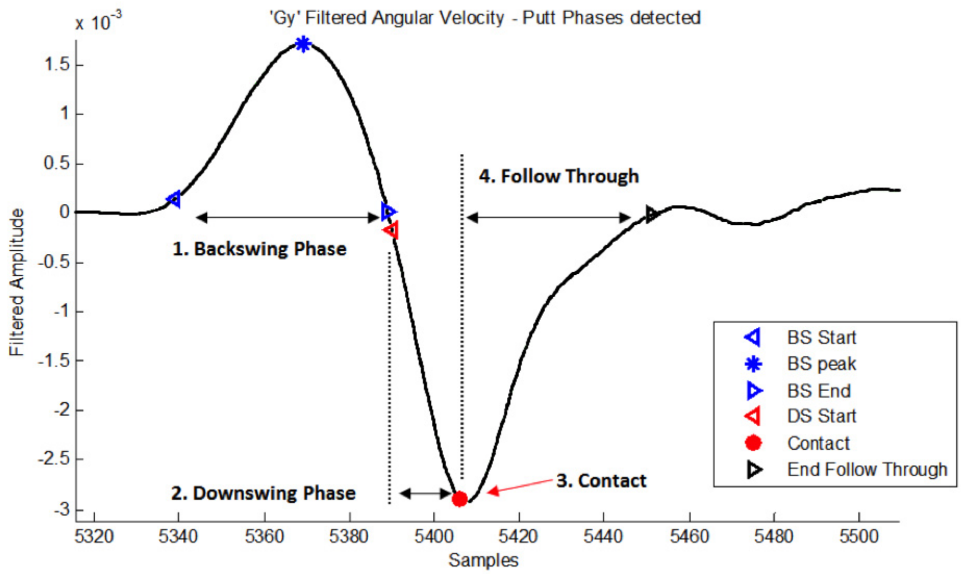

Fig. 3. Filtered gyroscope data with labeled putting phases. A Matlab algorithm is used to determine the duration of each phase and then calculate the tempo ratio. The markers indicate the points determined by the algorithm

3.2. Player Results

Table 1 shows the overall results for all participants in the study (n=9). It was found that the average Tempo improved from 2.25:1 before the intervention to 2.16:1 after the intervention. The standard deviation also decreased from ±1.02 before intervention to ±0.47 after intervention. This means that both the tempo and the consistency improved after the intervention. The accuracy also slightly improved after the intervention.

Table 1: Overall Tempo Average and Standard Deviation for the first and second set of 15 putts before and after intervention for all participants (n=9)

Performance Indicator	Before	After
Tempo Average (Ratio BS:DS)	2.25 : 1	2.16 : 1
Standard Deviation for all putts	±1.02	±0.47
Average number of successful putts (/15)	8.10	8.86

Table 2: Overall Tempo Average and Standard Deviation for the first and second set of 15 putts before and after intervention for experienced participants (n=4) and inexperienced (n=5) participants

Performance Indicator	**Experienced (n=4)**		**Inexperienced (n=5)**	
	Before	**After**	**Before**	**After**
Average Tempo (Ratio BS:DS)	2.41 : 1	2.25 : 1	2.12 : 1	2.08 : 1
Standard Deviation for all putts	± 1.46	± 0.48	± 0.42	± 0.45
Average number of successful putts (/15)	10	9.3	6.8	8.5

Table 2 examines the results for the Experienced (n=4) and Inexperienced (n=5) participants separately. The Experienced players had a greater improvement (0.16) in their average Tempo after intervention than did the inexperienced players (0.04). The standard deviation for the experienced players (0.98) showed an improvement in consistency whereas the standard deviation for the Inexperienced players (0.03) showed a slight decrease in consistency after the intervention. However the Inexperienced players had a greater change in average number of successful putts (+1.7) than the experienced players (-0.7).

The greater improvement in the timing and consistency for the experienced players suggests that having some prior experience of putting can help them adjust their technique when they receive the feedback. It should also be noted that the number of successful putts for the inexperienced players increased from 6.5 to 8.5 out of 15 putts, which is an 11.4% improvement.

Statistical analysis of the pilot results using the paired t-test indicated that the results were not statistically significant. It should also be noted that the total sample size was small (n=9). However, the results suggest that the method is worthy of further examination.

4. Conclusions

In this study, the majority of participants showed improvement after using the feedback GUI, as their putting Tempo became closer to the ideal 2:1 ratio. Their standard deviation of putting Tempo also decreased after using the feedback GUI indicating that the participants became more consistent. The improved tempo and consistency suggest that the feedback GUI may be useful to helping to improve the motor skills involved in performing a golf putt. Overall this paper shows the development and application of a feedback GUI for the golf putt that can be extended to other sports involving swing actions.

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