Inertial Measurement Unit Data Correction Using Consumer-grade Camera Recordings for Golf Swing Monitoring

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Summary

This study proposes a simplified sensor calibration method that utilizes video data captured by consumer-grade cameras as additional information to implement swing motion monitoring using an Inertial Measurement Unit(IMU) without requiring expensive equipment. The proposed method focuses on calibrating the orientation of the IMU and reducing drift errors, confirming that it can effectively reconstruct the three-dimensional wrist trajectory even in golf swings, which occur rapidly without repetitive motions.

Introduction

Golf swing is a high-speed, wide-range motion requiring precise monitoring. Traditional lab-based analysis ensures high accuracy but demands costly motion capture systems and frequent lab visits. Wearable devices offer portability but lack sufficient data quality. This study proposes a simplified IMU calibration method by integrating video data from consumer-grade cameras, which are commonly used for monitoring in driving ranges and other regular practice environments. This approach enables swing motion estimation without additional expensive equipment.

Methods

An experiment was conducted to collect ground truth golf swing data and synchronized IMU-video recordings. Four participants with an average score of 84.5 ± 8 participated, performing a total of 120 driver swings. To estimate the sensor's three-axis orientation, video recordings of the address and neutral stance, along with IMU data, were utilized. Additionally, a novel displacement correction method was integrated with an existing IMU-based velocity drift correction technique [1] to reduce drift error. The proposed method corrects drift by using the relative wrist position at impact compared to the address position. Assuming that the club grip end is close to the wrist position, the fixed club length for each participant and the 2D coordinates extracted from video recordings were used to estimate the 3D wrist position.

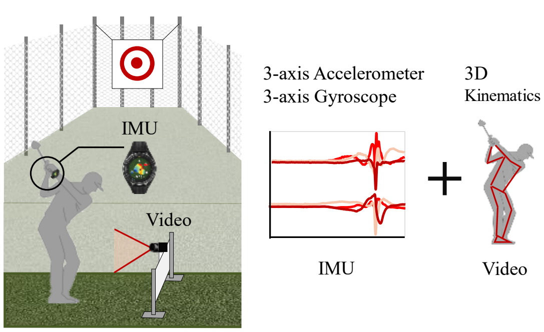

Figure 1: Integration of video and IMU data for golf swing analysis

Results and Discussion

The estimated 3D wrist position showed lower accuracy without correction due to IMU drift (Figure 2A). The mean absolute error was 132.6 ± 61.6 cm without correction, reduced to 25.48 ± 10.62 cm using the proposed method (Figure 2B), demonstrating its effectiveness in mitigating drift error.

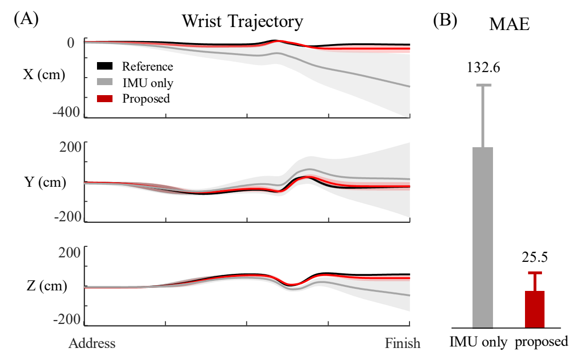

Figure 2: (A) Estimated 3D wrist trajectory across the entire swing motion. (B) Mean absolute error (cm) of wrist trajectory over the full swing sequence.

Additionally, due to the accumulation of errors in the orientation estimation process, the accuracy of the proposed method was lower than that of previous studies utilizing advanced techniques such as motion capture, which reported an error level of approximately 17 cm [1]. However, in the context of golf swings, where repetitive motions are absent and conventional sensor correction methods such as Zero Velocity Update [2]—commonly used in gait analysis—cannot be applied, the proposed simple sensor correction method successfully reconstructed the 3D wrist trajectory. This demonstrates its effectiveness in addressing the challenges of IMU-based motion monitoring for golf swings.

Conclusions

This study proposes a practical approach to golf swing monitoring by integrating IMU and consumer-grade camera recordings, enhancing wearable-based 3D monitoring feasibility and its potential for broader motion analysis applications.

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References

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