Proof of concept: Ultra-Wideband based Indoor Positioning systems for ice hockey on-ice testing

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Summary

Accurate measurement techniques are essential for evaluating and validating motion tracking and positioning systems. This study validates an indoor positioning system optimized with an optical light cell system and infrared radar, assessing their accuracy and reliability in an indoor ice rink. A multi-method approach analyzed spatial accuracy and signal stability, showing a desirable correlation among technologies for short-range tracking. The findings emphasize the need for optimization to enhance precision, supporting applications such as sports performance analysis.

Introduction

Optical light cells (Newtest, Finland) and infrared radar (Jenoptik LDM 300 C SPORT, Jena, Germany) are two extensively utilized technologies for high-precision motion and position tracking. Further, the Ultra-Wideband (UWB) indoor positioning system (Iiwari Tracking Oy, Vuokatti, Finland) is a relatively new and viable technology alongside these methods. Nevertheless, the validity and reliability all of systems must be assessed to ensure accurate data interpretation (1). This study presents a proof-of-concept for Iiwari`s indoor positioning system by evaluating its measurement accuracy and signal stability against optical light cells and infrared radar under controlled conditions. It evaluated performance for indoor ice rinks, emphasizing the need for system-specific adaptations to improve motion tracking reliability.

Methods

Two participants performed a total of twenty 30 m test skating trials (10 per person) to evaluate the accuracy of three different measurement systems: an indoor positioning system (50Hz), optical light cells, and infrared radar (100Hz). Time measurements were recorded simultaneously using all three technologies to ensure direct comparability. Signal processing conducted for both positioning and radar data using 8-state Extended Kalman Filter (EKF) including two dimensional components of position, velocity, acceleration, and rate of acceleration change as states. The primary objective was to evaluate the accuracy of the indoor positioning system in comparison to the light cells and radar, and to enhance the alignment between the three systems by analyzing the recorded times for each skating trial. The results highlight each system's alignment and suitability for high-speed motion tracking in dynamic environments. Associations were examined using the Mann-Whitney U test and the Kruskal-Walli's test. Additionally, the reliability of the measurements was assessed using Cronbach's alpha and intraclass correlation coefficient (ICC).

Results and Discussion

Only minor differences (0.89–2.13%, SD 1.6-1.9) were observed between the three measurements systems, none of which were statistically significant. A Cronbach's alpha value (0.969-0.984) indicates an exceptionally high level of internal consistency among the three measurement systems. Additionally, the intraclass correlation coefficient (ICC = 0.937-0.984) demonstrates excellent reliability of the average measurements. The Kruskal-Wallis H-test yielded a p-value of 0.168, which exceeds the significance threshold (α = 0.050), indicating that the distributions of results across the different measurement methods did not differ significantly (Fig 1).

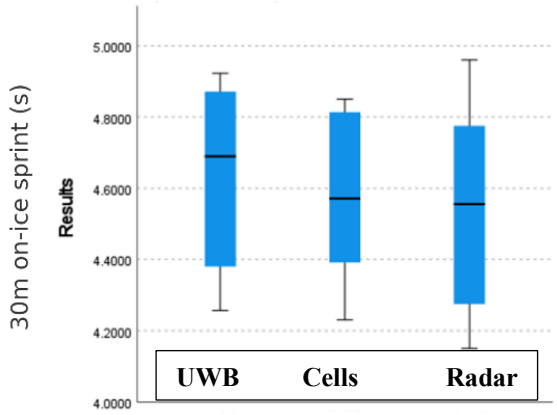

Figure 1: The comparison of three technology, the boxplot displays the means, SD and range of values, with the Y-axis representing time in seconds and the X-axis the different technologies

Conclusions

The proof-of-concept results indicate no statistically significant differences between the measurement methods. The high internal consistency and excellent reliability of the average measurements further validate the robustness of all three systems. There were no significant differences between the methods. The findings support the interchangeable use of the tested measurement systems in controlled environments like indoor ice rinks. Nonetheless, for sports applications demanding high accuracy (1–10 ms), further research and development are required to improve accuracy and reliability.

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References

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