Evaluating the Potential of Simulated 2D Radar for Gait Parameter Extraction

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Summary

Radar-based gait analysis provides a contactless, cost-effective alternative. This study evaluates a simulated 2D radar model for estimating spatiotemporal gait parameters, using motion capture (mocap) as the reference standard. 30 participants completed treadmill walking trials, with mocap data mapped onto a 3D animated model for radar simulation. The radar demonstrated high accuracy in cadence (97.02%) and step time (99.12%) but lower agreement in stance (76.72%) and swing percentage (48.82%), with root mean square deviation (RMSD) values of 17.28% and 17.21%, respectively. The simulation framework enables algorithm refinement before hardware implementation, improving efficiency and reducing costs. Future work will focus on enhancing gait phase detection by upgrading to 4D radar for improved spatial and angular resolution and limb differentiation.

Introduction

Radar-based gait analysis presents a promising, cost-effective, and contactless alternative to conventional mocap for gait assessment, offering enhanced privacy and the potential to overcome inherent challenges of the current gold standard [1, 2]. This study evaluated the feasibility of a simulated 2D radar model for spatiotemporal gait assessment by comparing radar-derived parameters to those obtained from mocap.

Methods

30 participants completed 60-second treadmill walks recorded with mocap. Participant anthropometric data was used to generate a 3D animated model, with the attached mocap data serving as input for the radar simulation. Participants were modelled as scattering centres reflecting radar signals, generating time-varying range and velocity profiles. Heel strikes were identified from the range-time profiles, though step events alternated due to the 2D radar's inability to distinguish between limbs. Spatiotemporal parameters were validated against mocap data using accuracy and RMSD.

Results and Discussion

Table 1 presents the comparison between 2D radar-derived gait parameters and motion capture data. Accuracy and RMSD values highlight the performance of the simulated radar model.

Table 1: Performance of simulated radar

Parameter	Accuracy (%)	RMSD
Gait Velocity (m/s)	83.28	0.23
Stance Percentage (%)	76.72	17.28
Stance Time (s)	27.60	0.59
Step Length (m)	89.23	0.10
Step Time (s)	99.12	0.04
Stride Length (m)	89.74	0.18
Swing Percentage (%)	48.82	17.21
Swing Time (s)	52.49	0.19
Cadence (steps/min)	97.02	10.96

The results highlight the potential and limitations of a 2D radar system for gait analysis. High accuracy was observed for cadence and step timing, suggesting effective step detection. However, discrepancies in stance and swing phase parameters indicate challenges in identifying limb-specific gait events, likely due to the radar's inability to differentiate left and right limbs. The simulation framework provides a controlled environment to refine gait analysis algorithms before hardware implementation, reducing development costs and improving model robustness. Future advancements will include further development of radar to a 4D model, enabling enhanced spatial resolution and limb differentiation.

Conclusions

While step timing was accurately captured, stance and swing phase discrepancies highlight limitations in distinguishing limb motion. Simulation provides a cost-effective environment for refining algorithms before hardware implementation. Future work will focus on improving gait phase detection through expansion to a 4D radar model for enhanced spatial and angular resolution.

References

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