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Obstacle avoidance for a robotic navigation aid using Fuzzy Logic Controller-Optimal Reciprocal Collision Avoidance (FLC-ORCA)

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Abstract
Robotic Navigation Aids (RNAs) assist visually impaired individuals in independent navigation. However, existing research overlooks diverse obstacles and assumes equal responsibility for collision avoidance among intelligent entities. To address this, we propose Fuzzy Logic Controller-Optimal Reciprocal Collision Avoidance (FLC-ORCA). Our FLC-ORCA method assigns responsibility for collision avoidance and predicts the velocity of obstacles using a LiDAR-based mobile robot. We conduct experiments in the presence of static, dynamic, and intelligent entities, recording navigation paths, time taken, angle changes, and rerouting occurrences. The results demonstrate that the proposed FLC-ORCA successfully avoids collisions among objects with different collision avoidance protocols and varying liabilities in circumventing obstacles. Comparative analysis reveals that FLC-ORCA outperforms other state-of-the-art methods such as Improved A* and Directional Optimal Reciprocal Collision Avoidance (DORCA). It reduces the overall time taken to complete navigation by 16% and achieves the shortest completion time of 1 min and 38 s, with minimal rerouting (1 occurrence) and the smallest angle change (12°). Our proposed FLC-ORCA challenges assumptions of equal responsibility and enables collision avoidance without pairwise manoeuvres. This approach significantly enhances obstacle avoidance, ensuring safer and more efficient robotic navigation for visually impaired individuals. © 2023, The Author(s), under exclusive licence to Springer-Verlag London Ltd., part of Springer Nature.

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Electronic travel aid; Fuzzy logic; Navigation aid; Obstacle avoidance; Optimal reciprocal collision avoidance

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