Human Movement Intention Prediction for Robotic Perception Systems Using Deep Learning and Trajectory Modeling

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Abstract:

Human movement intention prediction is an important capability for intelligent robotic perception systems operating in dynamic environments. The ability to distinguish between approaching and departing individuals can enhance situational awareness and support perception-driven decision-making in applications such as autonomous monitoring, service robotics, crowd management, and public-space surveillance. Traditional approaches for movement behavior analysis, including Line Partition and Bounding Box Diameter methods, often struggle in complex environments characterized by unpredictable human trajectories, varying viewpoints, occlusions, and dynamic scene conditions.

This paper proposes a trajectory-based human movement intention prediction framework that integrates deep learning-based object detection and tracking with linear regression modeling. The proposed approach captures human movement patterns using advanced detection and tracking algorithms, enabling the extraction of vertical trajectory variations from bounding box centers. These trajectory features are subsequently analyzed using linear regression to estimate movement trends and distinguish between approaching and departing behaviors.

The proposed framework was evaluated on 132 video sequences recorded under diverse environmental conditions, including variations in camera position, altitude, viewing angle, and movement direction. Experimental results demonstrate the superiority of the proposed method over traditional approaches, achieving an overall Accuracy of 86.36% and an F1-score of 0.86. The framework consistently outperformed both the Line Partition and Bounding Box Diameter methods across multiple evaluation scenarios.

The obtained results demonstrate that combining deep learning-based perception with mathematical trajectory modeling provides an effective and computationally efficient solution for human movement intention prediction. This work contributes to the fields of computer vision and intelligent robotics by introducing a robust framework for interpreting human movement behavior in dynamic environments, providing a foundation for future robotic perception and human-aware autonomous systems.

Keywords:

Human Movement Intention Prediction, Robotic Perception Systems, Deep Learning, Object Detection, Trajectory Modeling, Linear Regression, Human Behavior Analysis, Computer Vision, Intelligent Robotics.