Graduate School of Science and Technology Master's Thesis Abstract

Laboratory name (Supervisor)	Human Robotics (WADA Takahiro (Professor))		
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Thesis title	How I Can Guide You: Human Guidance Along a Defined Path Using a Robotic Dog Based on Tractor–Trailer and Data-Driven Models		

Abstract

Real guide dogs play a critical role in supporting the mobility of visually impaired individuals; however, their use is restricted due to the high cost and lengthy training process, limited availability, and the significant daily care required. A guide dog must ensure the safety of its handler by providing precise guidance during navigation and this thesis addresses these limitations by developing a robotic guide dog system that can reliably guide users along predefined paths. The research introduces two core approaches: a physical modeling method based on the tractor–trailer model and a data-driven model utilizing empirical sensor data and machine learning. In the initial stage, the human–robot pair is modeled as a tractor–trailer system, enabling real-time monitoring and corrective guidance by leveraging reference trajectories and Lyapunov-based control. While this approach proves capable of maintaining user pathfollowing, experimental results reveal persistent misalignments between predicted and actual human responses, primarily because the model cannot properly detect human reactions. To overcome these limitations, a data-driven model is developed, trained on real-world interaction datasets, including dynamic force measurements from a 6DoF force sensor. This model enables adaptive robot responses, because deeper understanding of human reaction. Comparative experiments demonstrate that integrating the tractor–trailer modeling approach significantly enhances guidance accuracy and user comfort. On the other hand, the data-driven model increases the system's understanding of human reactions, enabling more adaptive responses. These findings offer a viable solution for implementation in robotic guide dog systems, as accurately predicting human movements allows for improved safety and reliability during guided navigation.