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Ph.D. DISSERTATION DEFENSE

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ABSTRACT

Robots are increasingly becoming integral parts of our daily lives. Achieving safe and efficient navigation in complex and dynamic environments shared with humans presents significant challenges. This dissertation addresses the challenges of autonomous navigation in dynamic environments by developing learning-based methods that enable robots to navigate collision-free and to respond to natural language instructions. Traditional navigation systems fall short in these scenarios due to their inability to capture human social behaviors. By leveraging human trajectory data and advanced robotic simulation techniques, this research provides innovative solutions to improve robot navigation and human-robot interaction.

In Part I of this dissertation, we study the problem of robot navigation in crowded environments by learning human-like navigation behaviors. We first develop a new generative adversarial imitation learning approach to learn human navigation behaviors directly from the human trajectory data. To overcome the limitation of imitation learning in unseen scenarios, we also propose a customized deep reinforcement learning (DRL) based navigation algorithm using a customized deep deterministic policy gradient method that incorporates guiding points to direct the robot toward the global goal. Extensive simulation results demonstrate the superiority of these methods in reducing navigation freezing and improving success rates in crowded environments compared to existing solutions.

Part II of the dissertation focuses on integrating semantic mapping and natural language processing to enhance robot interaction capabilities. A system combining RGB-D (Red Green Blue-Depth) images and natural language commands enables robots to create semantic maps, interpret verbal instructions, and navigate to specified objects or locations. Tested in real-world environments, the system demonstrated high success rates in executing navigation tasks based on human instructions. By combining imitation learning, DRL, and multimodal data integration, the dissertation advances autonomous mobile robot navigation and human-robot interaction, providing a foundation for future developments in human-centered robotics.