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Semantic Trajectory Planning for Industrial Robotics

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ABSTRACT

The implementation of industrial robots across various sectors has ushered in unparalleled advancements in efficiency, productivity, and safety. This paper explores the domain of semantic trajectory planning in the area of industrial robotics. By adeptly merging physical constraints and semantic knowledge of environments, the proposed methodology enables robots to navigate complex surroundings with utmost precision and efficiency. In a landscape marked by dynamic challenges, the research positions semantic trajectory planning as a linchpin in fostering adaptability. It ensures robots interact safely with their surroundings, providing vital object detection and recognition capabilities. The proposed ResNet model exhibits remarkable classification performance, bolstering overall productivity. The study underscores the significance of this approach in addressing real-world industrial applications while emphasizing accuracy, precision, and enhanced productivity.

KEYWORDS

Industrial Robotics, Object Detection ResNet Model, Precision and Productivity, Semantic Trajectory Planning

INTRODUCTION

Industrial robotics has a rich background that has evolved over time to meet the needs of various industries. Initially, the focus of industrial robotics was on automating repetitive tasks in manufacturing processes to improve efficiency and productivity. Early industrial robots were primarily used for tasks such as welding, assembly, and material handling (Villani et al., 2018; Saab & Jaafar, 2021). However, with advancements in technology and the emergence of new applications, the role of industrial robots has expanded.

One significant development in industrial robotics is the integration of human-robot collaboration (HRC) in industrial settings. HRC allows humans and robots to work together in a shared workspace, combining the strengths of both to enhance productivity and safety. Authors (Villani et al., 2018; Shen & Saab, 2021; Awad et al., 2022) discuss the importance of safety and

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intuitive interfaces in HRC, highlighting the relevance of collaborative industrial robotics in modern manufacturing environments.

Another area of development in industrial robotics is trajectory planning. Trajectory planning involves generating optimized paths for robots to follow while considering various constraints such as obstacles, kinematic limitations, and task objectives. Authors (Sheng-xi et al. (2018)) focus on trajectory planning for a cutting robot in machining complex surfaces, emphasizing the significance of precise and efficient trajectory planning in achieving accurate tool positioning and smooth motion execution. Optimal trajectory planning is also crucial in industrial robotics to ensure efficient and collision-free robot motion. Authors (Patel et al. (2023)) propose a hybrid S-curve-PSO approach for trajectory planning, aiming to minimize path length and time while avoiding obstacles. This research highlights the importance of semantic trajectory planning in optimizing the performance of industrial robots in the presence of obstacles.

The proliferation of industrial robots across diverse industries has ushered in a transformative era, characterized by notable advancements in productivity, operational efficiency, and labor dynamics. These machines have found applications in sectors spanning manufacturing, healthcare, agriculture, and construction. Their contributions include elevating precision, safety, and productivity within production processes. However, the increased use of industrial robots has also raised concerns about the potential impact on employment (Zhao et al. 2022; Bacchetti et al. 2022). Authors (Zhao et al., 2022) analyze the effect of industrial robots on employment in China, highlighting the need for careful consideration of the labor market implications.

Within the realm of industrial robotics, semantic trajectory planning emerges as a pivotal domain, revolutionizing path planning for robots in complex, dynamic environments. This approach transcends mere trajectory generation, as it meticulously accounts for both the intrinsic physical constraints of the robot and the semantic attributes of the environment. This includes a comprehensive understanding of obstacles, desired task objectives, and paramount safety considerations.

Object detection and recognition have attained paramount significance in the milieu of industrial robots for multifaceted reasons. First and foremost, the capacity for robots to interact seamlessly with their surroundings hinges upon their ability to discern and identify objects with precision. Nowhere is this more salient than in applications like pick-and-place operations, wherein robots are tasked with the precise location and grasp of specific objects. The study by (Ansary et al., 2021) emphasizes the significance of object recognition in empowering autonomous service robots to navigate and interact effectively with real-world environments (Ansary et al., 2021; Ren et al., 2021).

Furthermore, the sphere of object detection and recognition plays a pivotal role in upholding the safety quotient in industrial robot operations. By adeptly detecting and recognizing objects within the robot's working domain, the potential for collisions and accidents is effectively minimized. A notable study delves into the synthesis of vision-based object recognition and human-robot communication, shedding light on the profound importance of this synergy within industrial contexts (Rogowski et al., 2020).

Moreover, object detection and recognition wield transformative potential in enhancing the efficiency and productivity of industrial robots. By accurately identifying objects, robots are primed to execute tasks with optimal efficiency, encompassing activities such as sorting, assembly, and quality control. The deployment of deep learning-based object recognition takes the spotlight, exemplified in its role in fostering equipment intelligence and propelling production automation within the automotive sector (Tan & Xia, 2023).

In addition, the adaptability of robots to dynamic environments relies heavily on their acumen in detecting and distinguishing objects. The industrial robotic landscape frequently presents scenarios involving mobile objects or evolving conditions. Notable discourse has emerged regarding the importance of object detection in multi-robot and swarm robotic applications, underlining its irreplaceable role in these contexts (Yilmaz & Bayindir, 2019).

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