Research Plan: Vision-Based Robotic Grasping and Control Planning

Background

With the rapid development of robotics, enabling robots to execute complex tasks, particularly precise grasping and path planning, in unknown and unstructured environments has become a key research topic. The current challenge focuses on the changes in the states of objects and robots in dynamic environments, in order to make real-time perception, reasoning and modeling. Robots need to understand the type of task they will perform, deeply analyze the features of the target object, and integrate prior knowledge about the object to make quick and accurate decisions during the grasping process.

Grasping strategies and the force applied need to be adjusted according to the specific material and shape of different objects to make sure candidate items are not damaged during grasping and release moment. Additionally, the transient impact force generated when the robot grasps and releases objects is a common issue. If not controlled, this force could damage the object or the robot itself. Therefore, designing a control strategy to mitigate this impact force is another key aspect of the research.

Research Objectives

The primary goal of this research is to enable robots to achieve real-time, safe, accurate, and rapid perception and prediction of target objects in complex environments (e.g., scenarios with multiple or stacked objects). Specifically, this research aims to enable robots to perform high-precision 3D modeling or keypoint skeleton generation of the target object, and identify the optimal grasping posture that aligns with human interaction habits. For example, the robot should grasp a cup by the rim rather than the handle, and scissors by the blade rather than the handle.

Furthermore, adjusting the grasping strategy and force is important to make sure that there is no damage to candidate items during grasping and release. An improved impedance controller will be used to buffer the sudden changes in force, in case of deformation and destruction when grasp and release.

Approach/Methodology

A vision-based robotic grasping system typically comprises four key components: target object localization, object pose estimation, grasp detection (or synthesis), and grasp planning. When dealing with complex objects, it is essential to design a detection network that can accurately and swiftly identify and locate the grasping position. This research will rely on eye-in-hand cameras with tracking algorithms to achieve real-time tracking and adjustment of grasping strategies in dynamic environments.

In terms of grasping strategy, this research intends to integrate analytic and data-driven approaches. It intends to utilize mathematical modeling, robotics theory, and incorporate modern techniques such as machine learning and reinforcement learning to optimize the grasping process. For example, deep learning techniques will be employed to train on large-scale grasping data, which enhances the system's adaptability in diverse scenarios.

In the control strategy, this research plans to employ an improved Kalman or other filters to mitigate the transient impact force during the moment of objects grasping and releasing. Meanwhile, this research also considers to apply classical and modern control theory to further refine this research region.

References

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