Real-Time Dynamic Robot-Assisted Hand-Object Interaction via Motion Primitives

Mingqi Yuan, Huijiang Wang, Kai-Fung Chu,
Fumiya Iida, Bo Li, Wenjun Zeng

Paper

This paper proposes a new method of dynamic robot-assisted hand-object interaction using hand pose estimation, adaptive robot control, and motion primitives. This method includes a transformer-based algorithm to 3D model the human hands from single-view RGB images, with a motion primitives model to translate human hand motions into robotic actions.

Motivation

There are current challenges in physical human-robot interaction, such as accurate real-time human motion perception, adaptive robot control, and effective human-robot. This paper introduces a system to improve robot assistance in tasks that require fine-grained physical collaboration.

Architecture

3D Hand Pose Sensing

The system first estimates the 3D hand pose from a single RGB image using a transformer-based model, MeshGraphormer. A moving average filter smooths oscillations in hand pose data caused by detection noise.

Motion Primitives Model (MPM)

A bidirectional LSTM processes time-series data of 3D hand joint coordinates to retain temporal context, and then map dynamic hand motions to predefined robotic actions, such as moving forward or grasping.

Robot Controller

The system lastly integrates open-loop control for both predefined actions with closed-loop control for dynamic, adaptive responses. Open-loop control executes

predefined motions when motion primitives are detected, while closed-loop control continuously adjusts the tobot's tool center point (TCP) based on real-time feedback.

Limitations

1. The system is trained on predefined motions and specific tasks.
2. The system has not been tested with various environments or complex objects.