Two-Stage Clustering of Human Preferences for Action Prediction in Assembly Tasks

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Motivation

Complex assemblies:
- Some actions can only be performed by human workers
- Robots can only assist in secondary actions like fetching parts

Worker preferences:
- Assembly tasks require different workers to execute the same task
- Different workers may perform the task in different ways

Need to assist workers based on their individual preference

Problem

Preferences in sequencing actions:
- Prior work considers goal-based preferences
- We consider preferences in sequence of actions

Preferences at different levels:
- *High level*: Preferred sequence of sub-tasks
- *Low level*: Preferred sequence of actions for each sub-task

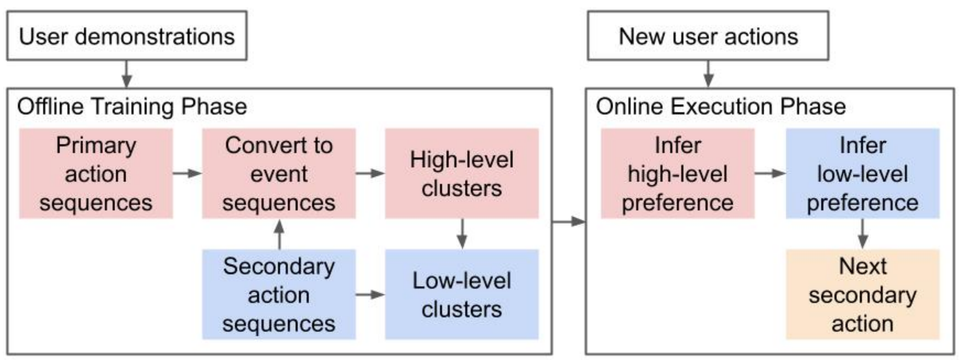
Learn dominant high- and low-level preferences of workers

Objective

- Learn dominant preferences of workers in assembly task
- Infer preferences of new worker
- Predict worker's actions based on inferred preferences
- Provide proactive assistance for the next action of worker

Two-stage clustering approach

Types of actions:
- Primary actions: Performed by the human e.g. replace bearing
- Secondary actions: Performed by the robot e.g. fetch new bearing



High-level preference: sequence of events (sub-tasks)
Low-level preference: sequence of secondary actions for an event

Learn high and low-level preferences in the by clustering users based on their sequence of events and sequence of secondary actions, respectively.

Online execution phase: Infer the high-level preference of a new user based on their actions. Then infer the low-level preference to determine the next secondary action to execute.

Assembly user study

Observations:
- Event: users preferred to perform similar actions consecutively
- Similar actions required similar parts to be fetched i.e. secondary actions

Preferences:
- Different users performed events in different sequences.
- For some events, users had different preferences about the order of the required secondary actions.

Impact

Industry: Will lead to improvements over current practices in human-robot hybrid workcells.
- Secondary tasks performed by humans leads to low human productivity
- Some tasks are ergonomically challenging and may pose risk to human health

Education:
- Participation of graduate and undergraduate students in this research
- Teaching modules for developed technology

Outreach:
- Introduce ~1000 K-12 students to robotics technologies through Robotics Open House.

2021 NRI & FRR Principal Investigators' Meeting
March 10-12, 2021

Award ID#: 2024936

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