Human-Conditioned Models for Robotic Manipulation: A Preliminary Investigation

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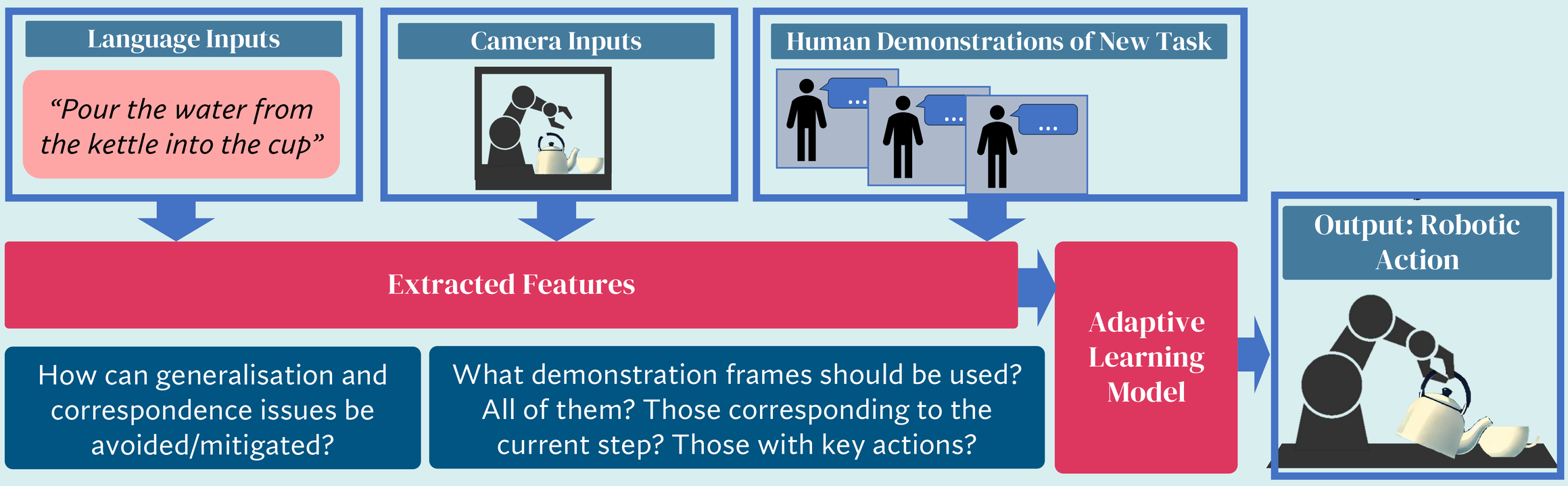
Motivation

- Robots deployed in dynamic environments need to adapt to new manipulation tasks quickly and effectively
- Adaptation in real-world settings can require complex updates to workflows during and/or after deployment
- Existing foundational models:
  - Struggle to generalise to new tasks/environments without computationally expensive re-training
  - Often require hundreds of expert demonstrations to learn tasks, which is impractical in dynamic scenarios

Human-Conditioned Models

Research Premise: Instead of relying solely on robot-centric demonstrations, which are hard to gather, robots should also be able to learn from "observing" and direct input from human teachers

The goal of our approach is to develop *"human-conditioned"* models able to learn tasks using few-shot observational learning, minimising the need for large task-specific datasets



How can generalisation and correspondence issues be avoided/mitigated?

What demonstration frames should be used? All of them? Those corresponding to the current step? Those with key actions?

A Human Observation Dataset

What input modalities are needed for effective task learning?

Observation Modalities

Visual Data
- Dynamic Body Pose
- Gaze Direction
- Hand Movements
- Object Segments
- Grasping Points

Verbal Data
- Spoken Guidance
- Task Rationale
- Object Description
- Non-Visual Elements (e.g. Force)

Sensor Data

Future Work

- Data Collection
  - We will record a dataset of human teachers performing manipulation tasks including multiple modalities of visual and verbal data
  - This dataset would contain multi-view, 3D recordings of demonstrations
  - Wearable sensors would also be included, to learn relationships between semantic descriptions, motion kinematics, and non-visual elements
- Feature Selection
  - Pre-trained models can be used to extract important features from the multimodal data
- Model training, conditioning and evaluation

Key Research Questions

- Can verbal instruction complement visual information for semantic learning?
- Can models conditioned through few-shot human observation perform new tasks without re-training?
- How can common issues in Learning from Demonstration such as correspondence be avoided?

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