Proactive Robot Assistance: Affordance-Aware Augmented Reality User Interfaces[1]

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Overview

Assistive robots can increase the autonomy and quality of life of people with disabilities and Augmented Reality (AR) User Interfaces (UIs) have the potential to facilitate their use, and increase trust through enhanced explainability. Existing AR UIs for the control of assistive robots are limited to assisting with atomic actions and do not readily provide options for longer-horizon plans that involve multiple steps. To overcome this limitation, we propose Affordance-Aware Proactive Planning (AP)[2], an algorithm that proactively identifies feasible sequences of atomic actions by leveraging large datasets of plans defined using human language. We have applied our affordance-aware Augmented Reality interfaces in multiple assistive applications in healthcare, including navigation of smart robotic wheelchairs, and the control of multiple collaborating robotic systems towards assisting users with disabilities.

Figure 1. Current affordance-based AR HMD UIs for robot control would require at least four input commands to complete a task such as "Pick-up the remote and put it on the bed": 1) [Robot's starting position] approach the tv-stand, 2) pick-up the remote, 3) approach the bed and 4) give the remote. [1]

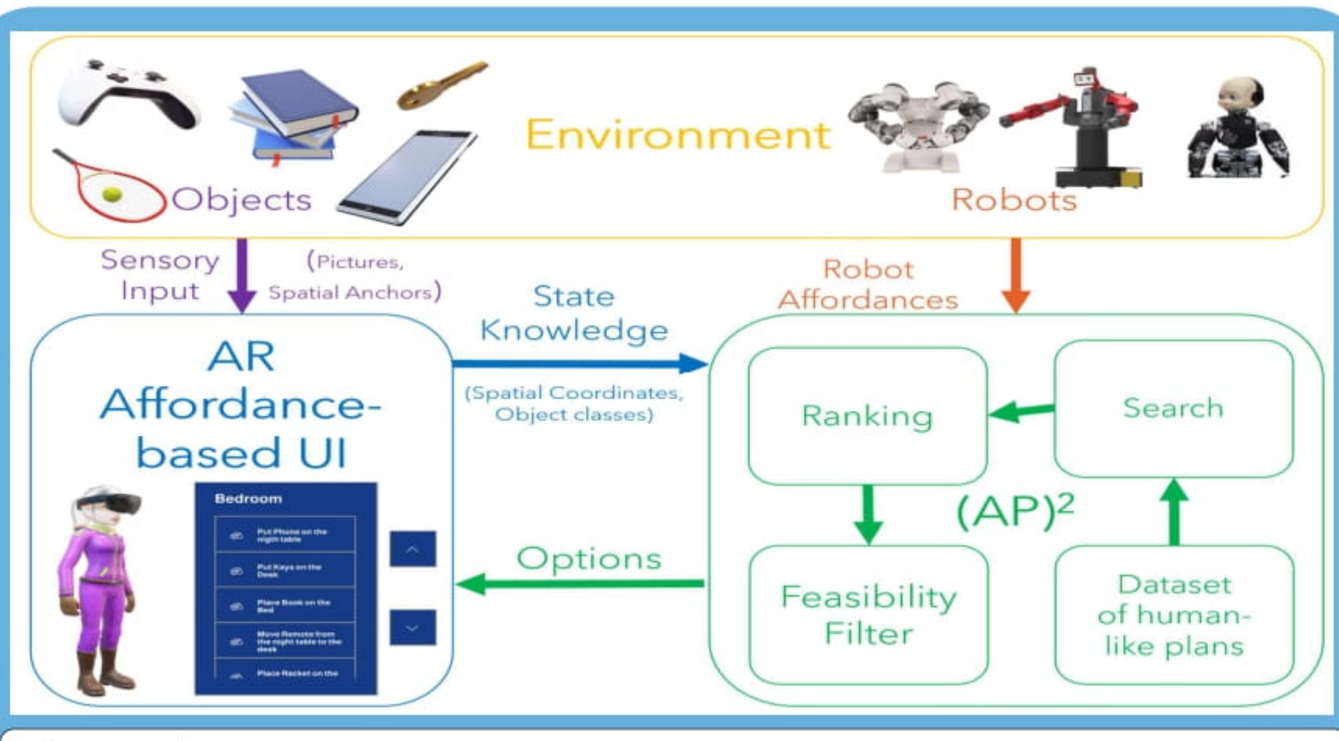

Figure 2. (AP)[2] proactively identifies the most relevant and feasible plans available by jointly considering objects and robot affordances. (AP)[2] integrates: 1) a dataset of plans expressed using human language, 2) a search algorithm that organises the dataset in a hierarchical context-dependent manner, 3) a ranking algorithm to identify the most relevant plans given the user's context, and 4) a feasibility filter, to determine whether a plan is feasible.[1]

Key Features

- **Affordances** are derived using sensor data and are presented to the user using **signifiers** overlaid into the environment with **AR**.
- Incorporates text-based **NLP** and **task planning** algorithms to provide the most relevant and feasible plans given the user's context.
- Increased complexity of affordances in terms of sequence length and action space.
- Validated with an assistive mobile manipulator deployed in a simulated bedroom environment and controlled using an AR UI.

Future Work

- We are designing and evaluating a series of graphical representations to communicate information non-verbally, potentially reaching a more diverse user base.
- We are incorporating the user's preferences and habits as part of the context information used during ranking to make its order more relevant.
- We are evaluating with user studies to what extent, if any, the proposed platform affects factors relevant for a successful HRI. These include **trust**, technology acceptance, and cognitive workload, among others.

References

1. R. Chacon Quesada and Y. Demiris, "Proactive Robot Assistance: Affordance-Aware Augmented Reality User Interfaces," in *IEEE Robotics & Automation Magazine*, vol. 29, no. 1, pp. 22-34, March 2022, doi: 10.1109/MRA.2021.3136789.

- **A supplementary video is available at https://www.imperial.ac.uk/personal-robotics/videos/**