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Affordance-based Reasoning for Robotics

Humans are able to come up with plans to achieve their goals, and to adapt these plans to changes in their environment, finding fixes, alternatives and taking advantages of opportunities without much deliberation.

For example, they may use a tea kettle instead of a watering can to water the plants, or a mug instead of a glass to serve water. Despite decades of research, artificial agents such as Jenny (see Figure 1) are not as robust or as flexible.

The project introduces three reasoning phases that use affordances to enable such robustness and flexibility in robot task planning & acting. Affordances are a concept for describing opportunities for action.

The first phase generates a focused planning problem. The second phase expands the domain where necessary while the third and final reasoning phase uses affordances during plan execution and monitoring. This is accomplished by combining Hierarchical Task Network planning, Description Logics, and a robust execution/monitoring system.

By exploiting affordances in the reasoning and planning process, we enable more opportunistic behavior and the creation of more general and flexible plans.

The process of substituting objects is triggered in two cases, during the process of carrying out the task (i.e. during the acting phase), or as a result of a failure to generate a plan due to missing objects or state information about them (e.g. no instance of imansTeacup is available, or a precondition stating that it is clean may not be met). This can be seen in Figure 2. In the case that the state is unknown, a placeholder instance of the teacup is created and the plan generation process proceeds optimistically. In the case where we know that the teacup is dirty, we lift our plan to enable the use of a different object.

To lift the plan, the domain is iteratively expanded to include objects that satisfy fewer constraints. Objects with the same functional affordance as that of the originally called-for object are preferred. This seems to be in line with our own preferences. The first level above that of using an instance of a given object is to use any object with the same functional affordance and high conceptual similarity. The next higher level would remove the constraint that the substitute should be conceptually similar, relying only on a shared functional affordance. Should the agent not find such objects and given the old adage that "form follows function" (the form of objects is based on their function), conceptual similarity is then used to identify those objects which do not share the same functional affordance and yet are conceptually similar. The top level attempts to infer the function-relevant attributes and identify objects matching these properties.

The same process of expanding the domain is also used in the case the agent discovers a missing or unavailable resource during acting. In this case, priority can be given to alternate resources which are in close proximity to the agent.

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Supervisors

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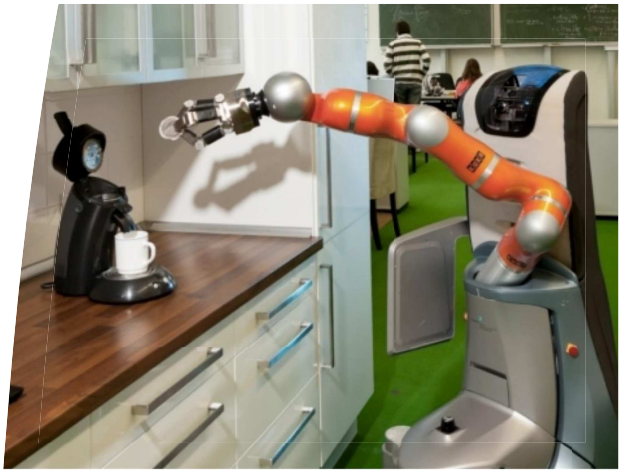

Figure 1: Service robots such as Jenny, pictured here, are expected to carry out routine household tasks such as making coffee, tidying up rooms, and finding our keys. In cases where a resource is missing, agents like Jenny would either fail to produce a plan to carry out the task, or at execution time, fail to perform the task. Enabling the substitution of objects allows the agents to find alternative ways to get the job done.

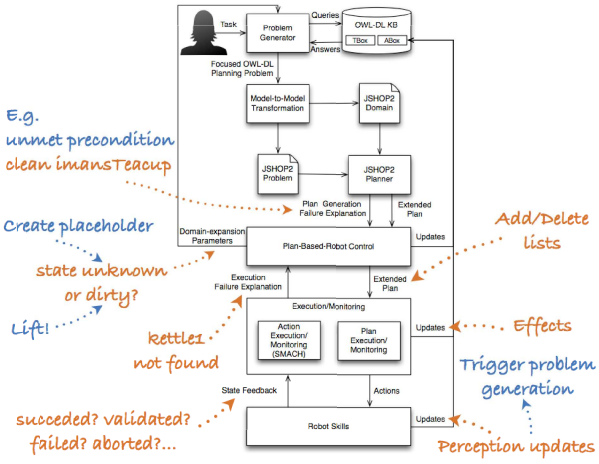

Figure 2: The architecture of the system annotated with explanations of various data (in orange) and showing how the system responds (in blue).

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