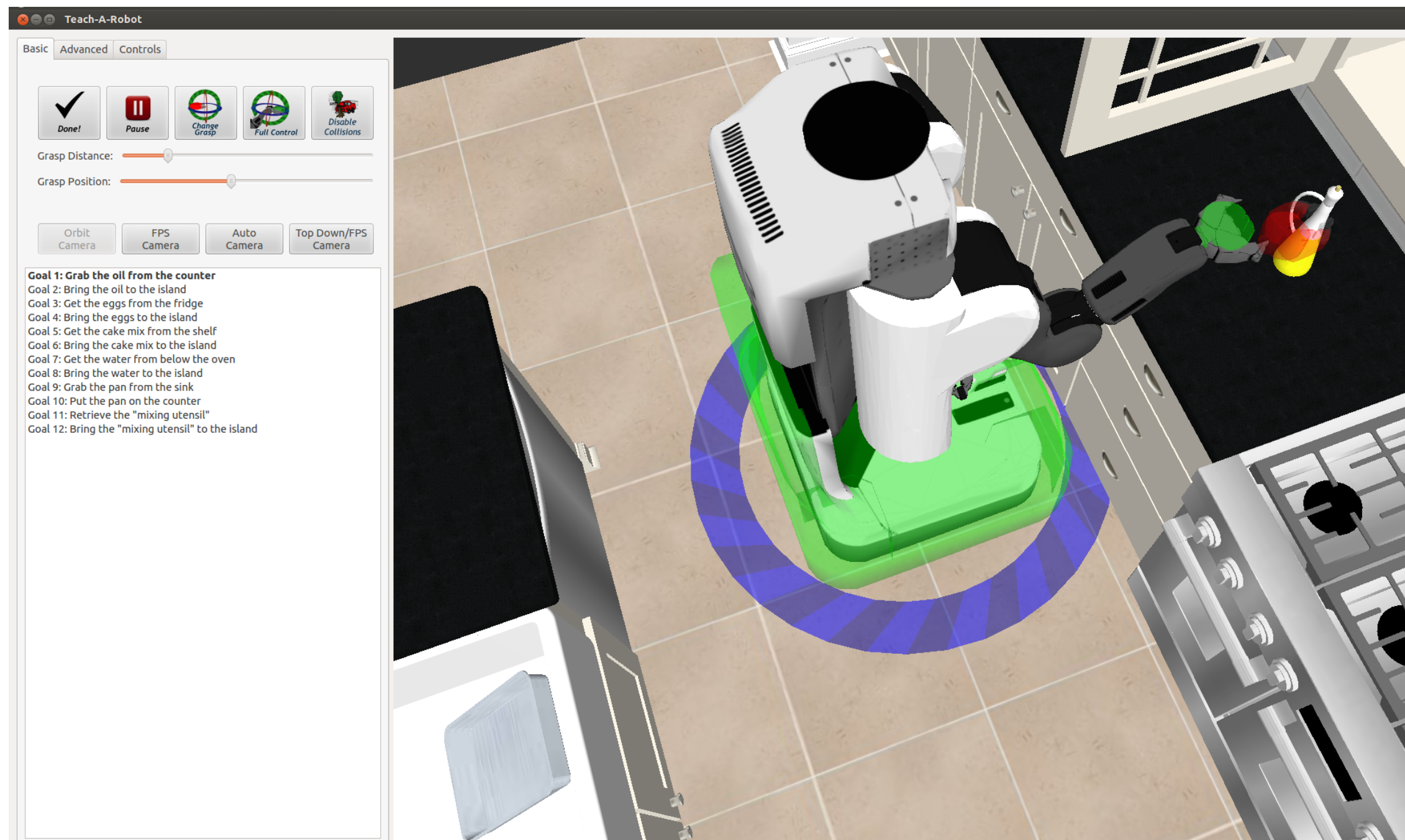


# An Infrastructure for Recording User Demonstrations of Complex Tasks

*Ellis Ratner, Mike Phillips, Benjamin Cohen, Maxim Likhachev*

## Introduction

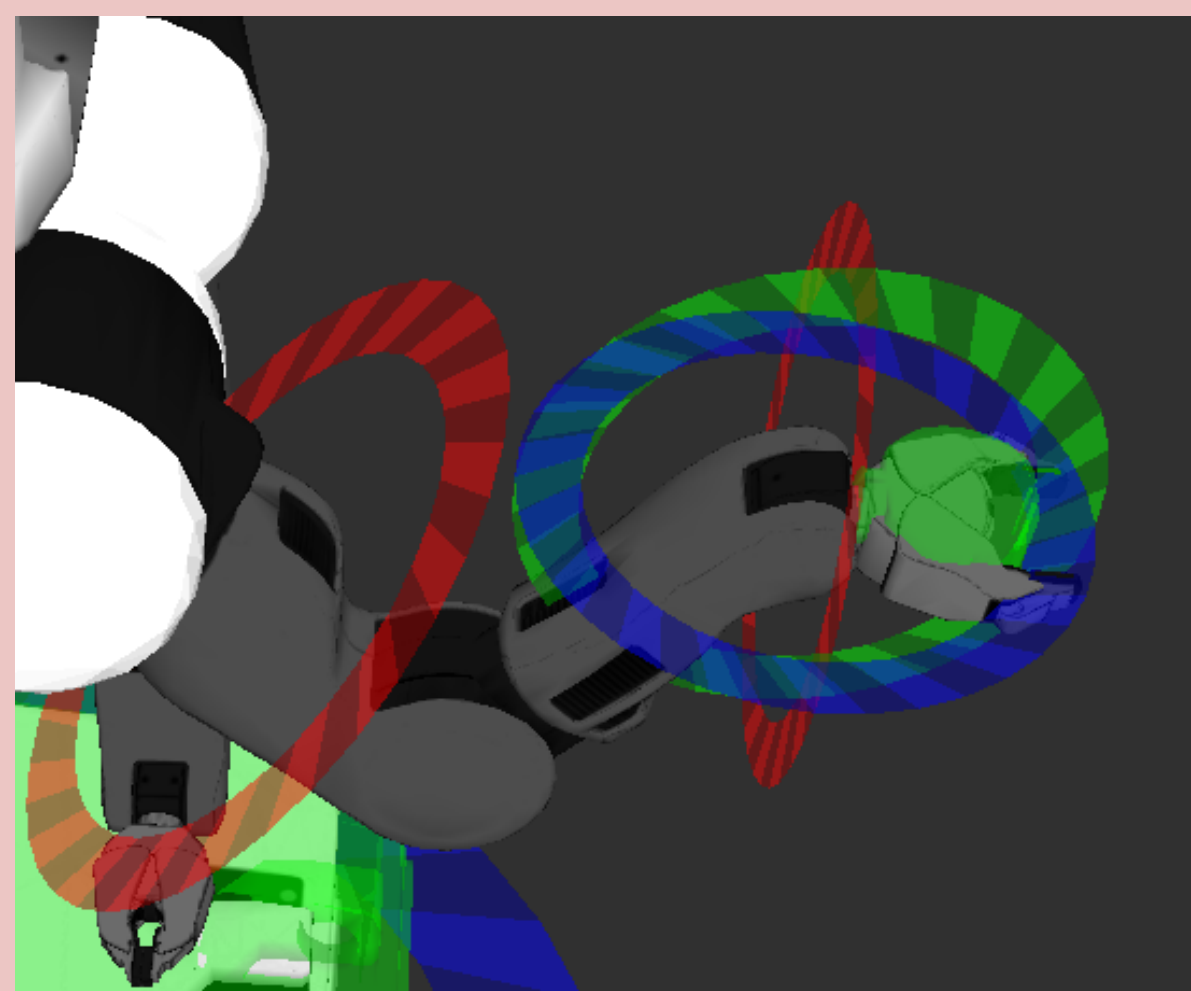
We developed a software framework for capturing user demonstrations of complex mobile manipulation tasks in a simulated environment using the PR2 robot. For example, picking up a bottle and placing it elsewhere.



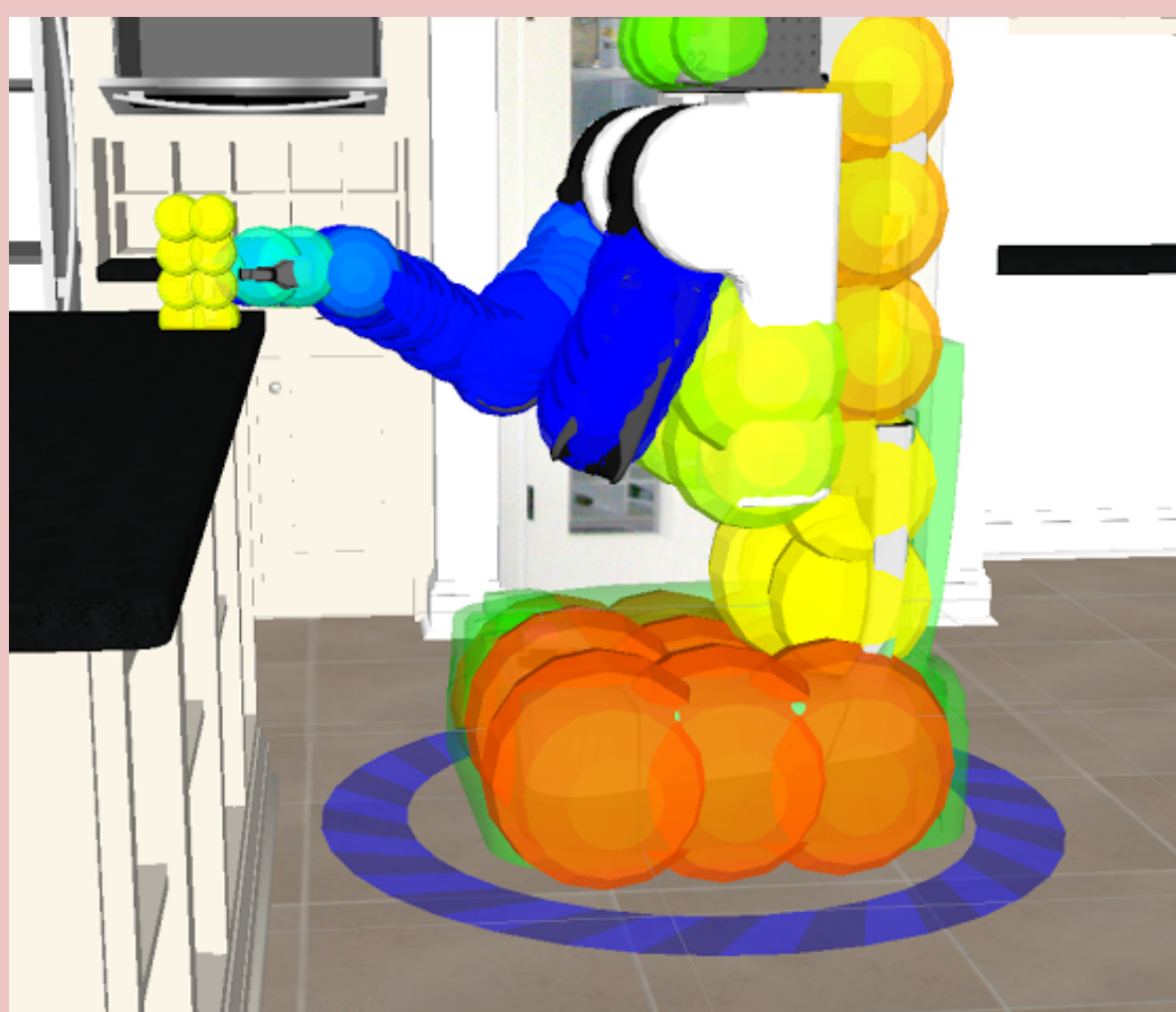
## User Demonstrations

User demonstrations are composed of 7 DOF arm motions and 3 DOF base motions ( $x$ ,  $y$ ,  $\theta$ ). We created two sets of controls: one mouse-based for novice users, and one that makes use of the mouse and keyboard in concert for advanced users.

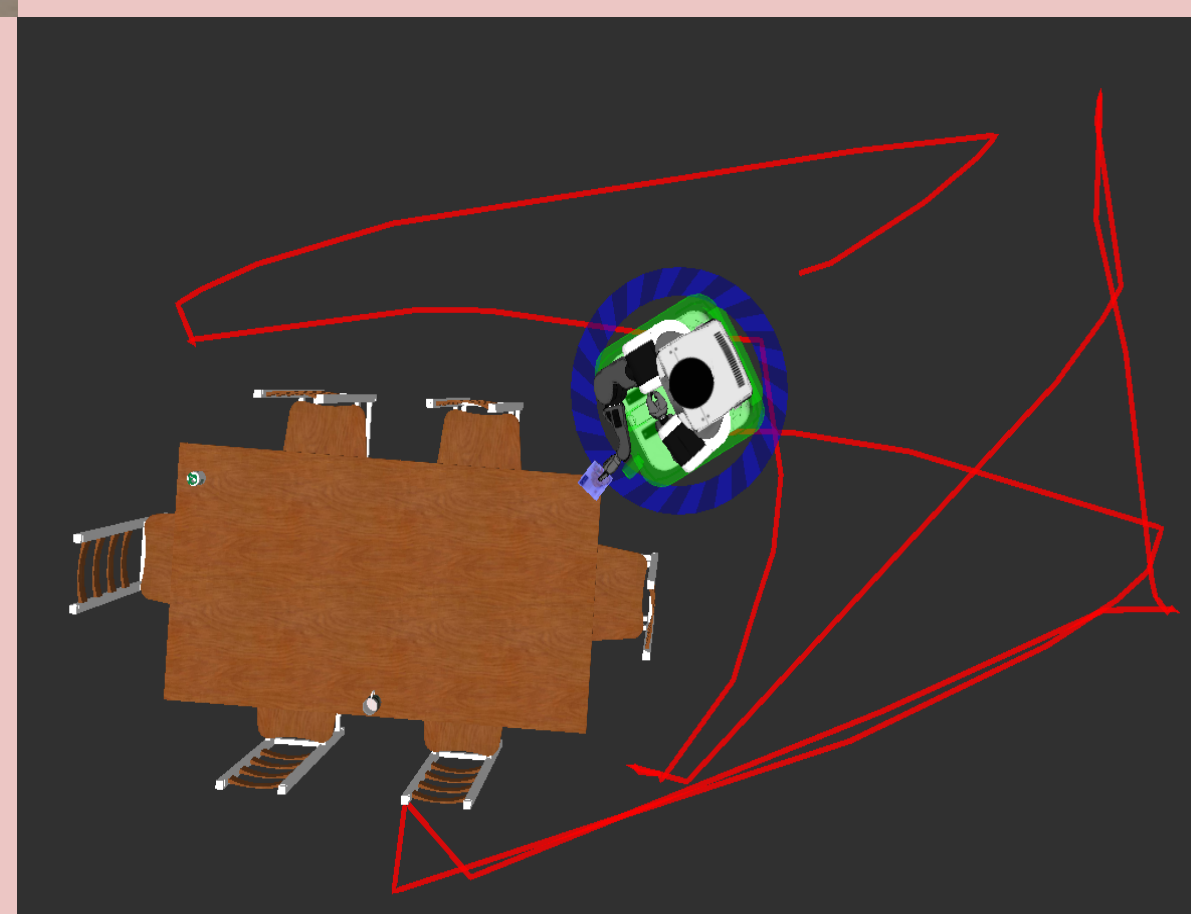
Users provide waypoints for the base and end-effector to a simple workspace controller (carrot controller).



As controllers move toward their “carrots,” movements are checked for validity against collision, kinematic, and other constraints.

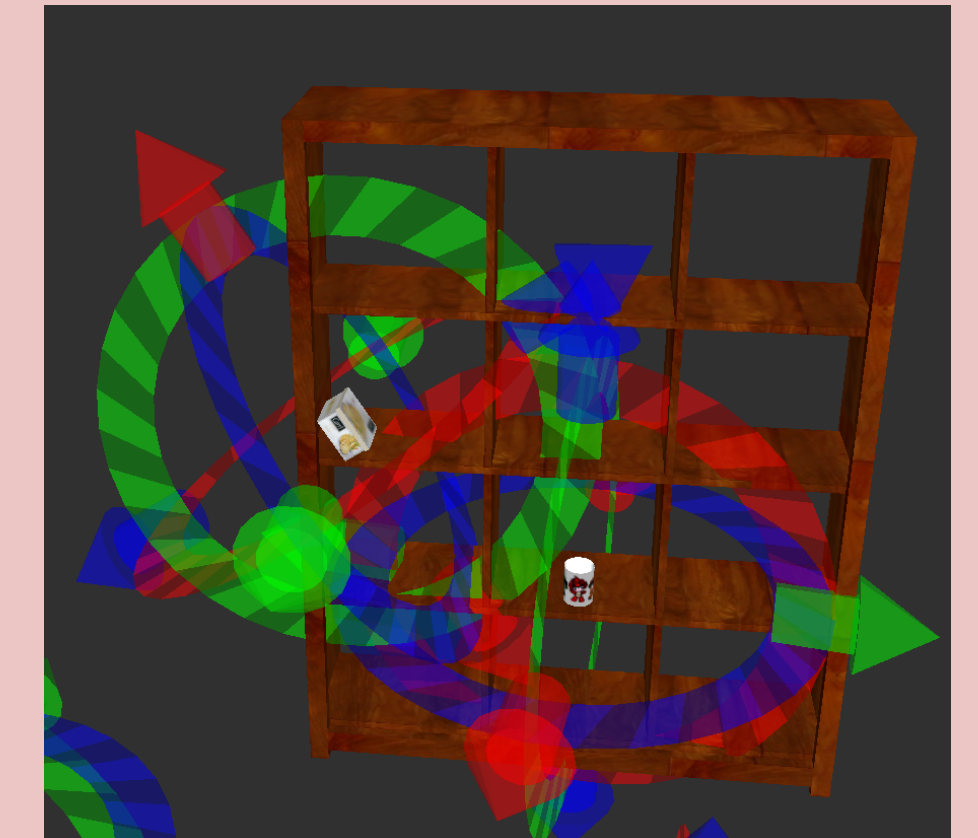


We record user chosen grasps, as well as the motion used to accomplish them. Full or partial demonstrations can be replayed from recorded files.

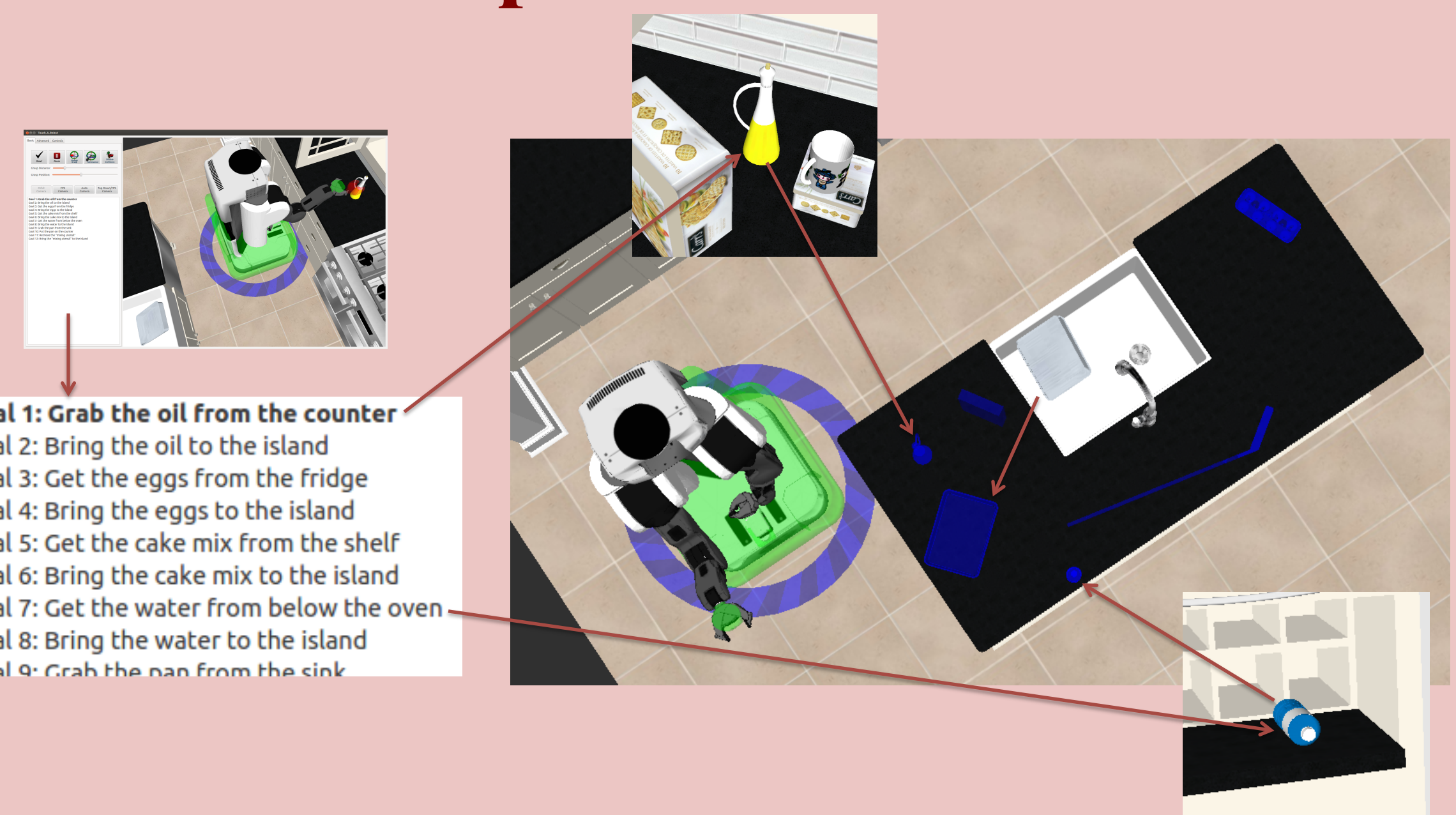


## Scene & Task Builder

**Scenes** are composed of objects, either statically placed in the environment or manipulable. **Tasks** consist of a sequence of goals (e.g. pick up or place an object). Researchers can easily build new scenes and tasks using a drag and drop interface. Suitable meshes are readily available from websites such as Google 3D Warehouse.



## Example Scene & Task



In this task, the user collects ingredients from the kitchen to make a cake. The items must be retrieved, and then placed as indicated by the blue markers.

## Research Applications

This tool will facilitate the collection of large amounts of data about complicated mobile manipulation tasks. Some applications include:

- Motion planning that makes use of previous plans, such as E-Graphs [1, 2].
- Studying context-specific object grasps.
- Learning motion primitives for graph-based planning.

## Future Work

- Incorporate usability improvements from a preliminary, 10 person user study.
- Embed this tool in a web browser to facilitate data collection.
- Publish our collected data for use in other research.

## References

1. Mike Phillips, Benjamin Cohen, Sachin Chitta and Maxim Likhachev, “E-Graphs: Bootstrapping Planning with Experience Graphs,” Proceedings of the Robotics: Science and Systems Conference (RSS), 2012.
2. Mike Phillips, Victor Hwang, Sachin Chitta and Maxim Likhachev, “Learning to Plan for Constrained Manipulation from Demonstrations,” Proceedings of the Robotics: Science and Systems Conference (RSS), 2013.