Appendix B

User Manual

System for research of analogy in robot object manipulation. For simplification, it is using axis-aligned bounding boxes.

- Design a scene in Microsoft 3D builder[1]
- Teach the system what are the ideal manipulation points and force vectors for specific tasks.
- Use the knowledge to solve the manipulation tasks in unseen situations using an analogy.

B.1 How to use the system

Assuming the installation is done. As a first thing activate venv with the following command.

```
source venv/bin/activate
```

Then you can run the system. There are two options. The first option is to add new knowledge to the knowledge base database. The second option is to solve or ask the system what are the best manipulation points and force vectors for a target object based on the current knowledge. You can have multiple different databases with different knowledge.

B.2 How to add new knowledge

This is a more general example of how to use the command.

```
./analogy.py add scene_name.obj knowledge_base.db
```

This is a specific example that will work immediately.

```
./analogy.py add scene_name.obj knowledge_base.db
```

If a file with the name of the knowledge base database does not exist, it will be created. If it exists, the knowledge will be added to the existing database.

You will see the scene shown in Figure B.1.

After the scene is opened and visualised in your web browser, select the target object for manipulation (click on it).

How to manipulate with the scene:

- Rotate the camera view: drag with the right mouse button (or Ctrl-drag left button).

[1] https://www.microsoft.com/en-gb/p/3d-builder/9wzdncrfj3t6?activetab=pivot:overviewtab

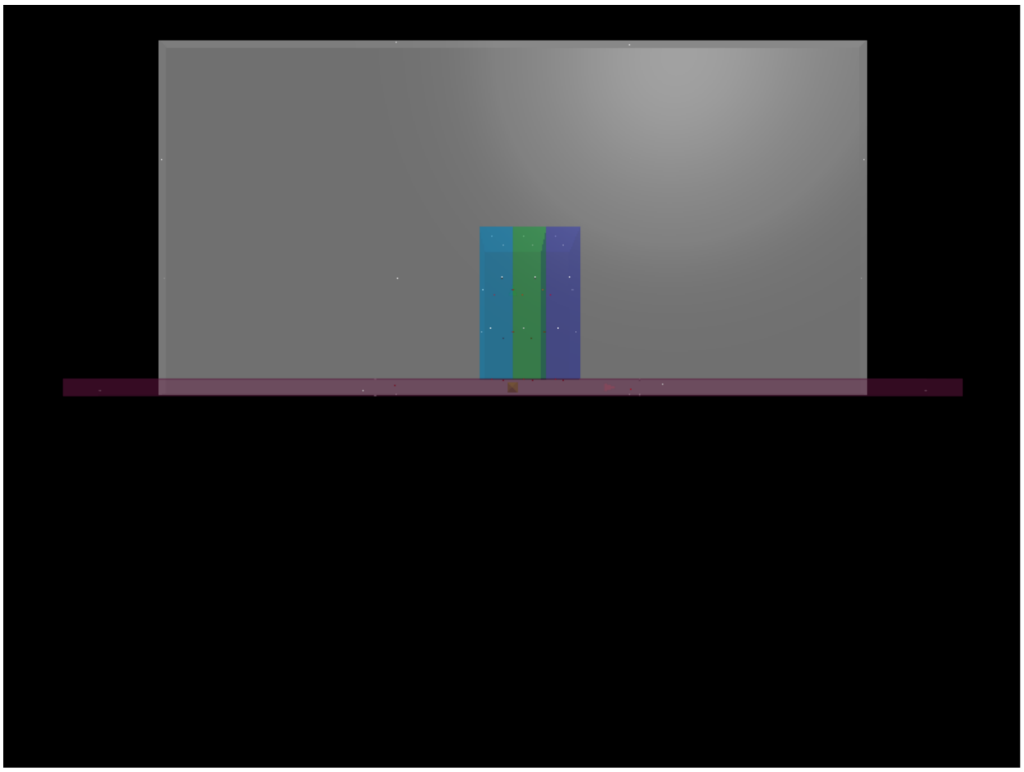

Figure B.1: books-shelf.obj scene without selected target object.

- Zoom: drag with left and right mouse buttons (or Alt/Option-drag or scroll wheel).
- Pan: Shift-drag.
- Touch screen: swipe or two-finger rotate; pinch/extend to zoom.

Figure B.2 shows how the target object changes opacity once it is selected.

Then follow the instructions in the terminal window. You will be asked to add the ideal manipulation points and force vectors for specific tasks. Currently, it supports only 3 tasks. The manipulation tasks are push, pull and using a spatula. In the end, knowledge is saved to the database.

The repository contains a few example scenes that you can find in `scenes` directory.

B.3 How to use the knowledge

This is a more general example of how to use the command.

```
./analogy.py solve scene_name.obj knowledge_base.db
```

```
./analogy.py solve scenes/books-shelf.obj all_scenes.db
```

After the scene is opened and visualised in your web browser, select the target object for manipulation (click on it). How to manipulate with the scene:

- Rotate the camera view: drag with the right mouse button (or Ctrl-drag left button).
- Zoom: drag with left and right mouse buttons (or Alt/Option-drag or scroll wheel).

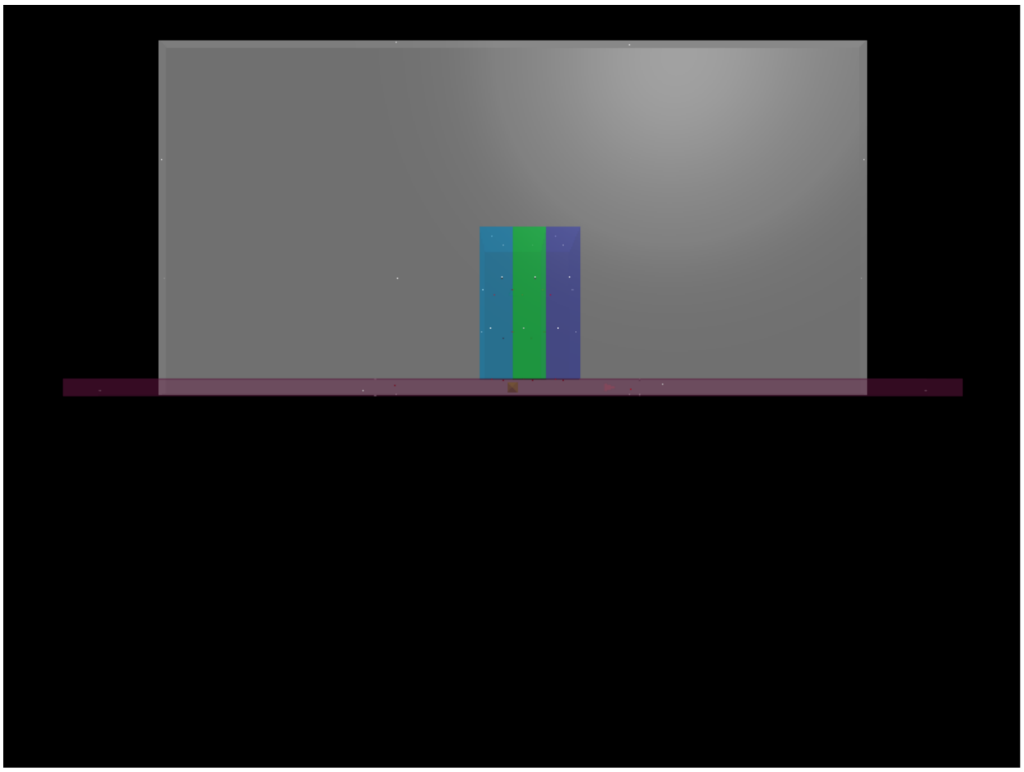

Figure B.2: books-shelf.obj scene with selected target object.

- Pan: Shift-drag.
- Touch screen: swipe or two-finger rotate; pinch/extend to zoom.

For example the middle book on the shelf. Then confirm the selection in the terminal window. You should now see the suggested manipulation points and their force vectors for specific tasks. This is presented in Figure B.3

White spheres are colliders for each axis-aligned bounding box. Based on the colour you can distinguish the manipulation tasks.

- Cyan colour = push
- Purple colour = pull
- Orange colour = using spatula

B.4 Analogy Example

It is interesting to see how the analogy works with limited knowledge. For example, `books-shelf.db` contains only knowledge about how to manipulate the middle book in scene `scenes/books-shelf.obj`. Now, if I want to solve a manipulation problem for a pizza box in a freezer in the scene `scenes/pizza-boxes-freezer.obj`, I just have to run this command.

```
1 ./analogy.py solve scenes/pizza-boxes-freezer.obj books-shelf.db
```

Notice that the last argument is the knowledge base we want to use. See Figure B.4

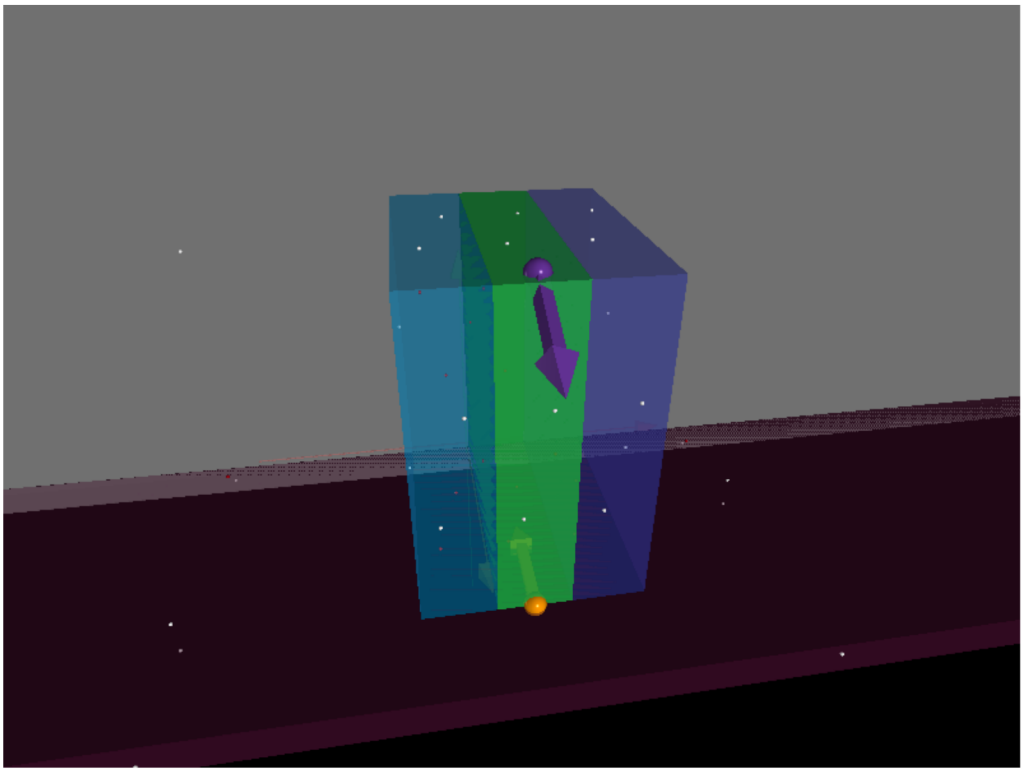

Figure B.3: books-shelf.obj scene with suggested manipulation points and force vectors.

Now you have to rotate the scene so you can select the target object (pizza box in the middle). See Figure B.5

After you confirm the selection in the terminal window you can see suggested points and force vectors. See Figure B.6

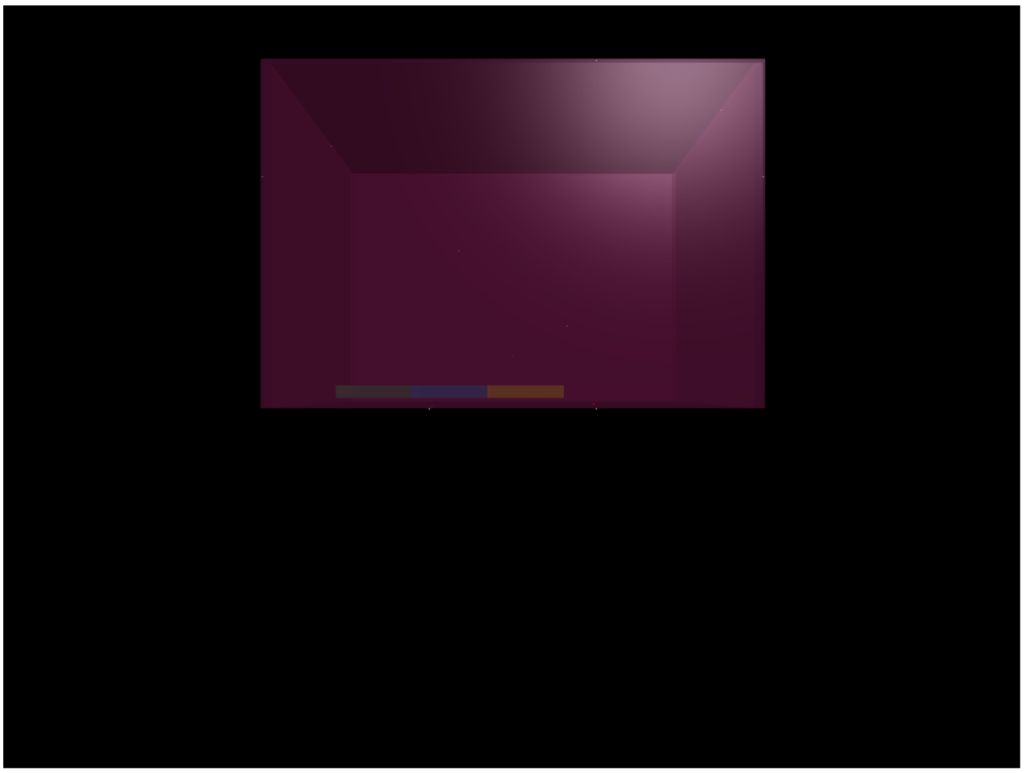

Figure B.4: pizza-freezer.obj scene without selected target object.

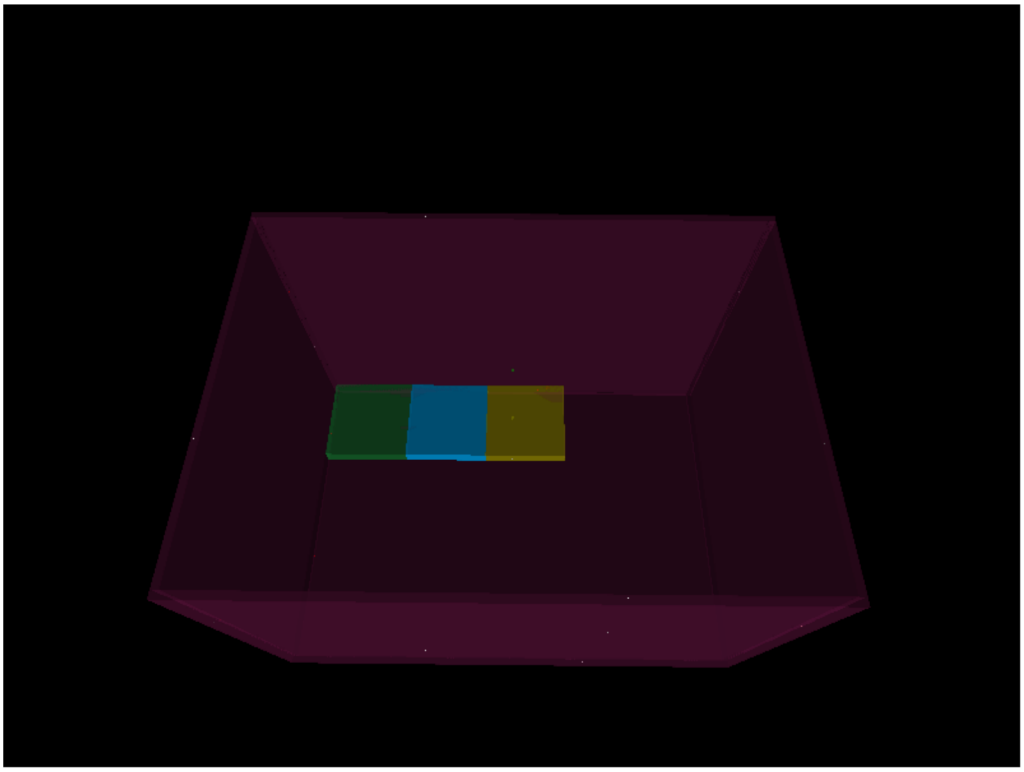

Figure B.5: pizza-freezer-2.obj scene rotated so it allows selection of the target object.

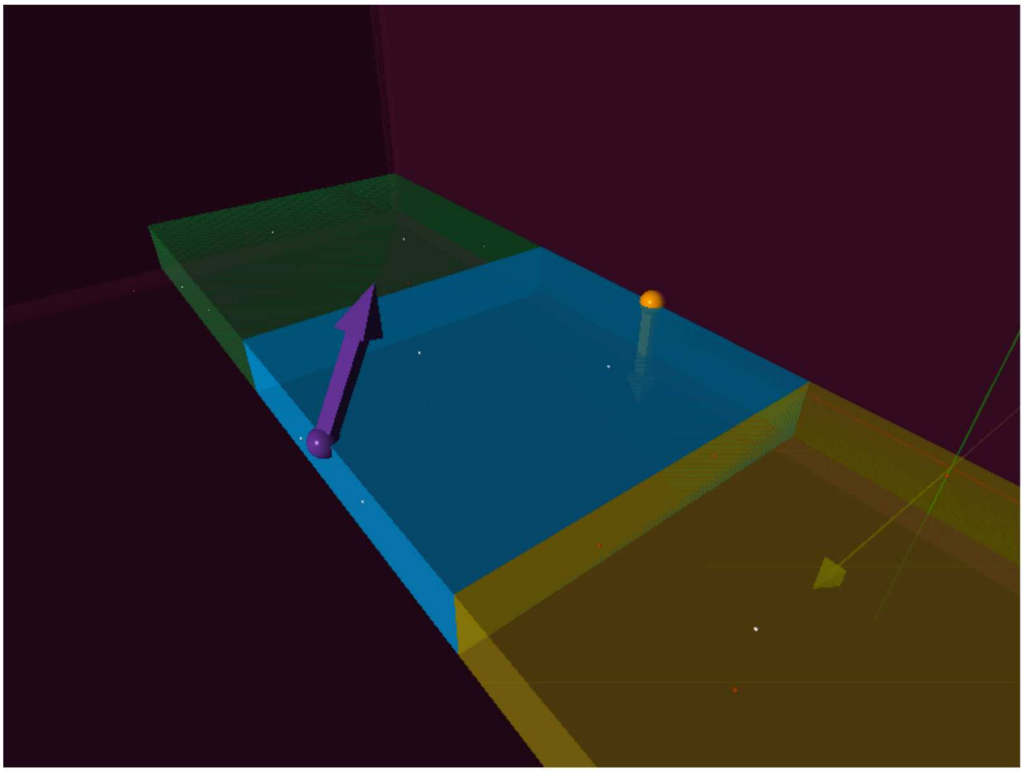

Figure B.6: pizza-freezer-3.obj scene solved using analogy.