IROS 2017 Grasping and Manipulation Competition

Manufacturing Track Qualifier

Purpose:

The IROS 2017 Grasping and Manipulation competition manufacturing track requires teams interested in competing in the manufacturing track to demonstrate the capabilities of their proposed system via written description and video. This submission allows competition organizers to assess capabilities and to adjust the difficulty of the actual competition appropriately as well as to select the most prepared teams in the case that there are too many entries to accommodate at the competition venue. Teams are welcome to reproduce the example manufacturing artifact presented below or to develop their own demonstration of assembly capabilities based on all or a subset of the following assembly topics: geometry insertion, threaded fasteners, snap-fit fasteners, and gear meshing. All assembly topics are contained within the assembly artifact presented below. Whether you are designing your own custom assembly tasks or reproducing the supplied artifact, appropriate tolerancing of mating parts should be produced, since at a minimum these same tolerancing schemes will be used during the competition. The tasks and rules presented with the assembly artifact should be followed for submissions using custom assembly artifacts.

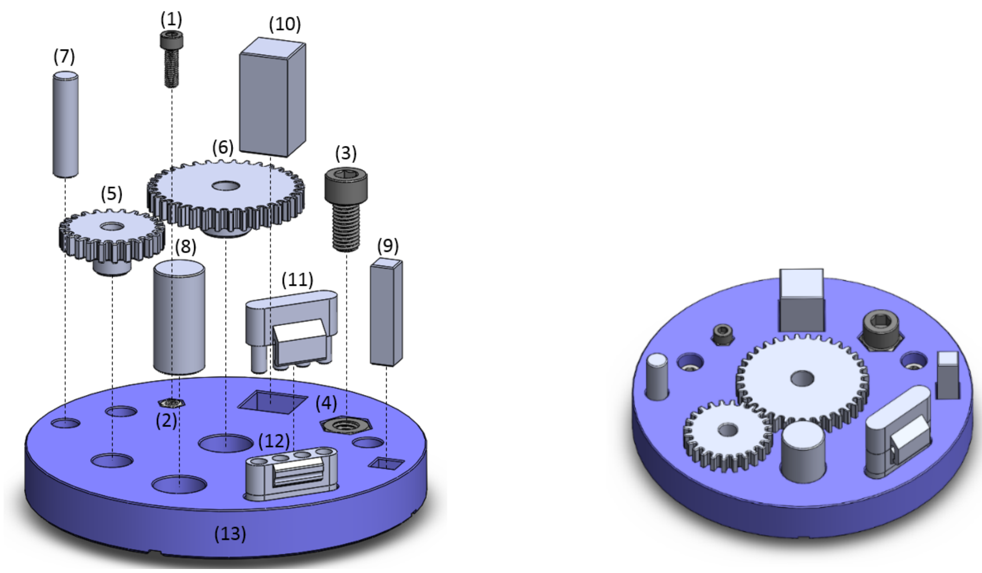
Assembly Tolerance Requirements:

1. Use standard metric socket cap screws.
2. Use standard running/sliding fits**.** For example, expect a clearance up to 0.25 mm for a cylindrical peg of 20 mm diameter and for a square peg with 20 mm sides. Similarly, expect a clearance up to 0.16 mm for a cylindrical peg of 10 mm diameter and for a square peg with 10 mm sides.
3. Avoid gear binding and allow for appropriate gear backlash for meshing clearance. In general, tolerances should be center distance +0 .05 mm for fine pitched gears and center distance + 0.1 mm for course gears, where center distance = (gear1 pitch dia. + gear2 pitch dia.) / 2. Note that 3D printed gears will add additional variability to backlash.
4. There are no standards for snap-fit fasteners. the following links provides some guidance on designing snap fits:
    a. http://fab.cba.mit.edu/classes/S62.12/people/vernelle.noel/Plastic_Snap_fit_design.pdf
    b. http://www.sciencedirect.com/science/article/pii/S2212827116303213

3D Printed Assembly Artifact

Components:

1) M5 x 0.5 Bolt
2) M5 x 0.5 Nut
3) M10 x 1.25 Bolt
4) M10 x 1.25 Nut
5) Small Gear (36 mm pitch dia.)
6) Large Gear (56 mm pitch dia.)
7) Small Cylindrical Peg (10 mm diameter)
8) Large Cylindrical Peg (20 mm diameter)
9) Small Square Peg (10 mm sides)
10) Large Square Peg (20 mm sides)
11) Snap-fit Connector (male, 4 pole)
12) Snap-fit Connector (female, 4 pole)
13) Base



(a) (b)

Figure 1. Assembly artifact in (a) exploded and (b) assembled views.

Construction:

SOLIDWORKS and STL files are provided. All parts can be 3D printed, except for the bolts and nuts (these are inexpensive and easy to obtain). Glue nuts into Base part. Press part (12) into Base part. Recommendations for 3D printing are as follows:

1) Use brim with Base part for improved plate adhesion
2) Build part (11) at 0.1 mm layer height for improved part strength
3) Print parts one at a time for best part surfaces. However, parts can be printed in batches, and surface defects may be filed.
4) If you must re-tolerance parts, then you should do so without jeopardizing the slip fit clearances. If you can easily drop your parts into the holes, then you have gone too far. See notes below for additional information on tolerancing.

Note: See Appendix A for information on 3D printing services.

Qualifying Task

Setup:
A kit drawing (Kit_Drawing.PDF, see Figure 2) is provided as an easy was to get started and to determine the locations of parts. However, demonstration of perception and manipulation capabilities are expected and ultimately this task should be demonstrated with random part placements and orientations that require in-hand manipulation, use of multiple arms, and/or extrinsic dexterity to achieve assembly goals.

Run:
Commence autonomous robot operation. Parts should be 1) localized, 2) grasped, and 4) manipulated, and 4) inserted in their designated locations on the Base part.

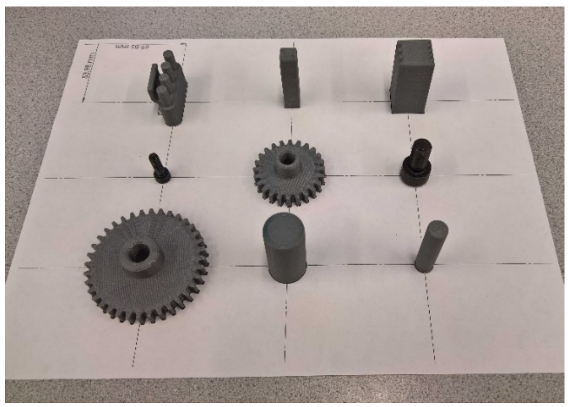


Figure 2. Structured kit provided for simplified localization of parts, to get started.

Task Rules:
1) It is advisable to demonstrate full insertions (including bolts).
2) Autonomous robot operation should try to complete the entire task in a continuous run.
3) Once the task is initiated, a human operator may not interfere through physical or remote means. If interference occurs, then the test must be reset. For example, manual end-effector changes are not allowed!
4) Completed parts can be manually removed to provide clearance for subsequent robotic assembly operations.
5) There is no restriction on the number of arms, grippers, sensors, etc.
6) Use of hand tools are allowed provided the robot localizes and acquires these tools without human assistance.

Submission Rules:
1) A raw, unaltered video recording of robot completing the above task to the extent possible must be submitted ideally with the most challenging perception and manipulation constraints.
2) Videos must maintain clear perspectives of both the task scene and robot system, and consist of a single, continuous run of the robot system completing the tasks along with the initial setup. For example, the start of each video should show how the parts were randomly just before autonomous robot operation is started.

Appendix A – 3D Printing Services

There are many 3D printing services available and it would be difficult to specify any particular one, especially on that is internationally available. 3D HUBS is a web portal that can help you locate 3D printing services globally for fee based on a percentage of your printing job cost. We found local U.S. printing services using this portal to produce the above assembly artifact for approximately 100 U.S. dollars. To use this service:

1. Go to https://www.3dhubs.com/.
2. Upload the files to print (use Assembly_Parts.stl and Qual_Board.stl located in the STL directory), where the first contains all the parts minus the base (minimizes setup costs) and the second file contains the base.
3. Select "Prototyping Plastic" which is the lowest cost solution. The other selectable printing services listed are much more expensive.
4. Select a company local to you based on their rating, available material types and colors, and shipping methods. We printed the parts in ABS, however other materials such as PLA should work as well.