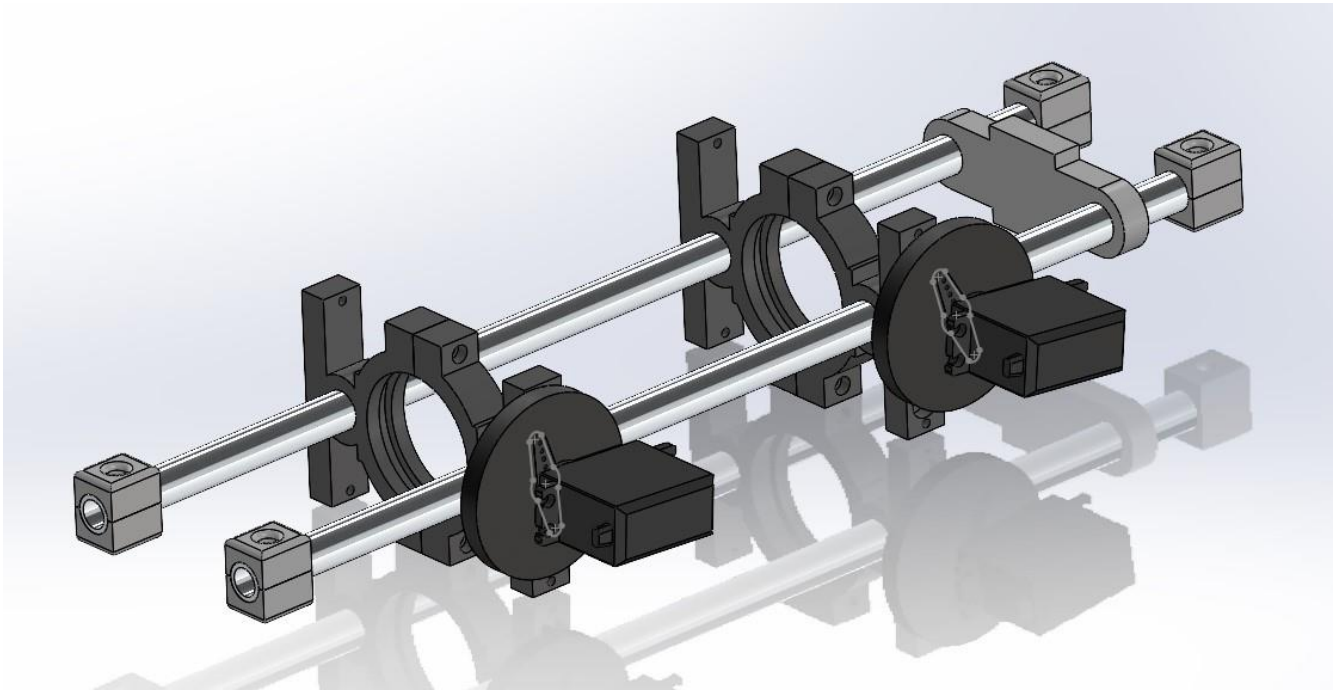
Manufacturing and assembly instructions (final product mechanism)

This document contains a basic guide to manufacturing the mechanism that holds and moves the lenses. It does not contain information on manufacturing the casing. Due to the modular design, this mechanism can be fitted into a very wide selection of cases, and therefore the casing design does not affect the manufacturing and assembly of this mechanism.



Basic familiarity with the following skills is assumed, but resources can be found online to rapidly learn these skills, should you not be familiar with any of them

- Slicing and printing basic parts in PLA (with the use of support structures)
- Cutting, deburring and drilling into aluminium tubing
    - Requires use of a pillar drill, ideally
- Using Solidworks to export STLs, check dimensions and open assemblies
- Very basic metal/wood-work skills, particularly around marking out areas to drill/cut using a tri-square and scribe/pen

Bill of materials:

- Aluminium tube
    - ½ inch outer diameter, 3.2mm wall thickness
    - 2 40cm segments, or one 80cm segment needed
- Tube holder
    - 8 copies needed in total, (2 per side per tube)
    - 3D printed in PLA
- Lens holder
    - 4 copies needed in total, (2 per lens)
    - 3D printed in PLA
- Camera holder
    - 1 copy needed

    - 3D printed in PLA
- Disk with Scotch (for the mechanism)
    - 2 copies needed
    - 3D printed in PLA (with larger wall thickness, explained in later sections)
- M3 bolts and threaded inserts, if assembly is being carried out.
    - An exact number is not specified here, as the final number will be dependant on how the mechanism fits into its casing. However, it is recommended to have a reasonable number of M3 bolts and inserts on hand, as they are used throughout the entire design.

Aluminium tube:

1) Cut the 80cm tube into 2 40cm lengths, if this has not been done already
2) Check the Solidworks assembly to find the distance of the holes in the aluminium tube from it's two ends.
    a. It is better to check each time as the design may have been updated as it is improved over time
3) Mark out these holes, ensuring that they are aligned to each other vertically
    a. This is a slightly tedious process, with the recommended method being to measure out 2 circles at the right depth from the tube's ends. Then a line should be drawn from one end of the tube to the other using a long ruler and tri-square. Mark out holes to drill at the intersections of the line and circles
    b. To summarise, the line is used to ensure that the holes are aligned vertically, and the circles (marked around the circumference of the tube), are used to ensure that the holes are the correct distance from the ends of the tube
4) Setup a pillar drill with the tube inside, ensuring that the vice you are using does not deform the aluminium, as it is a relatively ductile metal.
    a. Ensure that you are wearing safety goggles during this process.
    b. Use a 3mm drill bit, assuming that this has not since been changed in the design.
    c. Drill the holes. Make sure to deburr afterwards using a deburring tool or drill bit (which can be used a rudimentary deburring tool), to ensure that any sharp edges do not later cut your hand. This is important for safety during the manufacturing process. All metal parts should be deburred after cutting or drilling operations for safety, particularly if the person manufacturing the parts is not wearing safety gloves during the process.

3D printed parts:

1) The parts may have to be printed in batches, but the same instructions can be followed repeatedly. It is best to check the printer's settings by printing a single instance of each part the first time, to minimise waste if the print later fails
2) Settings will differ between different printers, but for PLA an extruder temperature of 210 degrees and a bed temperature of 20-70 degrees is recommended. For specific settings refer to the PLA filament's datasheet, as well as your 3D printer's datasheet.
    a. 20% infill is recommended for an ideal trade-off between weight and part strength. A wall thickness of at least 5 layers (the default is 3) is recommended. Most of the strength of 3D printed parts actually comes from the wall-thickness, and it adds negligible mass to the parts.
    b. We are printing using PLA as it is cheap, durable, and strong. It is brittle however, and future versions of the design may wish to use ABS instead (if a suitable supply of low-cost ABS filament and compatible 3D printer are available). Printing with different filaments (that are not PLA) is often a tedious process, as many filaments require careful handling and storage, before and after printing.

    c. Many plastics are unable to withstand exposure to the sun. This is something that has not been explored due to the short timeline of the project, but it is recommended that future versions of this design use plastic that is rated for outdoor UV exposure, or that the parts covered with a casing or coating that prevents damage from UV exposure.

3) Remove all supports after the parts have been printed.
    a. Ensure that you are wearing safety goggles during this process
    b. Wire-cutters or tough, metal tweezers are recommended for removing the bulk of the supports, following by a light sanding with medium-grit sandpaper if necessary (to remove any remaining excess material)

Assembly:

This is a fairly simple process, with most parts simply slotting together, and being held by the casing that covers this mechanism.

There are few important things to note when assembling this mechanism

- It is recommended to slot all parts into the tubes, on both sides, before adding the tube-holders at the end. This is because they prevent any more parts from being slotted into the tube after they have been attached
- It is possible to use bolts and nuts, or bolts and inserts to hold the parts together. The design currently using bolts, but this is not ideal. Future versions of this design should use inserts, as they result in a cleaner design and are more robust to vibrations. This would require increasing the hole diameters to 4mm for an M3 insert. Apart from this, the design is already compatible with the use of inserts. Be sure to only increase the diameter of the hole that will be containing the insert, not any other holes that the bolt will go through.
- Inserts should be inserted into parts by using a soldering iron (inserted into the M3 insert) to melt the plastic surrounding the hole where insert will be placed. It is recommended that you find online resources explaining this process, as there are many easy-to-understand videos available.