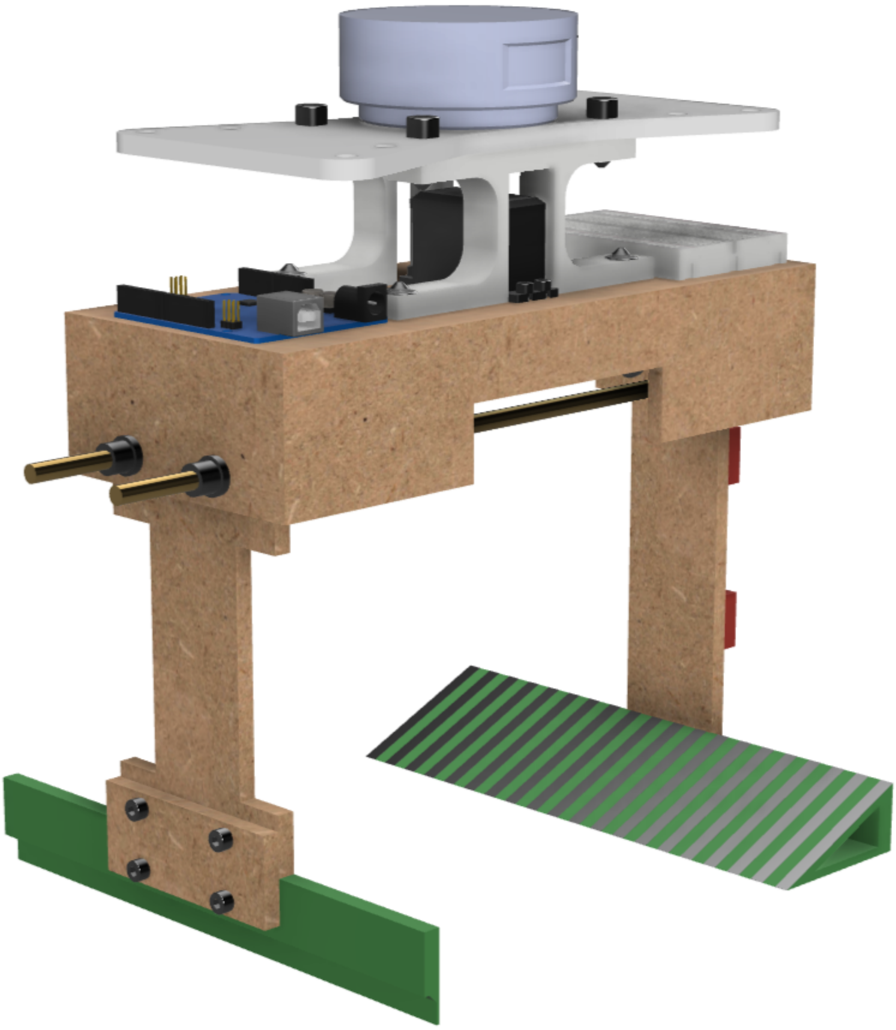
École Polytechnique Fédérale de Lausanne

Product development and engineering design: Gripper project (BA5)

Final Report - Group 8



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1 Summary of the approach

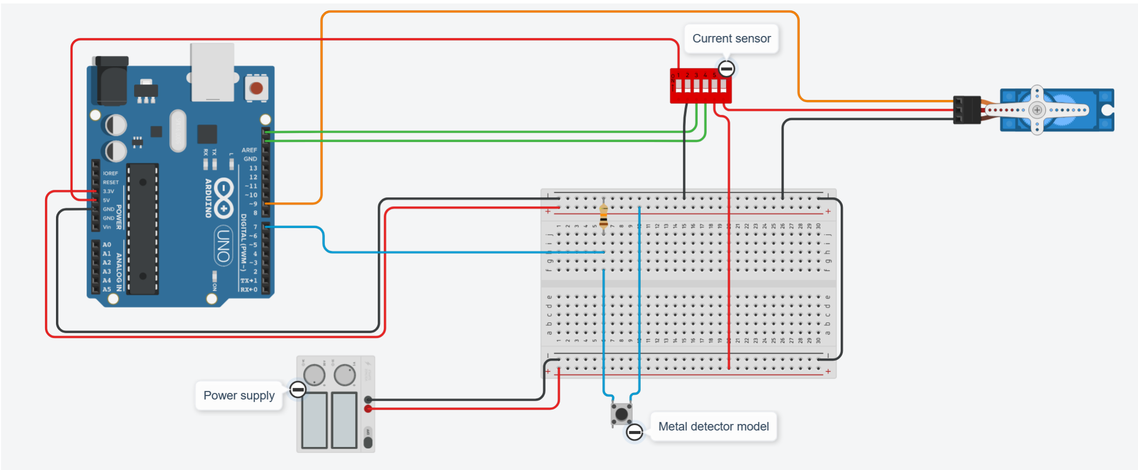
1.1 Choice of the mechanism

The gripper we built is inspired by the mechanism of an excavator. We have an inclined plane and a part that mimics a brush opposite to it. The shape of these parts were carefully chosen in order to lift various objects with different geometries. We figured that in this way, we will be able to lift something as small as grains and as big as apples.

A servomotor is used in order to convert rotational motion to linear motion along a rail. To minimise torsion and friction effects, we used brass rods and 3D printed bearings. At its maximum opening, the gripper is able to accommodate the required size of 15cm. At the smallest opening, the brush part slightly touches the inclined plane.

Since we had to assemble different types of materials together (MDF and PETG), we decided to go with the screws and nuts approach, ranging from M2 to M6. The bigger screws were used to connect the gripper to the mounting platform since we need a very solid assembly that supports loads in the vertical direction. However, even with the added load of the object, we think that our gripper is light compared to other design choices.

1.2 Choice of sensor



1.2.1 Current sensor : detects when the object is caught

The inclined plane has been designed to accommodate an apple, but not too large an object. When a large object needs to be caught, part of it will be on the inclined plane, while the other end will be maintained in position by the brush. To avoid damaging the servomotor, we used a current sensor to determine how far the gripper should be closed.

Indeed, when the gripper closes on an object, an opposing torque is created which increases the current drawn by the servomotor. By setting a limit value for this current, we can determine the correct moment to block the servomotor at that position.

The current sensor is the INA219, modeled by the red component in the circuit image above. Testing the values given by this sensor, we found that the threshold current (which defines when an object is caught) is 0.9A.

1.2.2 Metal detector : detects when the object is cutlery

Knowing that non-food items are bound to be metal, we decided to create a metal detector with an open circuit that the cutlery will close. To do this, we use the Arduino's 3.3V output, and a 10kΩ resistor in series with the "switch".

Alternating aluminum strips (+: 3.3V, -: GND) on the inclined plane define this switch. When a cutlery is caught, it closes the circuit by touching these strips, and the serial monitor indicates this.

1.3 Choice of material

The materials used are mainly PETG (3D printing) and MDF (laser cutting).

The outer frame of the gripper and the arms that slide to catch the object were cut from wood. The choice of 5 and 6 mm thick plates ensures the structural rigidity of the gripper.

The inclined plane, the brush, the connectors to the mounting platform and the plain bearings were 3D printed.

2 Reflection on the design

One of the major downsides of our design is that we use M2 screws directly in the MDF sliders to connect them to the bars. It works for our application because we deal with small objects but it generates a lot of stress on the screws. We also think that we could do better with the sliders in terms of friction. If we had a larger budget, we would have installed a linear bearing with a low coefficient of friction.

Another possible issue with our design is the fact that our metal detector has some reliability problems with false contact between the metallic wire and the aluminium scotch. Further investigations in the way to connect a metallic wire with aluminium scotch need to be done.

Nevertheless, we think our design is simple, compact and uses an elegant closing mechanism. We took a risk by not going with a classic design of a box that closes, and it ended up paying off when doing various tests before the competition day. The gripper worked quite well with big objects as well as small ones; we were once able to get a 100% success lift with a bunch of seeds. In addition, we respected the budget with a large margin (we used less than 50% of the budget allocated for the entire project) and most of the 3D printed parts for the prototype were reused, allowing us to minimize the waste.

3 Sustainability & scalability

The MDF and the PETG used in the gripper have the advantage of being easily recyclable. Once our gripper is no longer used, we can easily dispose of its different parts.

In terms of scalability, given the wooden and uniform structure of our gripper, it would be easy and fast to manufacture on a big scale. However, the 3D printed parts are slow to produce which is quite challenging. Moreover, we would have to rethink the integration of the metal detector because we attached the aluminium sheets by hand.

Between the first prototype and the final version, the majority of the components have been retained, thanks to some serious work on the 3D design. The wood used is entirely reclaimed from old cut-outs.

All these elements, from design to production, mean that our gripper has successfully met a good amount of sustainability challenges.

4 Literature and patent research

The actuating mechanism chosen was refined during the course of the project. Searching the literature on the subject, we found the article *Axiomatic design of a linear motion robotic claw with interchangeable grippers* [1] which studies a very similar mechanism: the idea is to transform the rotation of a servomotor into a linear motion of 2 arms. We decided to use this article as a basis for dimensioning and testing the first version of our gripper.

We also found the patent US6626476B1 [2] for the used mechanism. The inventors used a rotatory actuator coupled to a magnet to get the closed and open positions. This patent validates the mechanism we chose and allowed to have a solid basis while designing our gripper.

Our design differs in the grabbing mechanism because we wanted to grab small food products such as sunflower seeds. Therefore, the other inspiration for our concept comes from the article *A Scooping-Binding Robotic Gripper for Handling Various Food Products* [3] which uses a gripper fit to grab various food products. The gripper from the article was made of two inclined planes moving in a linear motion and elastic bands to maintain the objects during the grab. In our gripper, we use only one inclined plane and a brush because we aimed to maximize the opening of the gripper in order to handle a wide range of objects sizes. We also gave up on the idea of the elastic bands because we thought that using the current sensor would give us more control on the forces applied on the objects, and in our previous tests objects seems to stay in place without the elastic bands.

References

[1] B. F. Erlingsson, I. Hreimsson, P. I. Pálsson, S. J. Hjálmarsson, and J. T. Foley, "Axiomatic design of a linear motion robotic claw with interchangeable grippers," Procedia CIRP, vol. 53, pp. 213–218, 2016, The 10th International Conference on Axiomatic Design (ICAD2016), ISSN: 2212-8271. DOI: https://doi.org/10.1016/j.procir.2016.07.006. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S2212827116307417 (cit. on p. 2).

[2] B. I. Govzman and C. Foxman, "Robotic gripper apparatus," U.S. Patent US6626476B1, Sep. 30, 2003 (cit. on p. 2).

[3] Z. Wang, H. Furuta, S. Hirai, and S. Kawamura, "A scooping-binding robotic gripper for handling various food products," Frontiers in Robotics and AI, vol. 8, 2021, ISSN: 2296-9144. DOI: 10.3389/frobt.2021.640805. [Online]. Available: https://www.frontiersin.org/articles/10.3389/frobt.2021.640805 (cit. on p. 2).