JAMES DYSON FOUNDATION UNDERGRADUATE BURSARY

Design and Control of a Multi-modal Soft Gripper

PROJECT SUMMARY

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1 Introduction

Soft grippers have the potential to solve many existing manipulation challenges, particularly in agile industry applications or in the handling of delicate objects. This includes grocery and logistic warehouses where objects, varying in size, shape, surface texture and colour, are required to be automatically processed without human interactions. The automated process usually involves the picking and placing of an object from one location to another for packaging or inspecting using a visually guided robotic system. This process is known as pick and place and designing a mechanism to achieve the adaptability to hold a wide range of items has historically been an important research area for robotic advancement.

2 Novel Soft Gripper

Existing soft grippers are often limited in the range of objects they can pick, or by cluttered environments. The two most common grippers used in the industry are suction cups and contact grippers. The suction cup produces forces from pressure differences, and when a seal can form, it can pick any object that is larger than its size even in cluttered environments. Previous work saw the development of a suction cup that can avoid loss of pressure even on very uneven surface texture using a physical process called particle jamming, where negative pressure is applied within a soft membrane containing granular materials, such as coffee grounds, to hold its shape. However the suction cups is unable to pick objects smaller than its size. Contact grippers can pick these items that fail on the suction cup as they do not require a seal, hence it is good for objects smaller than its size. However, they are less versatile compared to suction cups as they require highly optimised designs to pick up objects of specific shape or size.

This project presents a mechanism for a soft gripper that embeds soft robotic contact grippers that can be actuated pneumatically, within a suction cup filled with granular material. The result is a soft gripper which can pick both by suction and pinching, allowing increased grasping diversity. In addition, an emergent grasping mode is observed, a hybrid of pinching and suction where the cup morphs around an object to form a seal over objects that conventional suction cups and unoptimised grippers will find challenging, as seen in Figure 1.

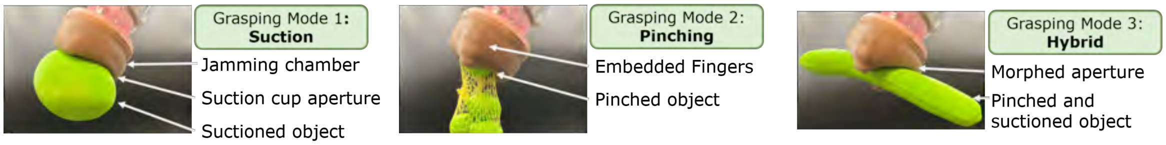

Figure 1: Different Modes of Novel Soft Gripper

For a range of objects, grasping strategy is presented where every object is assumed to be able to be broken down into three primary geometrical objects; spheres, cuboids and cylinders. A set of hierarchical, dimensional constraints on these objects allows the prediction of the optimal grasping mode out of the suction, hybrid and pinching strategies which show an increased grasping range when compared to other soft gripper designs. The proposed algorithms are found to be effective at selecting the optimal grasping strategies for primitives of different dimensions. Furthermore, the grasping strategies are successfully applied to more varied everyday objects, by first breaking these objects into primitive geometrical objects and using the algorithm to select the most suitable method of grasping, as seen in Figure 2. This control strategy is important for warehouse applications as an automated system is required to sort a large range of objects and it would be difficult to train the system for each of these objects individually.

3 Integrated System

Finally, a small scale industrial application of the novel soft gripper is exploited through the design of a fully integrated system that automates the pick and place process on real produce. Computer vision is used to find the objects to be picked on a platform arranged in front of a robotic arm. It can also identify the object to choose the most appropriate grasping mechanism, exploiting the multi-modal gripper for adaptive grasping. Real cucumbers, mangoes and limes are selected for these experiments as they each pose different challenges to the gripper and test different surface textures. The results show the gripper can perform pick and place for all three produce without damaging the fruit with various levels of consistency, as seen in Figure 3. The compliant nature of the soft gripper avoided any damage in the process, an important factor in the industry where produce needs to be delivered to customers in good condition. The overall results showed potential for the integrated system to be used in a larger scale industrial application.

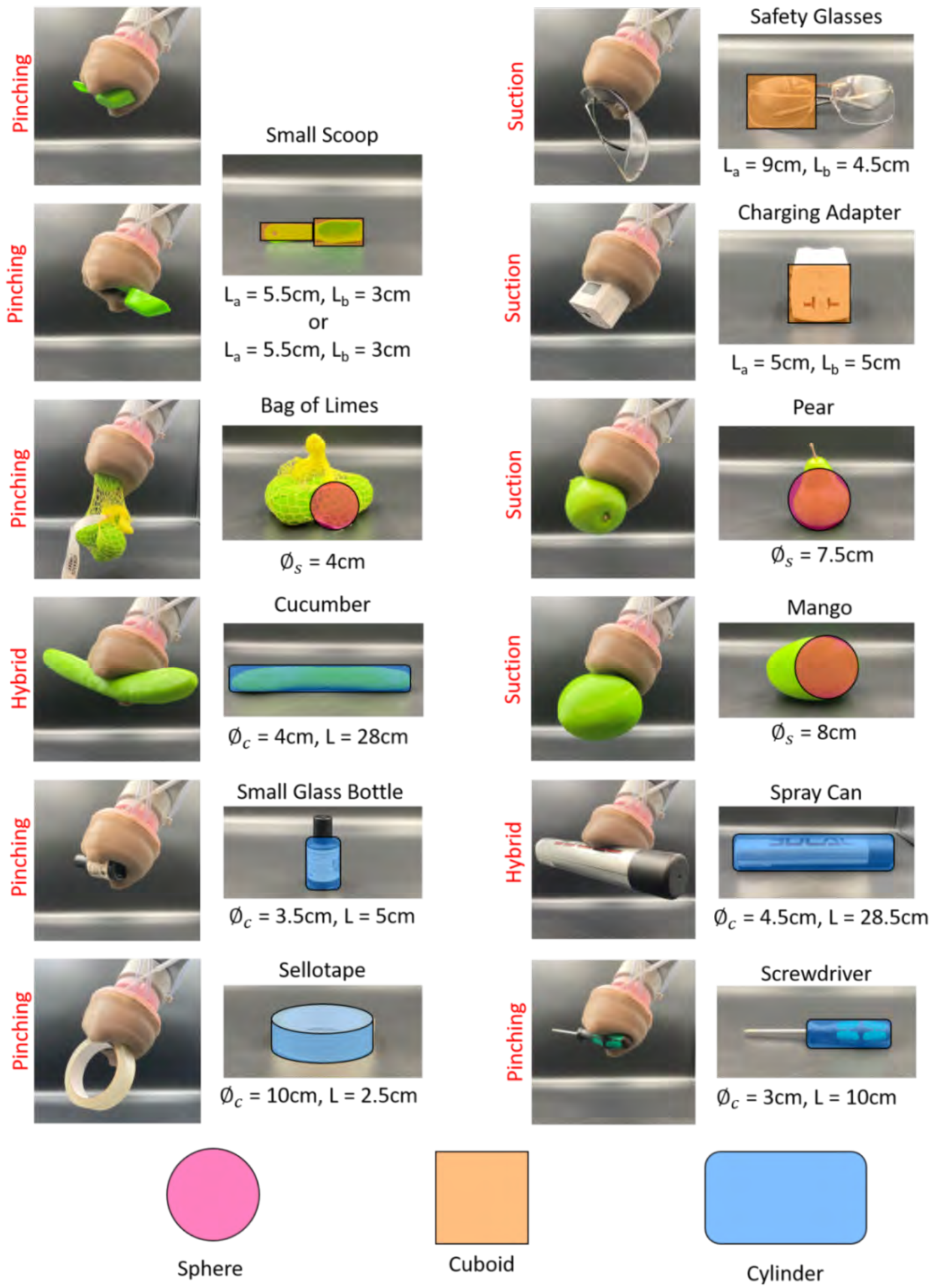

Figure 2: Demonstration of grasping on different real-world objects. Objects are broken down into primitives (overlaid).

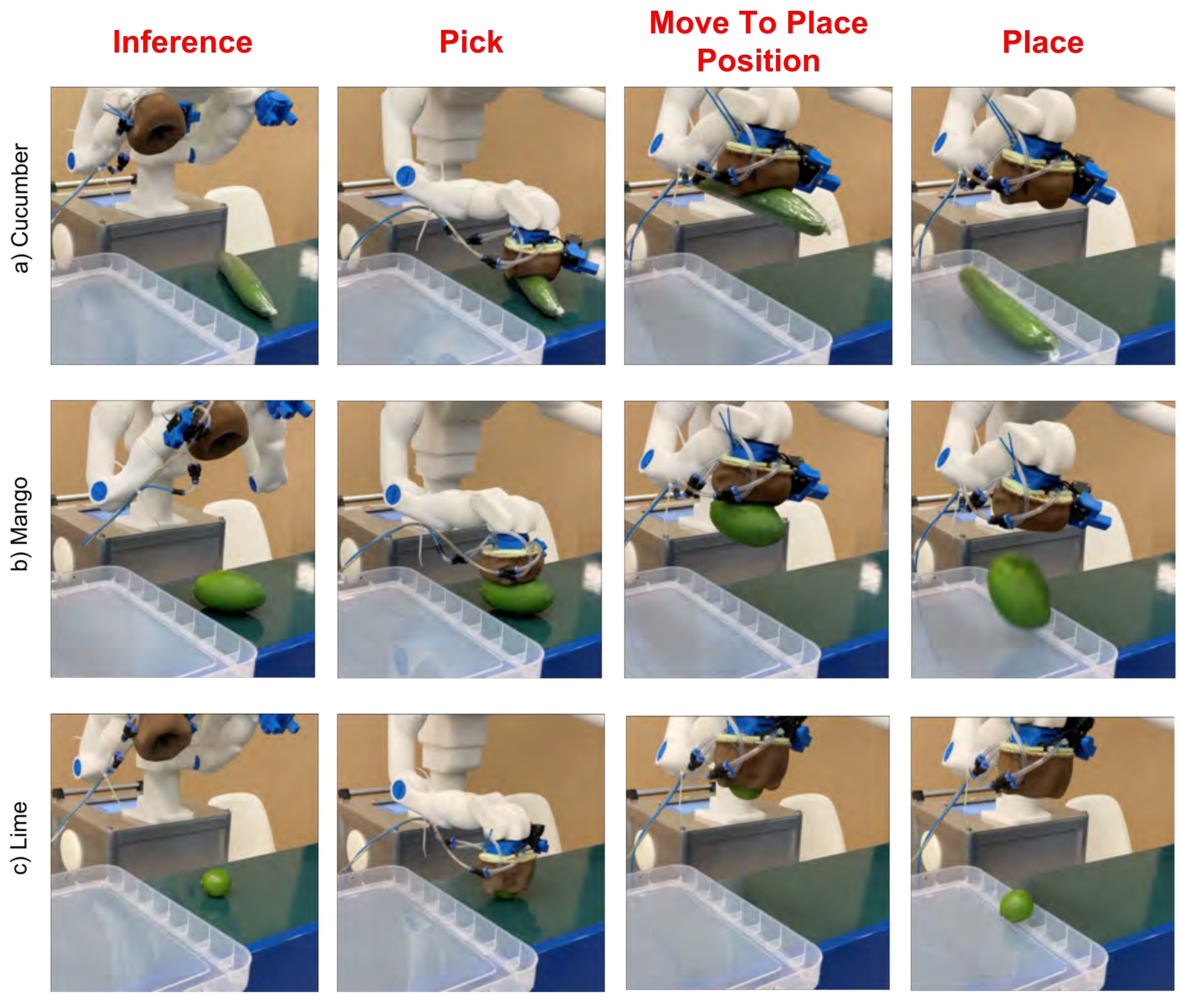

Figure 3: Example of Pick and Place for each produce: (a) cucumbers, (b) mangoes and (c) limes. The process is broken down into 4 steps: start up, pick (visually guided), Move to place position and Place

4 Conclusion

It may be concluded that the proposed mechanism for the novel soft gripper can lead to the development of next-generation adaptive grippers that can be used in industrial applications with large variations in objects. Provided further research in optimising the final mechanism, the soft gripper is expected to outperform other industry class soft grippers in diverse pick and place operations.