

Experimental Analysis of Soft Vacuum Cups for Automated Mushroom Picking

Introduction:

Abstract In this paper, the use of soft suction cups for automated mushroom picking is studied. The aim is to identify the vacuum level that starts to cause bruising for mushroom surfaces, in addition to the maximum torque that can be generated at this value to facilitate picking via twisting the mushrooms. An experimental setup was developed that controls vacuum level, controls rotation of the gripper, and records resulting torque during picking.

INTRODUCTION

The agriculture sector nowadays is interested in the use of robotics to automate labor-intensive harvesting tasks. Mushroom harvesting is an example which requires lots of human pickers that are becoming difficult to recruit. Picking involves skillful twisting of the mushrooms to separate them from the compost. Soft robotics offers various grasping technologies that are suited for delicate targets such as elastomer actuators, granular jamming, Gecko adhesion, Electro adhesion, and others. Suction based grippers can be a simple solution for mushroom picking, but vacuum can also bruise picked mushroom surface. This project studies the impact of vacuum on mushroom bruising and the maximum torque that can be generated for picking mushroom without bruising using a soft vacuum cup.

EXPERIMENTAL SETUP:

The pneumatic circuit in figure1 is demonstrating the working principle of the setup controlling the grasping operation of the suction cups.

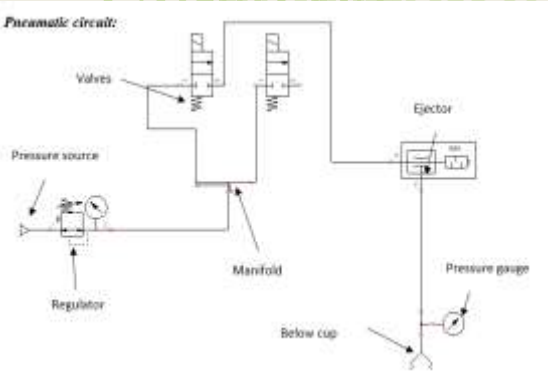


Figure 1: Pneumatic circuit

Figure 2 shows how the suction cup is installed on the testing frame.

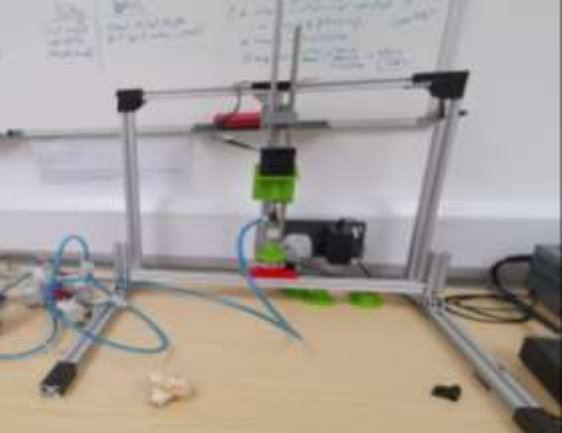


Figure 2:

Result:

Figure 3 shows the relationship between negative pressure at the cup and the supplied voltage to the pressure regulator for small and large mushrooms sizes. This relationship is mostly linear and can be used to estimate the voltage to set to generate the required negative pressure, which is not affected by mushroom size.

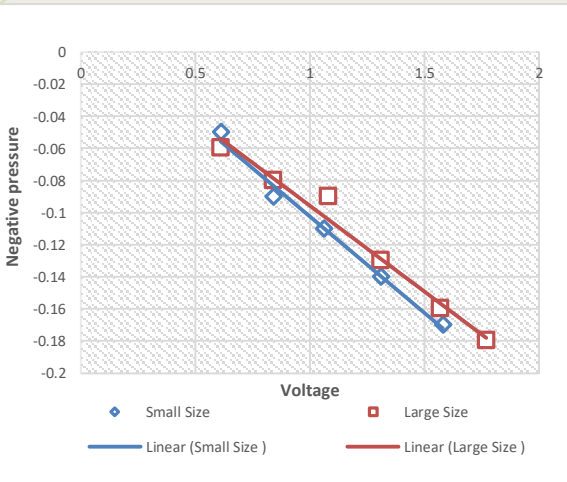


Figure 3

Moreover, the next stage of the experiment tested mushrooms at increasing vacuum levels to find out at what negative pressure the bruising occurs. figure 3(a) the mushroom had no damage at -0.02 bar inside the labelled circle where the cup touched the mushroom whereas the second photo figure 4(b) shows when the damage occurs at negative pressure -0.08 bar.



Figure 4

Table1 shows the maximum resulting torque for the tested mushroom when no damage to the cup occurs.

Pressure in(bar)	Negative pressure(bar)	Voltage	Average Torque
1.19	-0.02	0.65	0.0038

Improvement

Finally, the gripper was improved by using an additive method, the design was designed as a sample made of mesh to fit into the gripper. According to the experiment the sample of mesh shows a significant better performance than the benchmark and after repeatedly experimenting to find out the minimum level of vacuum that not damaging the mushroom see figure 5 and it was -0.23bar with inlet pressure of 3.55. However, to quantifies the maximum torqueing was impossible to experiment because the sample of mesh was not fixed on the gripper as well as the rotator motor required a fix gripper to test. Due to complication with COVID-10, the project was effective due to unforeseeable circumstances. it has been difficult to print the whole gripper with different mesh design and measuring the maximum torque.



Figure 5 Additive sample mesh result

Conclusion

As a result of the experiment by using the soft suction cups the negative pressure that can pick up mushrooms by twisting without showing any bruising was found out to be -0.02 bar. At this value, the torque generated during twisting was on average 0.0038 Nm, which is not sufficient to break the mushroom stalk. Whereas the result, by the use of the additive suction cup gripper the negative pressure is sharply increased approximately -0.20 more than the stander gripper as well as better gripping performance without damaging the mushrooms. The future plan is to test the performance of the torque to the additive gripper, because the mushroom is required some twisting force to make the picking easier, alternatively for any reason the additive gripper not operating well with required methods. It will be seeking to combing multiple smaller suction cups that can generate more stability and torque at the same vacuum level that the bruising does not occur.

ACKNOWLEDGMENT

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