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Design and Development of Gripper Mechanism Capable of Holding Different Shapes and Objects

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Abstract— The current paper describes a simple universal gripper, consisting of an elastic membrane which is filled by granular material. Using a combination of positive air pressure and vacuum, the gripper can rapidly grip and release a wide range of objects that are difficult for general purpose grippers. Such as flat objects, soft objects, or objects with complex shapes. The gripper successfully takes the shape of a target object, then vacuum is created inside the rubber bladder, later object is released by utilizing atmospheric pressure and it returns to a deformable state. The paper is aimed at mechanical design and implementation of this gripper and quantify its performance in actual practice. By using both air pressure and vacuum, we demonstrate increase in performance, reliability, error tolerance and the added capability to release objects by fast ejection. In addition, multiple objects are gripped and placed at once while maintaining their relative distance and orientation. At the end of this paper, we present a comparative study of the performance of proposed gripper with others in the field.

Keyword: *Universal Gripper, Robotic gripping systems, Gripper technology*

I. Introduction

The design and development of universal gripper's mechanism which will be capable to hold and pick complex shapes objects, size and while surface properties remains as it is, are challenging. Most current gripper are based on the multi-fingered hand, but this methodology involve hardware and software complexities. These grippers are made up of large numbers of controllable joints, they need force sensing devices if fragile objects are to be handled securely without crushing them, and the additional calculation and manipulation to decide how much stress each finger should apply and where. In this paper we exhibit a completely different approach to a universal gripper. As in case of individual fingers gripper are replaced by a single elastic membrane which is filled by granular material that, when pressed against a target object, flows around it and conforms to its shape.by using vacuum pump air is evacuated which results, the granular material to contracts and hardens quickly to pinch and hold the object without requiring any sensor and feedback. We find that volume changes to grip

objects reliably and hold them with forces exceeding many times their weight.

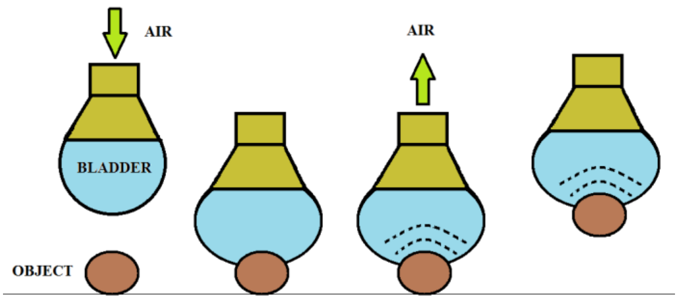

Fig. No.1. Operating Principle

We show that the ability of granular materials to transition between an unjammed, deformable state and a jammed state with solid-like rigidity. We delineate three separate mechanisms in fig. no. 1 that are friction, suction and interlocking, that contribute to the gripping force. Using a simple model we relate each of them to the mechanical strength of the jammed state. This opens up new possibilities for the design of simple, yet highly adaptive systems that excel at fast gripping of complex objects.

II. Literature Review

Universal robot grippers are robotic end effectors that can grip a wide variety of different shaped objects. The gripper we proposed that is universal grippers, have ranged in between vacuum-used suction grippers to multi-fingered hands, and these can be divided along a spectrum from active universal grippers to passive universal grippers [1]. The Most of gripper available in market are based on multifingered design with almost all independently actuated joints. Many such grippers have been developed [2]. The active universal grippers that have been proposed are capable of both grasping and manipulation but also introduced extensive physical and software or programing complexity [3]–[5]. The complexities of available universal grippers are come up with their correspondingly high costs hence resulting limited their acceptance among commercial robotics industries. Passive universal grippers [6]–[8] require minimal grasp planning. They often have ten or more degrees of freedom (DOF) per actuator and include components that passively conform to unique object geometries, giving them the ability to grip widely varying objects without readjustment. For example, Scott [6] presented a gripper design in which many independent telescoping pins could each passively slide in or out to conform to the shape of a target object, before pinching from the side to grip the object. Passive universal grippers are generally simpler to use and require minimal visual preprocessing of their environment, but they too have had limited success gaining widespread adoption. Often, their many passive components are easy to damage and difficult to replace. Passive universal grippers can be very expensive as well, and their ability to grip many different objects often renders them inferior at gripping any one object in particular (a mechanical no free lunch [9]).

The term underactuated [10] describes universal grippers falling somewhere between the active and passive distinctions. There are no clear dividing lines on this spectrum, but underactuated grippers [11]–[14] are in many ways comparable with passive universal grippers, especially when they possess many more DOF than actuators.

III. Design and Manufacturing

First In its simplest form, a jamming gripper needs only include some granular material that is contained in a flexible rubber bladder in order to achieve its gripping behavior the combination of mustard and a Rubber balloon has been found to work well .For proper working only vacuum pump is required to evacuate air from rubber bladder. As in case of other gripper motors, cables, or linkages are required but in our gripper they are completely eliminated. Here, we have designed and developed a slightly more advance jamming gripper that implemented with a robotic arm and it also includes a plastic collar surrounding the rubber bladder , as well as a positive pressure port and an air filter. An assembly drawing of the design is depicted in fig. No. 2. The design of this kind of gripper is very simple than other available grippers. The gripper comprises of just 4 components. Thisway it leads gripper to its low cost and easy manufacturability. The plastic collar of a gripper is an important component of the design because it helps to guide the gripper as it press the bladder against to an object, increasing the surface contact on vertical faces of the object and maximizes the gripping ability.

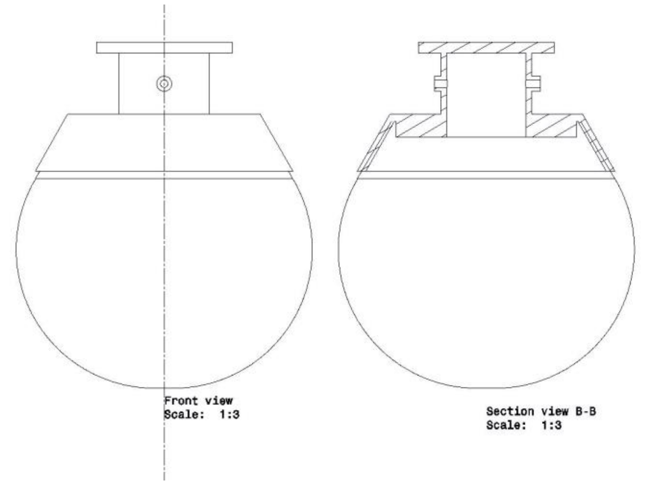

Fig. No. 2. Construction

The Rubber balloon is sealed between the flange and collar which facilitate an airtight seal. The rubber balloon membrane is filled with mustard beans. At this volume, the gripper is full but the membrane is not stretched; therefore, the gripper can be easily deformed in the unjammed state. The gripper is approximately spherical. The relatively low density of mustard is advantageous because it can be used in larger quantities without weighing down the gripper. The pressure in the gripper could also be neutralized with the atmosphere, and this state was used whenever the gripper was pressed onto an object. Vacuum pump is on/off manually.

IV. Reliability

The vacuum based universal jamming gripper was first manufactured for its capability in gripping objects of different shapes and size. All objects were situated at predefined position on floor, the software coding was not used for controlling the motion of robotic arm for pick and place operation. The universal jamming gripper is pressed onto an object and to then actuate the gripper to induce the rigid state, is done manually by operating a vacuum pump by using toggle switches. Next, the robot was operated to move to a place position, release the vacuum, to eject the object. All tests were performed in sequential manner. Spherical wooden component was used for testing purpose for universal jamming gripper, but here, we have chosen to use hemispheres so that the surface geometry of a sphere test would be preserved, but the height of the test objects would be reduced.

V. Test plan UNIVERSAL JAMMING GRIPPER

This is the test plan for the use of the Universal Jamming Gripper (UJG) as the end effecter for the robotic arm.

To be tested

- Amount of weight carried. The amount that the gripper can carry is an important property and will need to be determined.
- Material used in gripper. The material that is used in the gripper needs to be optimized. Previous studies have shown that a mixture of coffee and sand is the best mixture. Nothing has been mentioned on the use of other granular materials.
- Influence of dust (or water) on gripper. The gripper will be used in dusty environments; we want to see if the gripping power of the UJG is influenced by dust or other disturbances.
- Tearability-The Rubber used to make the gripper will have to be durable and not tear apart when gripping an unknown, possibly sharp or pointy object.
- Amount of air suction needed. The amount of air that needs to be removed from the balloon to create the air vacuum needs to be determined. What also should be evaluated is if the amount of air is proportional to the weight of the object.

VI. CONCLUSION

Thus we have concluded that,with this jamming gripper, objects of very different shape, weight, and fragility can be gripped, and multiple objects can be gripped at once while maintaining their relative distance and orientation. This diversity of abilities may make the gripper well suited for use in unstructured domains ranging from military environments to the home and, perhaps, for variable industrial tasks, such as food handling. The gripper's airtight construction also provides the potential for use in wet or volatile environments and permits easy cleaning. Its thermal limits are determined only by the latex rubber membrane, because of the temperature independence of the jamming phase transition; therefore, use in high- or low-temperature environments may also be possible with a modified design. Furthermore, the soft malleable state that the gripper assumes between gripping tasks could provide an improvement in safety when deployed in close proximity with humans, as in the home.

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