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Research Paper

A REVIEW ON IMPORTANCE OF UNIVERSAL GRIPPER IN INDUSTRIAL ROBOT APPLICATIONS

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The main object of this report is importance of Universal Hand/Gripper in industrial Robot applications and will deal exclusively with gripping of different variety of materials/parts by using the Universal gripper. So, that we can easily avoid the using of one type of gripper for each part. The design of the end-effector is a critical consideration in the applications of robotics to industrial operations. The end effector must typically be designed for the specific application. By comparison to the human hand, a robot's gripper is very limited in terms of its mechanical complexity, practical utility and general applications. In order to realize the full potential of future robotics technology, grippers must be designed more like human hand, both in their sensory and control capabilities as well as their anatomical configuration.

Keywords: Gripper, Manipulator, Degrees of freedom, Workpart

INTRODUCTION

A robotic gripper is an essential component of a robotic manipulator. It serves as the robot's hand and allows the robot to manipulate objects. Recently robotic gripper is widely used for different tasks in various fields. Variety of robotic grippers is developed in high flexibility and multi-function. Particularly, humanoid robot technology in this area attracts high attention of public. This project is aimed to study current existing robotic grippers and explain the importance of universal gripper to achieve simple grasping tasks of different workparts.

An end effector is the device at the end of a robotic arm, designed to interact with the environment. The robot's use determines the type of end effector needed. Robotic end effectors can be used in many applications. NASA has used end effectors on the robotic arms on the Space Shuttle and the International Space Station. The Space Shuttle's Remote Manipulator System (RMS) has been moved in varied ways to accomplish a particular mission. The RMS has seven Degrees of Freedom (DOF). In robot terms, this means that the arm can bend and rotate in seven

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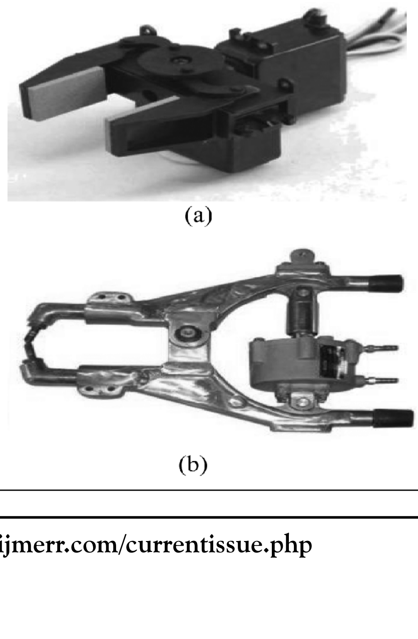
different directions to accomplish its tasks. Like a human arm, it has a shoulder joint that can move in two directions (2 DOF); an elbow joint (1 DOF); a wrist joint that can roll, pitch, and yaw (3 DOF); and a gripping device (1 DOF). The gripping device is called an end effector. That means it is located at the end of the arm and it has an effect (such as grasping) on objects within its reach. Other space utilization may include tools used on rovers for purposes of scooping up samples, imaging the contents of the scoop, and performing science experiments. NASA has also introduced a Robonaut that uses an end effector at the end of the arm that more closely simulates the human hand. Robonaut 2 is the latest addition to this effort. This robot can lift 20 lbs. with each arm and has nimble hands, fingers, and opposable thumbs using dexterous, human-like features to accomplish many jobs.

TYPES OF GRIPPERS

Grippers are end effectors used to grasp and hold objects. The objects are generally workparts that are to be moved by the robot. These part-handling applications include machine loading and unloading, picking parts from a conveyor, and arranging parts onto a pallet. In addition to workparts, other objects handled by robot grippers include cartons, bottles, raw materials, and tools. The Single gripper is only one grasping device is mounted on the robot's wrist. A double gripper has two gripping devices attached to the wrist and is used to handle two separate objects. The two grasping devices can be actuated independently. Grippers grasp and manipulate objects during the work cycle. Typically the objects grasped are workparts that need to be loaded or unloaded from one station to another. Grippers may be custom-designed to suit the physical specifications of the workparts they have to grasp. The robot end effecter may also use tools.

Tools are used to perform processing operations on the workpart. Typically the robot uses the tool relative to a stationary or slowly-moving object; in this way the process is carried-out. For example, spot welding, arc welding, and spray painting-which all use a tool for processing the operation-may all be carried-out in this way. Other examples where a tool is held by the robotic manipulator, and used against the workpart include: rotating spindle for drilling, routing, grinding, and similar operations; the use of a heating torch; and when using a water jet cutting tool. For each instance, the robot controls both the position of the workpart, and the position of the tool relative to the workpart; for this purpose, therefore, the robot must be able to transmit control signals to the tool for starting, stooping, and otherwise regulating the tools actions. Figure 1 illustrates a sample gripper and tool.

Figure 1: Robotic Gripper and Tool (Spot Welding)



(a)

(b)

As end effectors, grippers are described as follows:

Mechanical Gripper

It is an end effector that uses mechanical fingers actuated by a mechanism to grasp an object. The fingers, sometimes called jaws, are the appendages of the gripper that actually make contact with the object. The fingers are either attached to the mechanism or are an integral part of the mechanism. An example of mechanical gripper is shown in Figure 2.

Figure 2: Mechanical Gripper

Two or more fingers that can be actuated by robot controller to open and close on a workpart. The use of replaceable fingers allows for wear and interchangeability. Different sets of fingers for use with the same gripper mechanism can be designed to accommodate different part models.

Simple Mechanical Devices

For example, hooks and scoops.

Dual Grippers

Mechanical gripper with two gripping devices in one end effector for machine loading and unloading. Reduces cycle time per part by gripping two workparts at the same time. An example of dual gripper is shown in Figure 3.

Figure 3: Dual Gripper

Interchangeable Fingers

Mechanical gripper whereby, to accommodate different workpart sizes, different fingers may be attached. An example of interchangeable gripper is shown in Figure 4.

Figure 4: Interchangeable Gripper

Sensory Feedback Fingers

Mechanical gripper with sensory feedback capabilities in the fingers to aid locating the workpart; and to determine correct grip force to apply (for fragile workparts).

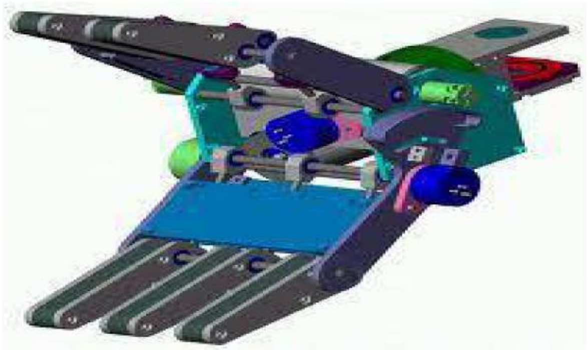
Multiple Fingered Grippers

Mechanical gripper with the general anatomy of the human hand. An example of multi fingered gripper is shown in Figure 5.

Standard Grippers

Mechanical grippers that are commercially available, thus reducing the need to custom-

Figure 5: Multiple Fingered Gripper



design a gripper for each separate robot application.

Vacuum Gripper

Suction cups are used to hold flat objects. Using strong suction cups to lift an item, the "vacuum" is used to lift large, flat, smooth sheets of material like wood paneling, metal, plastic and glass. An example of vacuum gripper is shown in Figure 6.

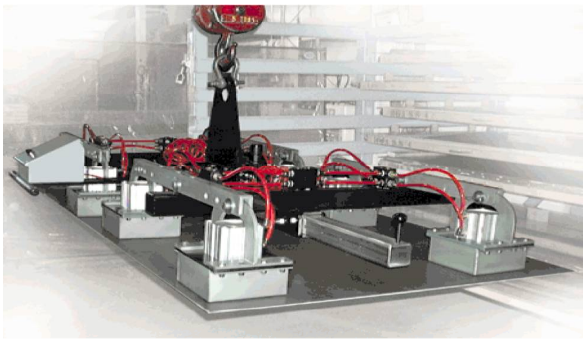
Figure 6: Vacuum Gripper

The robot arm moves into position and securely plants one or more airtight suction cups to the material, and then activates a powerful inward suction force. The vacuum requires less power than either of the other two designs, but is also more prone to mishaps due to misaligned suction cups that fail to achieve an airtight seal.

Magnetized Devices

Making use of the principles of magnetism, these are used for holding ferrous workparts. An example of magnetic gripper is shown in Figure 7.

Figure 7: Magnetic Gripper



Magnetic grippers are pickup different sizes parts very fast. Electromagnetic grippers are easier to control, but require a d.c power and an appropriate controller unit. Permanent magnets have the advantage of not requiring an external power source to operate the magnet.

Adhesive Devices

Gripper designs in which an adhesive substance performce the grasping action can be used to handle fabrics and other lightweight materials. An example of adhesive gripper is shown in Figure 8.

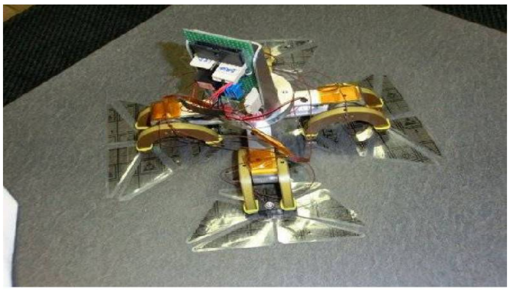
The requirements on the items to be handled are that they must be gripped on one side only. Deploying adhesive substances these hold flexible materials, such as fabric.

Various other types of grippers based on application are as follows:

The Clamp

Using a pincer-, scissors- or hook-arrangement, the "Clamp" style of gripper acts

Figure 8: Adhesive Gripper



(a)

(b)

like a human hand. The item to be manipulated is positioned between two extrusions which contract, trapping the item between them. This design is perfect for robots handling lightweight and/or odd-shaped items like empty boxes, packing material, toys and lumps of irregularly shaped material like rock or metal.

The Air Hand

The "Air-Hand" gripper uses an expanding piece of dense rubber material to press against the interior of an item and lift it that way. Think of dropping an un-inflated balloon inside of a cup, and then inflating it until it is tight against the sides of the cup. You could lift it by virtue of the friction created against the walls of the cup. This design is great for just that; robots designed to manipulate cups, buckets, hollow tubes or any other material that has an easily accessible hollow spot.

Basic Gripper

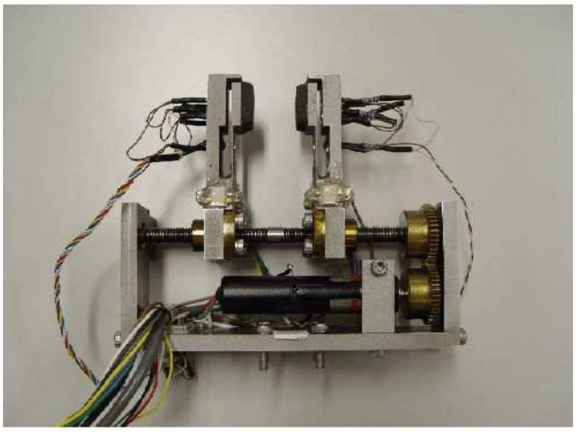
Basic gripper in this study context is an open-close gripper controlled by a DC servo motor equipped with rotary encoder from Maxon motors (18 V, 3.0 W, lift-torque 10.8 mNm, max rpm 16000 rpm) via spur gears and two-way ball screw with a 1mm lead. The encoder's resolution is 100 ulse/rotation. The unique part about the gripper compared to other grippers in the market is the thin part on both fingers that are sensitive to changes in force. Strain gages are attached on both sides of the thin part of a finger where the strain.

This is useful in maintaining the grasping force during tracing. A thick part just behind the thin part acts as a stopper in case of excessive force to prevent the thin part from failure. 4 sets of infrared sensor (Toshiba) are embedded onto the fingers to give information on whether clothes or fabric is inside the gripper or not. Based on the task, the thin part is designed to withstand 558 gf of force before it touches the thick part behind. This is more than enough for clothes handling. RCH-40 is always equipped with a basic gripper is shown in Figure 9a.

Roller Gripper

Roller gripper is a customized version of the basic gripper. Basically, this gripper is the same as the normal gripper except for the roller fingertips and the inner fingers. The gripper also has 3 sets of infrared sensors compared to 4 sets for the basic gripper. From numerous clothes manipulation experiments, it was found that 3 sets of infrared sensors are sufficient for clothes manipulation. The rollers at fingertips are made of identical spur gears (diameter: 14 mm, number of teeth: 14, module: 0.875) attached to the fingertips via roller bearings and can freely rotate on their axes. The purpose of the roller tips is to enable smooth movement of the gripper along the clothes edge when the tracing direction is parallel with the rollers' rotation axis. The gripper is also more sensitive to force change. This is due to the thickness of the thin part being 0.4 mm compared to 0.7 mm for the basic gripper. Similar to the basic gripper, strain gages are used to measure the grasping force. The maximum applicable load before the thin part touches the stopper is 95.1 gf. The gripper also has inner fingers used to firmly grasp the clothes Figure 9b. This is because the clothes might slip when grasped using the rollers alone since they have no brakes. When a big enough force is applied to the gripper, the thin part will bend outwards and enables the inner fingers to grasp the clothes. This depends on the thickness of the clothes. The gripper opening I controlled using the same model as the basic gripper via 2 spur gears with a 1:1.6 gear ratio and two ball screws with a 1 mm lead. The maximum opening is 45 mm.

Figure 9: Robotic Grippers (a) Basic Gripper; (b) Roller Gripper; and (c) Inchworm Gripper



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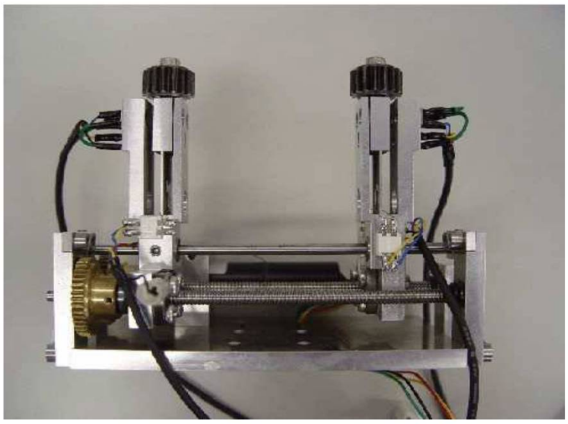

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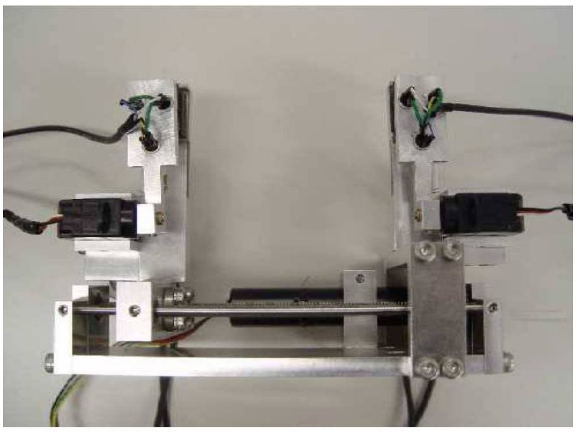


(c)

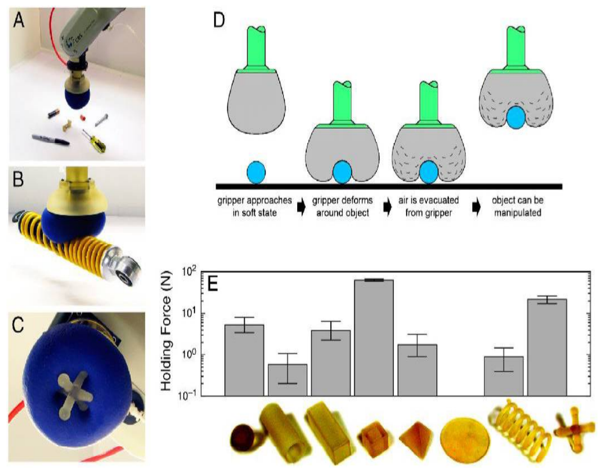
Inchworm Gripper

Unlike the basic gripper or the roller gripper, the inchworm gripper has two sets of grippers, one fixed (fixed gripper) and one slide-able (slide gripper) and 3 actuators, one for moving the slide gripper sideways and the other two for opening and closing of the grippers. The sliding motion is controlled by the same Maxon motor used in the other two grippers, the power distributed through a set of spur gears with a 1:1 gear ratio to a ball screw with a 1mm lead. The opening and closing of the grippers are controlled by micro analog servos. Unlike the other grippers, the actuators only control one of the two fingers of a gripper. The servos are directly connected to the fingers which makes the opening and closing motion to be rotational. This means the bigger the opening the harder for the infrared sensors to function properly because the opening is in rotation form and not linear.. There are 3 sets of infrared sensors on each gripper. The layout of the infrared sensors is the same as the roller gripper. The slide gripper can slide a maximum 60 mm away from the fixed gripper. Strain gages are attached to the thin part of the fixed finger on both the slide and fixed grippers. The thin parts of the grippers are 0.5 mm in thickness and should bear up to 339.5 gf of force before touching the thick parts that act as stoppers. This inchworm gripper is shown in Figure 9c, will enable the clothes to be firmly grasped at all times during clothes manipulation.

UNIVERSAL GRIPPER

Gripping and holding of objects are key tasks for robotic manipulators. The development of universal grippers able to pick up unfamiliar objects of widely varying shape and surface properties remains, however, challenging. Most current designs are based on the multifingered hand, but this approach introduces hardware and software complexities. These include large numbers of controllable joints, the need for force sensing if objects are to be handled securely without crushing them, and the computational overhead to decide how much stress each finger should apply and where. Here we demonstrate a completely different approach to a universal gripper. Individual fingers are replaced by a single mass of granular material that, when pressed onto a target object, flows around it and conforms to its shape. Upon application of a vacuum the granular material contracts and hardens quickly to pinch and hold the object without requiring sensory feedback. This advance opens up new possibilities for the design of simple, yet highly adaptive systems that excel at fast gripping of complex objects. Universal gripper with different applications is shown in Figure 10.

Figure 10: Universal Gripper with Different Applications



Source: Brown et al. (2010)

Tasks that appear simple to humans, such as picking up objects of varying shapes, can be vexingly complicated for robots. Secure gripping not only requires contacting an object, but also preventing potential slip while the object is moved. Slip can be prevented either by friction from contact pressure or by exploiting geometric constraints, for example by placing fingers around protrusions or into the opening provided by the handle of a cup. For reliable robotic gripping, the standard design approach is based on a hand with two or more fingers, and typically involves a combination of visual feedback and force sensing at the fingertips. Given the evolutionary success of the multifingered hand in animals, this approach clearly has many advantages. However, it requires a central processor or brain for a multitude of decisions, many of which have to be made before the hand even touches the object, for example about how wide to spread the fingers apart. Therefore, a multifingered gripper not only is a complex system to build and control, but when confronted with unfamiliar objects it may require learning the shape and stiffness of the object. The focus of this work is on the problem of gripping, not manipulation, and seeks to offload system complexities such as tactile sensing and computer vision onto unique mechanical design. This approach replaces individual fingers by a material or interface that upon contact molds itself around the object. Such a shapes and all shape adaptation is performed autonomously by the contacting material and without sensory feedback.

Universal robot grippers are robotic end effectors that can grip a wide variety of arbitrarily shaped objects. Proposed universal grippers have ranged from vacuum-based suction grippers to multifingered hands, and these can be divided along a spectrum from active universal grippers to passive universal grippers (Scott, 1985). Most active universal grippers typically have an anthropomorphic multifingered design with many independently actuated joints. Many such grippers have been developed, and multifingered grasping is an active area of research (Tella *et al.*, 1986).

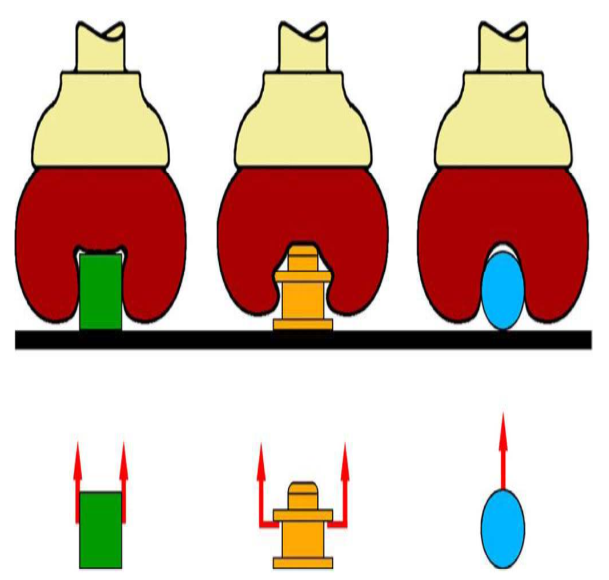
Consisting of a single mass of granular material encased in an elastic membrane, the gripper can conform to the shape of the target object, then vacuum-harden to grip it rigidly, later using pressure to reverse this transition-releasing the object and returning to a deformable state. An example of this gripper can be seen in Figure 11.

Figure 11: A Universal Gripper is Able to Grip a Wide Variety of Objects Without Grasp Planning or Sensory Feedback. Multiple Objects Can Be Gripped at Once

Source: Brown et al. (2010)

This universal gripper that exploits the temperature-independent fluid like to solid-like phase transition of granular materials. This gripper leverages three possible gripping modes for operation: 1) static friction from surface contact; 2) geometric constraints from capture of the object by interlocking; and 3) vacuum suction when an airtight seal is achieved on some portion of the object's surface (Pak *et al.*, 1995). These three gripping modes are illustrated in Figure 12. By achieving one or more of the three gripping modes, the gripper can grip many different objects with widely varying shape, weight, and fragility, including objects that are traditionally challenging for other universal grippers. For example, we have successfully been able to grip a coin, a tetrahedron, a hemisphere, a raw egg, a jack toy, and a foam earplug. When mounted to the robot arm, the gripper functions entirely in open loop-without grasp planning, vision, or sensory feedback. Optimal performance of a universal gripper is maintained by resetting the gripper to a neutral state between gripping tasks. Prior to the work presented here, this was accomplished by shaking the gripper, by kneading or massaging the gripper, or by pushing the gripper against some resetting apparatus that was mounted in the workspace, for example. We call this process manually resetting the gripper, and without it, the ability to grip subsequent objects degrades rapidly. A capability that we call shooting, which may serve as a new method for robots to extend their workspace and perform tasks like sorting objects into bins in a factory or throwing away trash in a home.

Figure 12: A Universal Gripper Can Achieve Three Separate Gripping Modes. (Left) Static Friction from Surface Contact, (Center) Geometric Constraints from Interlocking, (Right) Vacuum Suction from an Airtight Seal



CONCLUSION

In this paper, we have presented a universal gripper in industrial robot applications will deal exclusively with gripping of different variety of materials/parts comparing with other various types of grippers. So, that we can easily avoid the using of one type of gripper for each part. The design of the end-effector is a critical consideration in the applications of robotics to industrial operations. The end effector must typically be designed for the specific application. By comparison to the human hand, a robot's gripper is very limited in terms of its mechanical complexity, practical utility and general applications. In order to realize the full potential of future robotics technology, grippers must be designed more like human hand, both in their sensory and control capabilities as well as their anatomical configuration.

With this universal 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.

The prime interest of this paper is to explore the advantages of universal gripper and its applications for different product type manufacturing robot application industries. So, the industry performance will increase and decrease the cost of the product effectively.

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