A Review on Technologies in Robotic Gripper

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Abstract: Robots are replacing human workers in many industries due to increased efficiency, productivity, and thus results in high operational quality. An intelligent robot is the one which interacts with the environment and can take the decisions itself. Domestic robots can also provide assistance to physically disabled or elderly people in their day to day life. Pressing the demands of enhanced productivity has necessitated the deployment of robot to automate tasks (Baizid et al., 2015). A manipulator can be geared with end-effector to complete variety of tasks. Robotic grippers are used in agriculture, food processing industry, packaging of food, palletizing of boxes and many more. Grippers are the device that enables robots to grasp and grip objects. The design of end effector should be done by considering its specific application in industry. On comparison of gripper with human hand, a robot’s gripper is very bounded in terms of mechanical movement, practical service and general applications. To use the full ability of robotic technology, the gripper must be designed more of a like human hand. This paper attempts to describe the different technologies of Robotic gripper which help the people which would be a Businessman as well as common people or Industrialist. The main target of this paper is to contribute some information on different on robotic grippers, since selection of gripper plays a fundamental role in robot’s productivity and performance.

Keywords: Robotic Gripper, End-Effector, Robot Manipulator.

I. INTRODUCTION

Grippers were introduced in the early part of the 20th century. The new era of intelligent manufacturing is replacing the traditional one. This fourth industrial revolution has gained the attention of most of the industry which are looking to increase product quality and decrease production costs. An end-effector is the crucial part in the robotic industry. In robotics, an end-effector is a gadget which is coupled at the end part of the robot arm and only this part interacts with the environment. This part helps the robot to pick or place an object in effective manner [1]. Gripping mechanism is done by the grippers or mechanical fingers. Manipulation and grasping can be defined in many ways depending on the situation and application.

But in general, it can be defined as an act of exerting force or torque on an object causing motion or deformation, whereas holding an object can be termed as grasping [1]. Or in other words, it is a machine’s controllable “hand” that grasps and releases parts that are being moved by the automation [2]. Some of the important aspects in choosing type of gripper are manipulation speed, object shape, weight and many more parameters. Robotic grippers are one of the most essential components in the industry because of their efficiency to manage objects. They can be used in several applications, such as industry, medicine, space exploration, and so on. Each application presents different characteristics and needs specific solutions. Generally, grippers have different sorts of applications. The most common operation performed by manipulators is grasping. For task of grasping the objects, each manipulator needs a gripper which is mounted on the end-effector of manipulator [3]. Manipulation speed, object shape, weight and other characteristics are important factors in choosing the type of gripper [3]. For automotive manufacturing industries the composite gripper concepts are introduced and more discussion about it is described in [4]. The gripper which enables soft interaction with the surroundings while maintaining the ability to apply significant forces are soft grippers or termed as soft manipulators [5]. The performance of current micro grippers is presented and offer a stroke extending from 50µm to approximately 2mm and a maximum force varying from 0.1µN to 600mN [6]. However, there is no published review paper that covers most types and a wide range of technologies used in robotic grippers. Therefore, the main contribution of this paper is to provide a brief and general review on different technologies in robotic grippers and their classification.

II. RESEARCH GAP

A comprehensive review article will allow gaining in depth understanding of the research field. By doing the systematic literature review the first researcher gets to understand the complexity, challenges and limitations in the particular research field. A complete review paper will reveal research gaps for the research project. While writing a review paper, a large amount of literature and data will be accumulated and an researcher will be able to know what is still missing in that field. By publishing a review article in recognized journal an individual will enhance his/her profile, by doing this contribution other researchers will use the work as a reference study in the same research field. That means more people will find and read about the work.
The main purpose of writing a review paper is to share new knowledge with the other researcher and students in their respective field.

III. GRIPPER TECHNOLOGIES

Robotic grippers are the physical terminal between a robot arm and the workpiece. At the end of robot there is one of the most important parts known as End-of-Arm Tooling (EOAT). A gripper comes directly in contact with the workpiece so it is necessary to choose an appropriate gripper. Based on the technology grippers can be classified as:

A. Technology Based on Robotic Gripper

1. Robot Gripper with 2 Fingers

A Robotic Gripper is simple device which are suitable for many industrial products and easy to manufacture [7]. The gripper with 2 fingers can achieve large reorientations over Π/2 rad through kinematics of the hand object system alone, without use of highly complex contact sensors. This type of gripper has simple design and makes it useful to industrial use. The basic components of a two fingered gripper consists an actuator, finger, finger tips and many more which are presented in [8]. Fingers are the elements that grasp the object, finger tips are directly in contact with the grasped objects. Grasping mechanism is the transmission component between the actuator and the fingers [9]. Actuator is the power source for grasping action of gripper.

Fig 1. (a) Robotic gripper with 2 Fingers (b) Mechanical design for 2 Finger Gripper

2. Robot Gripper with 3 Fingers

This type of gripper is used to pick up delicate objects with strength and precision [10]. It is generally used to pick up parts which are cylindrical in shape. The robotic hand uses radically symmetric, pragmatically actuated fingers controlled by a single actuator [11]. This type of gripper allows picking up cylindrical as well as spherical objects.

Every finger of the gripper has three joints that are actuated by motors and can be driven and controlled independently [12]. This type of gripper can be fabricated by using stepper motor, piezoceramic transducer, 3-D printing and many more methods.

Fig 2. Grasping of different objects by 3-Finger Gripper (a) Cylindrical grasp (b) Spherical grasp (c) Planar grasp (d) Fingertip grasp (e) high payload (f) Low payload, small shape grasp.

3. Robot Gripper with Flexible Finger

The robotic grippers with flexible fingers are newer in the market and fit to different objects. These types of gripper are generally used to pick up objects which are delicate like food. The gripper is specially designed to pick up arbitrarily solid shaped objects, nonporous items of weight up to 800 gm [13]. This type of gripper consists of sensors, generally used for grasping shape detection. Some soft computing methods like extreme learning machine (ELM), support vector regression (SVR), fuzzy, neuro fuzzy and artificial neural networks are applicable to design this type of gripper for shape detection [14]. These types of robotic gripper are capable of picking up irregular shaped objects. The design of fingers is made in such a way that fingers completely surround the object making it easier to hold any object.

Fig 3. The design of Flexible Finger Gripper in Depressurization State
4. Grain Filled Flexible Ball Gripper
Grain filled Flexible Ball grippers are also known as Universal Gripper because it can grip a wide variety of arbitrarily shaped objects[15]. This gripper consists of a mass of granular material encased in an elastic membrane. By using a combination positive and negative pressure, the gripper can grip by irregular shaped objects. The gripper passively conforms to the shape of a target object, then vacuum-hardens to grip it rigidly[16], later utilizing positive pressure to reverse this transition-releasing the object and returning to a deformable state [17]. Using Universal Gripper performance, reliability, and capability of the robot increases.

![Fig. 4. Universal Gripper holding different variety of objects](image)

B. Technology Based on Actuation
1. Vacuum Gripper
Vacuum grippers are often used for grasping and moving very large and heavy objects[18]. These grippers use the difference between atmospheric pressure and a vacuum to lift, hold and move objects. These grippers are used in the robots for grasping non-ferrous objects. It uses vacuum cups as gripping device, which are also known as suction cups[19]. Generally, suction cups will be in round shape. These cups are made up of rubber or other elastic materials[20].

![Fig. 5 Heavy duty Vacuum Gripper](image)

2. Pneumatic Gripper
A pneumatic gripper uses compressed air and pistons to operate its ‘jaws’ (also known as ‘fingers’) [21]. Most commonly found in 2-finger and 3-finger configurations, pneumatic grippers are versatile tools that can be used in a wide range of applications [22]. A pneumatic gripper is a type of pneumatic actuator that uses either parallel or angular motion of surfaces to grip an object, often known as “tooling jaws or fingers”. A regular pneumatic gripper operates with the assistance of a piston to open and close their fingers [23]. Pneumatic gripper can be classified as;
(A) 2 Jaw parallel Gripper
(B) 3 Jaw parallel Gripper

Pneumatic Grippers are often used in companies such as biotech and pharmaceutical industries, Injection molding and plastic molding, Processing in the lab, automated systems and many more [24].

![Fig. 6 Multiple initial grasping positions (a) All fingers close (b) Two fingers adjust distance (c) All fingers adjust distance (d) and (e) All fingers spread out](image)

3. Hydraulic Gripper
Hydraulic Grippers are heavy-duty grippers that apply the type of forces required to handle heavy objects (>50 kg) [25]. This type of gripper uses pressurized fluids to move a piston. When the piston moves, it transfers this force to the claw, opening and closing it [26]. The main advantage to these grippers is that their gripping power is excellent, but with that power come several disadvantages, including the added complexity of handling oil, a pump, and a reservoir. These grippers have high maintenance cost compared to other grippers. They’re simple and easy to install, requiring only one power source and some plumbing.

4. Servo-Electric Gripper
Electric grippers are a popular choice for many robot applications including machine tending and pick & place. While they don’t offer the same level of gripping power as hydraulic grippers, they are suitable for applications that require high speed and light/moderate gripping force. Most electric grippers come with microprocessors that enable you to vary gripping force and speed [27]. The addition of a force sensor enables electric grippers to easily handle different part types. These grippers are highly flexible and allow for different material tolerances when handling parts. An input command is sent to the gripper from a robot control unit. The command from the robot is received by the gripper control module responsible for driving the gripper motors. The servo-electric motor reacts to the signal.
C. Technology based on Application

1. Surgical Application

In surgery, suturing is the use of needle and thread to join cut and damaged anatomical structures together [28]. The needles are almost always curved in shape, and it is handled by surgeons with a special tool called: needle driver [31]. Medical robotics in surgery has gained ground over the past years due to its promising clinical results [29]. A gripper is designed to create a solution that enables the robot to grip needle driver. A gripper tool is developed that enables a collaborative robot to perform suturing with one of the most common types of needle drivers used in surgery [30].

2. Assistive Application

This type of robotic gripper can assist people with disabilities and older persons in the activities of daily living. For physically disabled people caregivers are there which interact with this people [32]. Caregivers have to assist people in performing the routine activities of their daily lives, such as eating, changing clothes, changing their posture, moving from one location to another, and bathing. Among all these activities, eating meals is one of the most essential daily activities [33]. A robot is designed and developed to help the people with disabilities which are known as self-feeding robot. This type of robot is used for people who do not have a hand or having any other medical problems [34]. Many robots are developed to help people with disabilities such as:

(1) Brain-Machine Interface (BMI) to assist people in daily pick and place operations.
(2) A new robotic gripper was designed and constructed which helps people for daily activities to be used with Wheelchair-Mounted Robotic Arm.

3. Underwater Application

Underwater robots are programmed to go to remote, dangerous, and often previously unexplored parts of the ocean to measure the key characteristics- from salinity and temperature to the speed and direction of currents. By developing a army of small robots and making them work in sync under ocean is more efficient then developing a large robot [35]. Developing this type of robots helps us to make a new way of research, a look at marine life, an unhindered exploration, a new mining technique and many handled is hard and rigid [36]. This type of gripper has rigid fingers due to which it applies more force on the object to be grasped.

4. Soft Grippers

Soft gripper is one of the most popular research directions of robot. The Soft gripper has modular soft fingers [37]. A curvature sensor is installed inside each finger to measure the curvature during grasping. The finger allows to softly adapting to object shapes [38]. This gripper enables soft interactions with the surroundings while maintain the ability to apply significant force.

Fig. 7 Servo Electric Gripper

Fig. 7. Soft Fingered Gripper (a) & (b) Soft gripper grasping and lifting a soft container

IV. CONCLUSION

Thus, there are many technologies prevailing in the industry. To design a gripper, there are some factors and requirements that need to be taken into consideration. Force and torque are the major parameters that are examined to design a robotic gripper. Many technologies prevail in the market but selection of gripper must be done according to the requirement of the operation [39]. It has been identified that the performance will get increased once the robotic gripper has been selected. Overall, grippers that have more sensor feedback tend to track and grasp the objects easily. Each gripper has a specific application in different fields. The role of human in this system is to just monitor the work which robots are performing.

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