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A Review on Technologies in Robotic Gripper

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***Abstract** Robots are replacing human workers in many industries due which increases efficiency, productivity and thus results in high operational quality. An intelligent robot is the one which interact with the environment and can take the decisions itself. Domestic robots can also provide assistance to physically disabled or elder 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 designing 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 part 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.

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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.

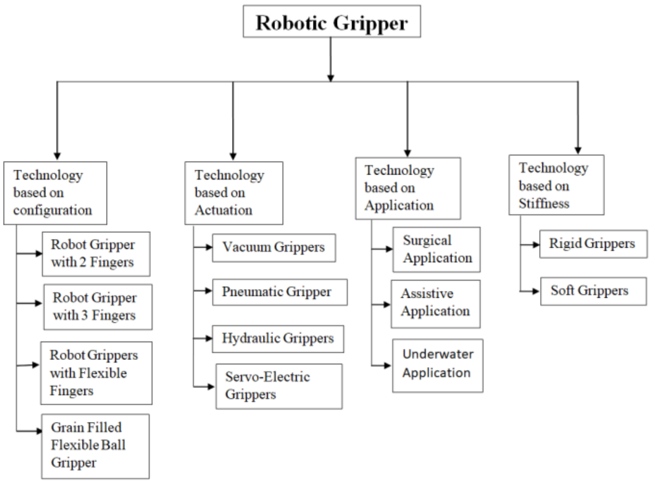
II. RESEARCH GAP

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 work piece 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.

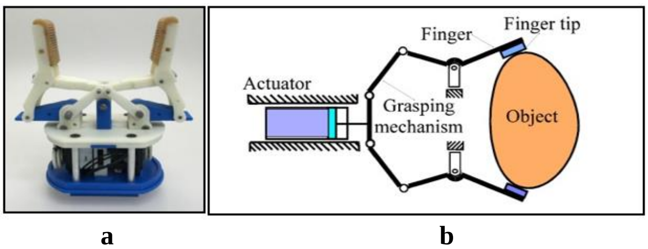


Fig 1. (a) Robotic gripper with 2 Fingers (b) Mechanical design for 2 Finger Gripper

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. As the name suggests it has three jaws spaces at 120 degrees apart. 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.

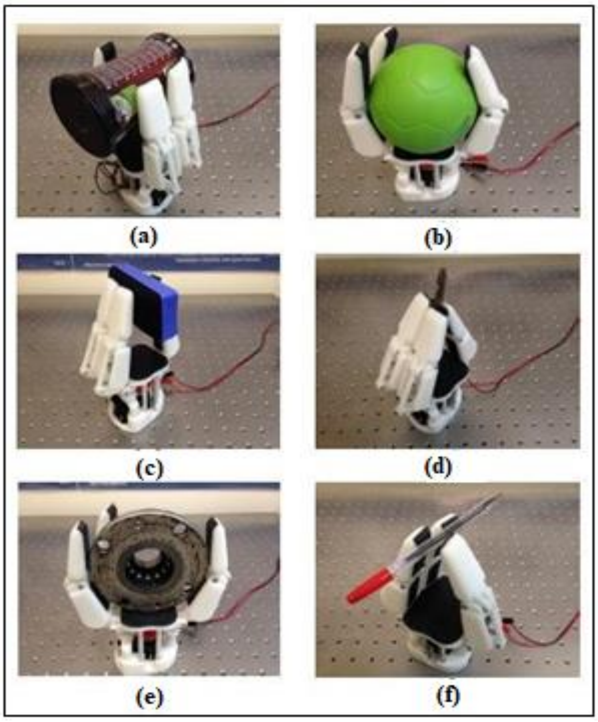


Fig 2. Grasping of different objects by 3-Finger Gripper (a) Cylindrical grasp (b) Spherical grasp (c) Planar grasp (d) Fingertip grasp (e) high payload (f) Low payload, small shape grasp.

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.

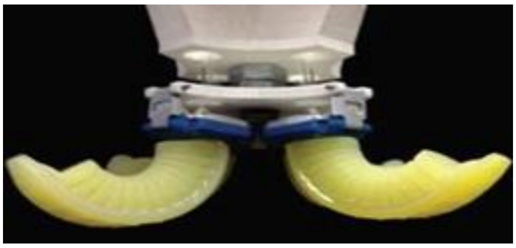


Fig 3. The design of Flexible Finger Gripper in Depressurization State

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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.

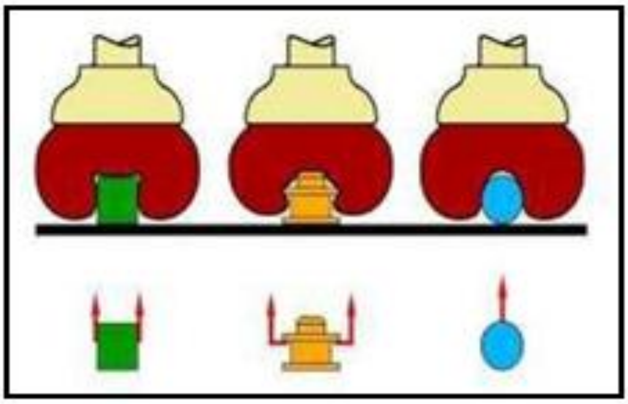
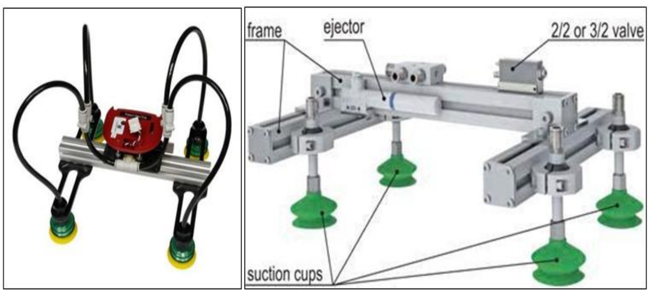


Fig 4. Universal Gripper holding different variety of objects

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].



(a) **(b)**

Fig.5 Heavy duty Vacuum Gripper

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].

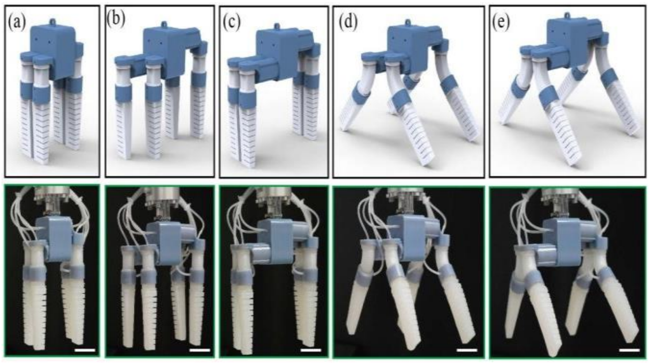


Fig. 6 Multiple initial grasping positions (a) All fingers close (b) Two fingers adjust distance (c) All fingers adjust distance (d) and (e) All fingers spread out

3. Hydraulic Gripper

Hydraulic Grippers are heavy-duty grippers that apply the type of forcesrequired 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 grippersis 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.

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Fig. 7 Servo Electric Gripper

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 needledrivers 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 this 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.

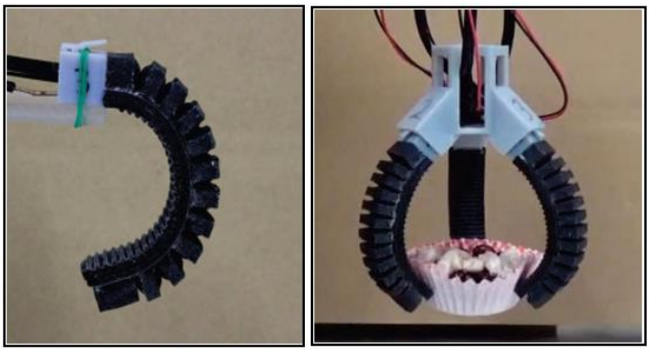
(2) A new robotic gripper was designed and constructed which helps people for daily activities to be used with Wheelchair-Mounted Robotic Arm.

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 itapplies 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.



(a) (b)

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 thework which robots are performing.

DECLARATION

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Ethical Approval and Consent to Participate	No, the article does not require ethical approval and consent to participate with evidence.
Availability of Data and Material/ Data Access Statement	Not relevant.
Authors Contributions	All authors have equal participation in this article.

REFERENCES

1. Tahir A M, Zoppi M and Naselli G A 2018 PASCAV Gripper: a Pneumatically Soft Cubical Vacuum Gripper. In: 2018 International Conference on Reconfigurable Mechanisms and Robots (ReMAR)(IEEE) pp 1-6 [CrossRef]
2. www.kellertechnology.com/blog/8-types-of-end-of-arm-tooling-devices-for-automation-projects/ , last accessed : Feb 14,2019
3. Yang yang, Yonghua Chen1, Ying Wei, Yingtian Li, "Novel Design and three- Dimensional Printing of Variable Stiffness Robotic Grippers" (10th November 2015) [CrossRef]
4. N. Minsch, F. Nosrat-Nezami, C. Cherif, "Review on recent composite gripper concepts for automotive manufacturing" 26th CIRP Design Conference (10th October 2016) [CrossRef]
5. Josie Hughes, Utku Culha, Andre Rosendo, "Soft Manipulators and Grippers: A Review", Frontiers in Robotics and AI, vol. 69, (16th November 2016) [CrossRef]
6. J. Agnus, P. Nectoux, and N. Chaillet, "Overview of microgrippers and design of a micromanipulation station based on a MMOC microgripper" , Proceedings of the IEEE International Symposium on Computational Intelligence in Robotics and Automation, CIRA '05., June 2005.
7. M. Ceccarelli, Ed., in "Fundamentals of mechanics of robotic manipulation" , Dorfrecht : Kluwer Academic Publisher, 2004. [CrossRef]
8. Chiara Lanni and Marco Ceccarelli, "An Optimization Problem Algorithm for Kinematic Design of Mechanisms for Two-Finger Grippers", The open Mechanical Engineering Journal, 2009. [CrossRef]
9. Walter G. Bircher, Aaron M. Dollar and Nicolas Rojas, "A Two-Fingered Robot Gripper with Large Object Reorientation Range", International Conference on Robotics and Automation (ICRA) Singapore (29th May 2017). [CrossRef]
10. Spencer B. Backus, Aaron M. Dollar, "An Adaptive Three-Fingered Prismatic Gripper With Passive Rotational Joints", IEEE Robotics and Automation Letters, Vol. 1 (2nd July 2016). [CrossRef]
11. Guozhi Li, Cong Fu, Fuhai Zhang, "A Reconfigurable Three-Finger Robotic Gripper", International Conference on Information and Automation (August 2015).
12. Kuat Telegenov, Yedige Tlegenov and Almas Shintemirov. "A Low Cost Open Source 3-D-Printed Three-Finger Gripper Platform for Research and Educational Purposes",(15th May 2015). [CrossRef]
13. Vaidehi Patil, Tanisha Narnaware, Narendra Gangwani, " Development of Flexible Universal Gripper for Handling Light weight parts of arbitarty shape" (1st July 2020).
14. Dalibor Petkovic, Amir Seyed Danesh, Mahdi Dadkhah, "Adaptive control algorithm of flexible robotic gripper by extreme learning machine" (29th September 2015). [CrossRef]
15. Yufei Hao, Zheyuan Gong, Li Wein, " A Soft Bionic Gripper with Variable Effective Length", Journal of Bionic Engineering (May 2018).
16. John R. Amend, Nicholas Rodenberg,Hod Lipson, " A Positive Pressure Universal Gripper Based on the Jamming on Granular Materials" IEEE Transactions on Robotics, Vol.28 (2nd april 2012). [CrossRef]
17. Balaji A, Mithil J, Jason Gousanal, "Design and Analysis of Universal Gripper For Robotics Applications".
18. K. Jaiswal and B. Kumar, "Vacuum Gripper-An Important Material Handling Tool", International Journal of Science & Technology, Vol.7 (1st February 2017).
19. Robert Schaffrath, Erik Jager, Georg Winkler, "Vacuum Gripper without central compressed air supply" (August 2018).
20. Giacomo Mantriota, "Theoretical model of grasp with vacuum gripper" (2nd May 2006). [CrossRef]
21. Yafeng Cui, Xin-Jun Liu, Huichan Zhao, "Enhancing the Universality of a Pneumatic Gripper" IEEE Transactions on Robotics.
22. Rocco Antonio Romeo, Michele Gesino, "Combining Sensors Information to Enhance Pneumatic Grippers Performance" (24th July 2021).
23. Yang Chen, Hui Yang, Lina Hao, " Size Recoginition and Adaptive Grasping using an integration of actuating and sensing soft Pneumatic Gripper" (28th February 2018). [CrossRef]
24. Hao Yufei, Gong Zheyuan, Wang Tianmiao, " Universal Soft Pneumatic Robot Gripper with Variable effective Length" Chinese Control Conference (27th July 2016). [CrossRef]
25. M. Lazeroms, A. LA Haye, W. Jongkind, " A Hydraulic Forceps With Force Feedback" Mechatronics Vol.6 (March 2017).
26. Yuma Yamanaka and Masahiro Yoshikawa, "A Gripper with three opposing Fingers Driven by a Hydraulic Actuator". (June 2015)
27. Lillian Chin, Michelle C. Yuen, Luis H. Trueba, "A Simple Electric Soft Robotic Gripper with High-Deformation Haptic Feedback" International Conference on Robotics and Automation (ICRA).
28. L. Chin, J .Lipton, "Compliant electric actuators based on handed shearing auxetics" in 2018 IEEE International Conference on Soft Robotics(April 2005). [CrossRef]
29. Takeshi Yoneyama, Tetsuyou Watanabe, Mitsutoshi Nakada, "Force-detecting gripper and force feedback system for neurosurgery application" (15th December 2012).
30. Mathieu Stephan, R. Beira, Santos-Carreras, "Modeling and Design of a gripper for a robotic surgical System Integrating Force Sensing Capabilities in 4 DOF" (October 2010) [CrossRef]
31. Libu George B and R Bharanidaran, "Design of compliant gripper for surgical applications" Australian Journal of Mechanical Engineering.
32. Andres Ubeda, Jose M. Azorin, "Brain-Machine Interface Based on EEG Mapping to Control an Assistive Robotic Arm" 4th International Conference on Biomedical Engineering (24th June 2012). [CrossRef]
33. Won-Kyung Song and Jongbae Kim, "Novel Assistive Robot for Self-Feeding" Korea National Rehabilitation Research Institute.
34. Redwan Alqasemi, Rajiv Dubey, "Design and Construction of a Robotic Gripper for Activities of daily Living for People with Disabilities" 10th International Conference on Rehabilitation Robotics (June 2017)
35. J. R. Bemfica, C. Melchiorri, L. Moriello, "Mechatronic Design of a Three-Fingered Gripper for Underwater Applications" The International Conference of Automatic Control (April 2013). [CrossRef]
36. Spadafora, M. Burno, F. Ribas, "Design and Construction of a Robot Hand Prototype for Underwater Application"
37. Zhongkui Wang and Shinichi Hirai, "A 3D Printed Soft Gripper Integrated with the Curvature Sensor for Studying Soft Grasping" (December 2016).
38. Daniel Caedin-Catalan, Simon Ceppetelli, Angel P. del Pobil, "Design and analysis of a variable-Stiffness Robotic Gripper" Alexandria Engineering Journal (17th June 2021).
39. Josie Hughes, Utku Culha, Fabio Giardina, Andre Rosendo, "Soft Manipulators and Grippers: A Review" Frontiers in Robotics and AI (16th November 2016). [CrossRef]

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