A Review: State of The Art of Robotic Grippers

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Abstract – *In this paper, we present a recent survey on robotic grippers. In addition, newer materials are being used to improve functionality of grippers, which include piezoelectric, shape memory alloys, smart fluids, carbon fiber, soft fabrics, micro electro mechanical systems, and synthetic sheets and many more. Industrial robots are commonly used in a large number of applications because they present superior performance in terms of accuracy, precision, rigidity, and most importantly speed. Although they are fast enough for pick and place operations, sometimes they cannot catch up with the speed of objects on the conveyor thereby missing some pieces so, a robot gripper must be lightweight and must have the ability to grasp objects of any size or shape stably. In addition, sufficient gripping force, a low cost, and a friendly shape are necessary. To satisfy the above requirements, this researchers designs a new robot grippers. With the recent introduction of ambitious industrial strategies such as Horizon 2020 and Industry 4.0, a massive focus has been placed on the development of an efficient robotic workforce.*

Key Words: **robotics, grippers, end effectors, types, degree of freedom**

1. INTRODUCTION

Because of the wide variety of objects manipulated in industrial processes, many different grippers, based on different principles, have been developed. Gripper choice or gripper design is often considered the last problem to be solved when a process is automatized. Since human beings are very familiar with object prehension, the process of automatizing the grasping of an object is often underestimated. In fact when objects have to be grasped in an automatic way, many problems arise: many depend on the object physical properties (e.g. porosity and deformability), but also the conditions in which the object is fed and the characteristics of handling, positioning and releasing increase the complexity of the gripper choice. Parts correctly fed require a less versatile gripper, while in bin picking situation the gripper has to properly grasp pieces with different positions, orientations, part tangling, etc. Similarly, high accelerations, reorientations, high precision releasing etc. during the handling phase, increase the constraints in the gripper design or choice[13]. Mechanical paws and rubber suction cups are the most commonly used end-effectors, but because they have to make contact with the workpiece, they may cause some damage to it. For instance, they may induce mechanical scratches, local stress concentration, frictional static electricity, or blots on the workpiece. Such damage is usually fatal to precision workpieces such as LCD glass substrates, and silicon wafers. Furthermore, in the food and pharmaceutical industries, contact between the end-effector and the workpiece may cause contamination, reducing the quality of the products. In addition, usually they need control strategies which are sometimes very complicated. In order to solve these problems, researchers have developed a variety of noncontact handling devices also.[10] developed a noncontact end effector for handling of bakery products. the pneumatic non-contact gripper, which uses air as the force transmission medium, is widely used. It does not produce a magnetic field or need feedback control. In addition, it has a simple construction and is easy to maintain [10] Recently, diverse types of robot hands have been developed all over the world. The types of robot hands can be largely divided into two groups: dexterous robot hands and gripper type hands. Dexterous robot hands can handle various objects skillfully and can undertake humanlike motions such as a handshake and sign language in addition to gripping objects like human hands, but there are several problems that must be resolved. Due to their complex structure, they do not have sufficient gripping power. Moreover, they are expensive for a service robot. Next, gripper-type hands are used only to grip an object. They usually have one or two DOF and are commonly used in industrial fields. Because they have a simple structure, they also have a high payload/weight ratio and are reasonably priced. However, they cannot grip a wide range of objects and do not have a human-friendly shape [8]. The design guidelines may be as follows[6] :-

2. LITERATURE SURVEY :

1] E.J.C. Bos, J.E. Bullema, F.L.M. Delbressine,P.H.J. Schellekens, A. Dietzel[1]

This article gives information about A lightweight suction gripper for micro assembly and discussed problems during assembly in the micro world with an emphasis on forces during the assembly process. A new design is proposed for a gripper with a moving mass less than 1 g for a pick up needle with a 6mm diameter. In the design friction and hysteresis are neglectable. The paper focus is on gripper design, realization and experimental results A prototype gripper is realized with a magnesium needle. It has a length of 45 mm, a diameter of 6.3mm and a mass of 0.8 g. By using air bearing and magnetic gripper we can reduce the size of gripper further. The needle in the prototype version is supported in axial direction using a bellow. The axial needle position is prescribed by a mechanical stop, Positional needle deviations with respect to the housing have been calculated to be less than 1 m for accelerations up to 10G and components up to 1g. The collision force with the gripper for an approach speed of 130 mm/s is measured to be 60 mN or less. Finally, the gripper is successfully used to pick up and release several sapphire spheres with a diameter of 0.3 mm.

2] Taylan Atakuru, Evren Samur[2]

In this article they discussed about A robotic gripper for picking up two objects simultaneously. In this study, a novel two degree-of-freedom gripper for industrial manipulators has been designed and developed. The idea behind the study was to pick up two randomly-arriving objects simultaneously with a single manipulator, so that cycle time and energy consumption of the manipulator was reduced considerably. But no other gripper suits for this task. So, the proposed 2-DOF gripper is novel, and differs from the state of-the-art grippers. After performing preliminary analysis they got that the 2-DOF gripper resulted in reduced cycle time and energy consumption in the benchmark PnP operations compared to a single gripper. Cycle time and energy reduction tests were performed with the single gripper and the 2- DOF gripper. The measurement results indicated that cycle time and total energy consumption for a given task are reduced considerably. The findings of the study will redound to the benefit of industry.

3] Lionel Birglen, Thomas Schlicht[3]

In this article they gives A statistical review of industrial robotic grippers. In this review, the authors focused on pneumatically driven, parallel grippers with two jaws and compiled the specifications of hundreds of product. They showed that if the number of grippers on the market is large, most of them share similar characteristics such as a small stroke and limited force. Efficiency as measured by the C-factor on the other hand is quite distinct from one manufacturer to the other. The C-factor of the grippers studied here range from 0.36 to 28.57, a difference of almost two orders of magnitude. An important limitation of the C-Factor though is that it does not take into account the cycle time of the gripper. This issue can be very simply solved by dividing the C-Factor by the latter and thereby quantifying the power-to-mass ratio of the gripper, defined here as the C ⋆-Factor. The large difference between average and median values of many specifications also highlights the significant tilt toward the lower end of the spectrum value. This is where the glut of the products coexist and almost all manufacturers compete.

4] Bjartmar Freyr Erlingssona, Ingólfur Hreimssona, Páll Indriði Pálssona, Sigurður Jóhann Hjálmarssona, Joseph Timothy Foley[4]

This article gives information about Axiomatic Design of a linear motion robotic claw with interchangeable grippers for that they start to work on,

1] A lightweight robot end-effector which can pour a beer bottle.

2]Move smooth bottle-shaped objects by gripping them.

After looking at various technologies for making a robot end-effector, a design concept was chosen Servomotor claw with compliant high-friction grippers moving linearly. Though the implementation was unsuccessful due to manufacturing issues, we believe this paper to be a valuable example of Axiomatic Design being employed on a challenging electro-mechanical problem. Due to the generation of Functional Requirements, Design Parameters, and design matrices, the authors were able to catch reliability issues (due to coupling) before the construction began. Future efforts will build upon the designs described here to further improve the gripper employed in the automation course.

5] Hongtao Pana, Xiang Gaoa, Jianjun Huanga, Huibin Suna, Xiaodong Lina, Jiangang Lia, Yinxian Jiea, Qing Zanga, Yuntao Song, Eric Villedieud [5]

This paper describes the design and implementation of a 3-DOF gripper for EAST in-vessel maintenance. The gripper prototype was developed based on modular joints and two-finger claw. The integrated design of the mechanics and electronics, all the external sensors and the optimized control system were presented. Preliminary tests both on single joint and the full robot have been carried out to evaluate the feasibility of the gripper. The results show the good potentialities of the design choices, but also some limitations that are being considered in the next version of the gripper. In addition, more experimental activities will be demonstrated in vacuum and temperature environment.

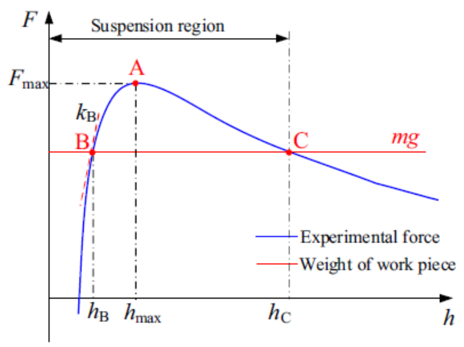
6] Vaibhav Raghav, Jitender Kumar and Shailesh S.Senger[6]

an object can be tracked in real time and the optimal grasp points can be determined by use of a fast algorithm for the computation of the optimal grasp force, so that a three finger robot can capture it.A Grasp skill can be provided to a superior robot system which can coordinate movement of hand of a robot and arm of a gripper to determine grasp patterns depending upon the object shape. Different Systematic grasping and control algorithm can be proposed to adjust the motion of the gripper without the risk of object crushing or dropping and also to maintain the object slip in a reasonable limit.With the help of a new methodology, micro-clasp gripper, stable gripping and manipulation of micro scale complex shaped object can be accomplished.A formulation can be achieve for a kinematic design of gripper mechanism with optimal characteristics with improvement of existing solutions.

7] Tae-Jin Jung. Jun-Ho Oh[7]

This research designed a robot gripper for a rapid service robot. A robot gripper for a rapid service robot requires a strong gripping force, a rapid closing velocity, a reasonable price and a human-friendly shape. It also must be lightweight,able to grip various objects, and capable of stable grasping. In this research, they designed a new robot gripper that satisfies the above conditions. With the four-bar linkage underactuated system, we can reduce the number of motors,which constitute the bulk of the weight of the gripper. In a simulation, the four-bar linkage was designed so that the rollback ejection phenomenon would not occur and so that the ejection phenomenon could be utilized as an opening motion that gives the gripper parallel grasping capabilities.With the parallel four-bar linkage system, the gripper can perform a parallel grasp as well as a power grasp, making it suitable for gripping small objects, even in tight spots. While other studies place emphasis on preventing rollback ejection,in this research they emphasized the maximum utilization of both parallel and power grasping using a compliance jaw and a four-bar linkage design. In addition, the compliant jaw enhances the stability of the grasp by allowing powerful grasps to be performed during a parallel grasp. The worm gear enables stability of the gripper grasp and reduces the gripper's weight. Using a force sensor, the device is capable of sensitive force control. Consequently, they designed a robot gripper that meets the requirements currently needed for rapid service robots. Future work can include the study of more refined controls using other types of sensors, such as tactile sensors, and an investigation of other implementations of underactuation.

8] Jianghong Zhao, Xin Li[8]



(1) The suction force F depends on the spacing between the workpiece and the gripper, h, and the F–h curve at a given supply flow rate is convex, i.e., there is an optimum spacing hmax at which the suction force is maximum Fmax. Furthermore, according to experimental results, as the supply flow rate increases, Fmax has an approximately quadratic relationship to Q, whereas hmax has a slight decreasing tendency.

(2) We nondimensionalized the F–h curves by replacing F with F/Fmax. It was found that the dimensionless F–h curves of different supply flow rates have the same variation tendency, which implies that the dimensionless F–h curve is an inherent characteristic of the gripper. We also deduced that the increase in flow rate causes the dimensionless F–h curves to have a slight translation to the left, thus decreasing the suspension region slightly. However, such variation is only noticeable when the flow rate is very small; all the curves almost overlap beyond a certain value of the flow rate.

(3) they decomposed the pressure distribution into two parts: the vortex flow part, which is not affected by changes in h,and the gap flow part, which is very sensitive to changes in h. Based on this decomposition, we proposed a simplified calculation method for the suspension stiffness, and the stiffness calculated by this method was found to be very close to the experimental value. In addition, we analyzed the physical significance of the slope of the dimensionless F–h curve at the stable suspension position

9] Huixu Dong, Ehsan Asadi, Chen Qiu, Jiansheng Dai, I-Ming Chen

Geometric parameters of a two-finger gripper driven by TDMs are studied in this work by extracting a mathematical model of the force/torque transmission between an active force and contact forces based on the geometric analysis. In addition, a mathematical model is presented to obtain the transmission efficiency of the tension force when a tendon wraps a joint mandrel by the geometric relations. Genetic Al-gorithm is applied to optimizing the dimension of the gripper and the tendon routes. Specifically, we construct the two genetic-based fitness functions to be optimization objectives based on the grasping stability and the efficiency of the force transmission. The geometrically optimal approach provided by us has the characteristics of the versatility and can also be referred to optimizing most of the under-actuated robotic gripper with TDMs. We have validated this presented method by constructing an under-actuated gripper with TDMs depending on the optimized results and performing the practical experiments. In particular, the gripper can realize the stable grasps for a wide range of objects in household and of- fice environments, and adapts to the shape of the grasped object because of the under-actuated mechanism.

10] Gualtiero Fantonia,b, Saverio Capiferria, Jacopo Tillib

At the present moment the system adequately defines the grasping principles capable to perform the required operation together with some fundamental recommendations. However, finding a way to evaluate every possibility, including the variability of the objects, still requires further study and work that could be done iteratively. Since the system is based on a set of rules that can be easily updated, in future it could work as a self-learning system. This turns into an increase in terms of effectiveness and efficiency.

11] A.F. Alogla, F. Amalou, C. Balmer, P. Scanlan, W. Shu, R.L. Reuben

Conclusions This work demonstrates a pneumatically actuated micro-gripper that has the ability to pick and place micron-sized objects with the potential to provide tactile feedback. The pneumatic micro-actuator can have its pressure-force relationship measured and controlled in both static and dynamic modes with a simple setup. The two stainless steel gripper arms can be fabricated using low-cost, scalable photo-etching manufacturing technique with arrange of dimensions, allowing this design to be scaled to fit the chosen application. As the photo-etching manufacturing is a photo-lithography technique with high precision, it is possible to fabricate stainless steel based gripper with dimensions smaller than 100 m for single cell manipulation. The stiffness of the two torsion bars can aid in tailoring the use of the gripper with the bars behaving almost as a pivot or used to down-regulate the input force (for more delicate tasks). Besides controlling the input and output forces, the design of the gripper arms can be tuned in order to provide a deflection of the arms, whose measurement can be used to measure the gripping force in operation and can potentially be fed back to control the force or used to assess the gripped object. Besides the potential use of gripper for manipulating embryos for cloning applications, the mechanical micro-tweezers may provide a new way to pick-and-place cell aggregates for bio fabricating synthetic tissues [25,26]. Future work will focus on further miniaturization of the gripper for manipulating smaller objects (e.g. single cells) and treatment of the gripper surface to overcome potential striction issues. Further improvement of the gripper's tactile sensing may also lead to mechanical assessment of biological tissues in vivo.

12] Wei Wang, Hugo Rodrigue, Hyung-Il Kim, Min-Woo Han, Sung-Hoon Ahn

In this study, an SMA-based SSC hinge actuator capable of pure bending motion was developed that consists of a SMA wire embedded in a PDMS matrix with segmented rigid components. Based on the design characteristics of this actuator, it is possible to manufacture actuators with one or multiple hinges. From the results, it can be observed that a smaller flexible length ratio of the hinge actuator will lead to a larger maximum bending curvature and a longer flexible length will lead to a larger maximum bending angle. Also, for an actuator containing multiple hinges, if the total flexible length of the hinges of the actuator is fixed, the maximum bending curvature of the hinges of the actuator is constant regardless of the number of hinges. A model was developed to verify the experimental results. Results show that the model is capable of predicting the maximum bending deformation of the hinge actuator. The results obtained in this study can serve as rough guidelines when designing this kind of bending actuator in order to match its capabilities with the application's requirements. Afterwards, a gripper with three fingers making use of the proposed hinge actuator was designed and tested. In order to show the passively adaptive capability of the gripper, cylindrical objects with diameters ranging between 1 mm and 80 mm were grasped by the gripper using two types of grasps, namely fingertip grasping and power grasping. Afterwards, the pulling force of the gripper in different grasps and while changing between grasps was tested. Results showed that the proposed gripper concept is capable of seamlessly transitioning between the power grasp and the fingertip grasp, although the pulling force produced by power grasping is larger than that from fingertip grasping. The developed actuator concept is lightweight, has little implementation requirements and is capable of passively adapting its shape to its environment, such that it has potential applications in a wide range of field. It also has potential to be integrated with other types of sensors or electronic systems regardless of whether they are soft or stiff since it takes advantage of both soft hard segments in its mechanism. This mechanism can be also embedded with other mechanisms to generate a larger range of motion. Future work will focus on design improvements such that the actuator is capable of being used in a wider range of applications

13] Kevin Tai, Abdul-Rahman El-Sayed, Mohammadali Shahriari*,Mohammad Biglarbegian and Shohel Mahmud
End-effectors or grippers are very versatile components that have been used in applications such as automotive industries, manufacturing lines, vegetable pickers, MEMS grasping, surgical applications and prosthetic arms. Most of these grippers utilize an impactive gripping strategy. Since then, impactive grippers have branched into many segments including grippers that have added sensors, added cameras, piezoelectric grippers, soft grippers, MEMS, multi-fingered grippers, under actuated grippers, elastic and malleable grippers, and multi-arm grippers. Overall, grippers that have more sensor feedback tend to track and grasp objects more frequently. Piezoelectric and MEMS grippers actuate with high precision, however they do not have much grip strength. Malleable grippers can pick up many oddly shaped objects, however they may deteriorate after many cycles of actuation. Dual and multi-arm grippers are trending to replace humans in many tasks such as assembly lines and healthcare. We discussed that how the performance of the grippers can be improved in future in different applications through robust controllers, instrumentations as well as structure design. We analyzed the implementation of human gripping capabilities on robotic grippers by employing vision sensing, incorporating visual feedback, artificial muscles, and smart and soft materials. We explored detailed advancements of performance and flexibility of robotic grippers through different designs and applications. The challenges in implementation different designs are discussed. We showed that soft, modular and adaptive grippers by utilizing different gripping components and materials can increase both performance and flexibility; however, as we argued the challenges in these improvements, introducing softness into the robotic gripper design requires set of design and control principles compared to hard grippers, and smart materials are not

capable of providing strong gripping force. This paper covered the earliest types of robotic grippers, the improvements made to them and recent advancements along with applications. We hope that by comparing and categorizing these robotic grippers under certain applications, new innovative methods can be discovered to solve real world problems present newer challenges that can be investigated to further push the boundaries in gripping mechanisms.

3. Conclusion:

Considering all above thinking of researchers we can conclude that robotics is the one of the main aspect which plays important role in industries, home appliances, production line and medical fields. Now a days, industries are changing to the costumer oriented production in which pull type production takes place. Where inventory is in small area and inventory requirement is also less.

Industry 4.0 is the leading industry will be taking place in coming years. For this type of industries different types of robots and their movement is required. In the robots grippers plays important role for all PNP operations.

Magnetic, mechanical and suction are the three types of grippers which are mostly used but all these are contact type of gripers which couses harm or crashes on the product to avoid this, vortex type of gripper is introduced which keeps air gap between product and gripper.

Sensor and actuators plays important role in robotics which couses less energy consumption and it is to much economic than labours wages. It gives feedback on real time and reduces couses of accidents.

Production or working in any environment can be done by robots which means working flexibility is high in it.

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