DESIGN AND OPTIMISATION OF ROBOTIC GRIPPER: A REVIEW

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Abstract

In this paper, the field of robotic gripper and the work in this area over the last two decades has been reviewed. In the recent past many different robot grippers have been developed to grasp one or a few specific objects. Those grippers are well suited for continuous work in structured environments. On the other hand, some researchers have focused their attention on sophisticated general purpose grippers having kinematics and dextrousness similar to the human hand. With the evolution of automation in industries, grasping become an important topic in robotics research community. The paper emphasis on study of current existing robotic grippers, their basic design and optimization of the same.

Keywords: Robotic gripper, Design, Flexibility, Optimization parameters.

1. INTRODUCTION

A gripper is the mechanical interface between the robot and its environment. Without it, the robot cannot perform the pick-and-place functions. In industrial applications it is common to handle objects with different geometries and weights. Variety of robotic grippers are developed highly flexible and multi functioned.

Particularly humanoid robotic technology attracts high attention of researchers. The highly dynamic and highly accelerated gripper model can be easily set at intermediate positions by regulating the pressure. Pneumatic grippers are very easy to handle and are generally cost-effective because air hoses, valves and other pneumatic devices are easy to maintain.

Since a gripper gives a great contribution to practical success of using an automated and/or robotized solution, a proper design may be of fundamental importance\cite{6}. A proper gripper design can simplify the overall robot system assembly. It also increases the overall system reliability and decreases the cost of implementing the system\cite{5}. Thus, the design of the gripping system is very important for the successful operation.

It is not possible literally to apply all the guidelines to a specific set of design. As one guideline may suggest one design direction while another may suggest the opposite.

So the most suitable technique is to examine each particular station and then coming to a conclusion which favours the more relevant guidelines.

The design guidelines may be as follows \cite{4}:

1) Gripper weight should be minimized. This favors the robot to accelerate more quickly
2) Grasping of objects should be secure: This allows the robot to run at higher speeds in zig-zag profile thereby reducing the cycle time.
3) Completely encompass the object with the gripper: This is to help hold the component securely.
4) Grasp the object without deformation: the object are easily deformed and so care should be taken during grasping these objects.
5) Minimize finger length: The longer the fingers of the gripper the more they are going to deflect during grasping an object.
6) Design for proper gripper-object interaction: If, however, a flat surface is being used, then a high friction interface is desired since the part would not be aligned anyway and the higher friction increases the security of the grasp.
7) Flexibility: The ability of a gripper to conform to parts that have irregular shapes and to adapt to parts that is inaccurately oriented with respect to the gripper.

The ideal gripper design should be synthesized from independent solutions to the three considerations shown in Figure 1. Grippers essentially replace the human hand. If the gripping abilities of a mechanical five-fingered
“hand” are denoted as 100%, a four-fingered hand has 99% of its ability, a three-fingered hand about 90%, and a two-fingered hand 40%.

Figure 1.

OPTIMALITY CRITERIA- In general, an optimum design procedure can be considered by means the following steps:
1) Identification of design constraints and performance characteristics for a given application;
2) Formulation of basic performances;
3) Analysis of optimality criteria through numerical algorithms;
4) Formulation of a single and/or multi-objective optimization problem for design purposes;
5) Numerical solution of the multi-objective optimization and interpretation of results;
6) Determination of a design solution through a suitable model;
7) Mechanical design of all the components and details

2. Literature Works
1.) K.S. Venkatesh, A. Dutta, P. Guha, T. Mishra [7] - In the last two decades several researchers have studied the problem of grasping of a moving rigid object based on vision data. However the problem of grasping a moving and deforming object still remains unsolved. In this paper, they have presented the development of a fast algorithm for the computation of the optimal force on a slowly moving and deforming object so that grasp point could be known. Their main focus was to find the best grasp points as the object deforms, to track objects position at a future instant and then transfer gripper grasp to that location. At first the potential grasping configurations satisfying force closure are evaluated through an objective function that maximizes the grasping span while minimizing the distance between the object centroid and the intersection of the fingertip normal. A population based stochastic search strategy was adopted by them. They conducted Experiments to prove that the object can be tracked in real time and the optimal grasp points can be determined so that a robot can capture it. This method works in real time so it has great potential for application in industries for grasping objects whose shapes are not clearly defined (e.g. cloth), deforming objects, or objects that are partially occluded.

2.) G. Brethbauer, D. Osswald, J. Martin, C. Burghart, R. Mikut, H. Wörn [8] - This article presents the approaches taken to integrate a novel anthropomorphic robot hand into a humanoid robot. The requisites enabling such a robot hand to use everyday objects in an environment built for humans are presented. Starting from a design that resembles the human hand regarding size and moving ability of the mechatronical system, a low-level control system providing reliable and stable controllers for single joint angles and torques, entire fingers and several coordinated fingers. Also the high-level control systems connecting the low-level control system with the rest of the humanoid robot are presented. It provides grasp skills to the superior robotic control system, coordinates movements of hand and arm determines grasp patterns, depending on the component to grasp and the task to execute. Finally some preliminary results of the system, which were currently tested in simulations, were presented

3.) L. Saggere, S. Krishnan [9] - This paper presents the design and development of a new tool, called the micro-clasp gripper, for accomplishing firm and stable gripping and manipulation of complex-shaped micro-scale objects in any orientation using a single rectilinear actuator. The micro-clasp gripper is a compliant mechanism comprised of an end-effector with a closed-loop boundary that can be folded and unfolded in a plane by the action of the rectilinear actuator. Upon actuation, the end-effector of the micro-clasp gripper clasps an object by
first encircling the object, and then, folding to the object to accomplish multi-point contact with the object. This clasping of the micro-object with multi-point contact ensures a stable grip on the object regardless of its shape and initial orientation, even in presence of ambient disturbances the transport of the object or complex micromanipulation and micro-assembly tasks. The design of the micro-clasp gripper is obtained through a systematic modelling and topology optimization techniques, and a proof-of-principle device is micro-fabricated using conventional micromachining techniques. The device design is validated through experiment-model correlation studies on the input-output characteristic of the micro-machined prototype, and practical feasibility of the clasping functionality of the gripper is demonstrated through experiments involving grasping and repositioning of irregularly shaped micro-particles on a glass substrate.

4.) D. Rituparna and D. Kalyanmoy[1]-In this paper, a multicriteria optimization of robot gripper design problem was solved using two different configurations involving two conflicting objectives and a number of constraints. The main objective was minimization of the difference between maximum and minimum gripping forces and simultaneous minimization of the transmission ratio between the applied gripper actuator force and the force experienced at the gripping ends.

5.) Chiara Lanni and Marco Ceccarelli[6]-The author has analysed the mechanisms in two-finger gripper to formulate an optimum design procedure. The design problem has been approached and formulated as a new optimization problem by using fundamental characteristics of grasping mechanisms. In order to optimize a mechanism for two-finger gripper, an original multi-objective optimum algorithm was used by considering four different objective functions including grasping index, encumbrance of grasping mechanism, acceleration and velocity for finger gripper with confined working area. This new formulation will achieve a kinematic design of gripper mechanism with optimal characteristics even as improvement of existing solutions.

6.) Jianqiang Wang- The author has tried to achieve Intelligent grasping through gripper design, automated part recognition, intelligent algorithm for control of the gripper, and on-line decision-making based on sensory data. A three-fingered gripper actuated by a linear servo actuator designed and developed in this project for precise speed and position control is capable of handling a large variety of objects also Generic algorithms for intelligent part recognition were developed. Fuzzy logic was successfully utilized to enhance the intelligence of the robotic system.

7.) A. M. Zaki, O. A. Mahgoub, A.M. El-Shafei, A. M. Soliman[4]-In this paper, a gripper was designed and implemented to grasp unknown objects with different masses, geometry, and surface roughness. The design and control of the gripper system has taken into consideration simplicity in the mechanical system, large variety of grasped objects and low cost. The proposed grasping process during object lifting and handling was mainly based on the slip reflex principle, as applying insufficient force leads to object slipping, and dropping may also occur. On the other hand, applying extra force during grasping may lead to object crushing. A new system controller using fuzzy logic based on empirical investigation of the human hand skills was proposed. Experimental confirmation was obtained for of the distance of the slippage and process time. Simulation and experimental results were discussed.

8.) S.Costo, G.Altamura, L.E.Bruzzone, R.M.Molfino, M.Zoppi[10]-This paper deals with the design of the mechatronic device enabling the multi point grasp and firm hold of limp one layer of leather sheets for the automation of leather manufacturing operation in industries. The design assures low inertia, high modularity and full flexibility adapting to the environment.

Conclusion
This paper presents a survey of work in design of robotic gripper over the last twenty years. It is impossible to do justice to all the work in this area, particularly because of the breadth of the field and its close connection to dexterous manipulation.

From the above study it is concluded that 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.

REFERENCES