



**INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH
TECHNOLOGY**

Minimal Grasper for Pick-and-Place Tasks

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Abstract

In this paper, a New technology for the grasping of components was introduced, which is flexible and proposed for pick-and-place tasks with low manipulation complexity for industrial applications. Here it having two main characteristics: self adaptively and flexibility. Self-adaptively says that the proposed grasper can grip an object in a self-adaptive way such that various process complexities (e.g., sensing, force control, and sensor-motor coordination) are significantly reduced. In flexibility, we can see, by using a flexible material, a stable grip can be implemented to cause increased friction between the grasper and the target object as a result of increased contact area. These two properties help the proposed grasper to minimize internal forces in a passive manner and to achieve successful force distribution with self-adaptivity when performing enveloping grasping. Three sets of experiments were performed with an average success rate of 93.2% in pick and-place tasks. An average success rate of 93.2% were permomed.

Keywords: Minimal grasper.

Introduction

There have lots of grasping technologies which has developed and implemented on the industrial technologies but for the future implements we need more manipulated and accurate technologies. For that this will be the more and efficient method for grasping in the human hand has approxly 200 of freedom 17000 tactile sensors are distributed over the outer skin of the hand. Moreover, about 40% of the motor cortex of the brain is devoted to controlling the hands. Like that other systems use several sensors for this sensing., A number of studies have been performed to develop anthropomorphic dexterous hands [2][3]. Anthropomorphic robotic hands are advantageous in that both a precision grasp and a power grasp are possible.

The robot Hand is a very complicated system composed of a large number of joints. Also, there are limitations of size and weight in the development of the robot Because of these reasons, to manufacture an useful robot hand is a difficult work. To mimic the grasping tasks hand. Because of these reasons, to manufacture a useful robot hand is a difficult work. Firstly, we define several requirements of a robot hand in the sense of structure and function. Although it is difficult to satisfy all of the requirements.

Performance is the ability to perform fine manipulation in stable and robust ways. Simplicity

means mechanical, control, and computational simplicity, which directly relates to the cost of products. These are the two main disadvantage performed here.

As shown in [1], numerous under actuated manipulators have been proposed as an intermediate solution [4] to decrease the complexities of control, manipulation, and sensor-motor coordination. This hyper redundant robot manipulators [5][6] have been proposed to improve the grasping manipulability in robotic hands. They have lots of merits that they are robust against unusual environments. Noticeable implementations have been and whose motions are similar to those of biological manipulators such as trunks and tentacles. When the joints increases, the manipulability of the manipulator decreases with computational costs.

By the using of the human hands structural method, various research works have studied the effects of the flexibility of the finger grasping [7][8] for the effective operational purpose hand using shaped deposition manufacturing fingers and joints with viscoelastic materials [9]. Finally, based on the concept of simplicity, the Target Collaborativize (TAKO) gripper [10] and ultralow-cost simple graspers [11] have been suggested. The main drawback of the finger grasper is very unrealistic to satisfy all functional requirements for the broad range

of tasks using current state-of-the-art technology while simultaneously accomplishing simplified mechanical design.

Above we says about other graspers here we have done the robotic grasper called a “minimal grasper”, which is a hybrid implementation of hyper redundancy, flexibility, and simplicity. The purpose of the design is to develop a robotic hand that can be used for automatic manipulation tasks with various uncertainties in control, sensing, object shapes, etc. Our approach is to implement a hyperredundant flexible closed loop shown in fig 1(a).

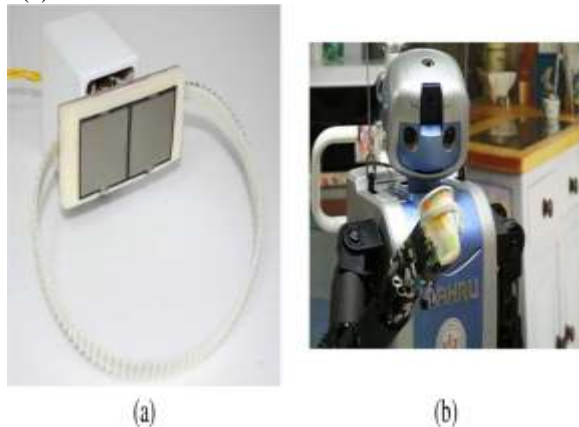


Fig. 1. Proposed grasper in (a) stand-alone and (b) humanoid integrated forms.

TABLE I Mechanical Specifications Of The Minimal Grasper

Size (W × L × H) (mm)			(g)
AGP	PGP	Driving System	Weight
200 × 140 × 50	120 × 10 × 50	55 × 75 × 75	405

In this our approach is an implementation of an enveloping grip using a hyperredundant flexible loop in a closed form, as shown in Fig. 1(a). Grasping is conducted in three steps: 1) The target object is positioned by the grasper; 2) inserting the grasper from top to bottom of the object; and 3) squeezing the loop to establish an enveloping grip. The proposed grasper has the features self adaptivity, i.e., the grasper adapts itself to the shape of the grasped object and also by using flexible material, the friction between the target object increases because of the increased contact force. Due to these features, the grasper was designed in a minimal way: one direct current (dc) servomotor as an actuator, one encoder to measure motor rotation, and two

force-sensing resistor (FSR) sensors. For the validation of this robust and stable way for pick-and-place task three sets of experiments were performed. From this experiments we get an average of success rates of 93.2%. By using a 20-W dc motor, the grasper was able to stably hold an object up to 4 kg. This paper is organized as follows.

Mechanical Contribution For The Minimal Grasping

Table I shows the mechanical contribution of the proposed grasper. The grasper consists of four major components as in Fig. 2: active grasping part (AGP), passive grasping part (PGP), driving system, and controller which shows the minimal grasper.

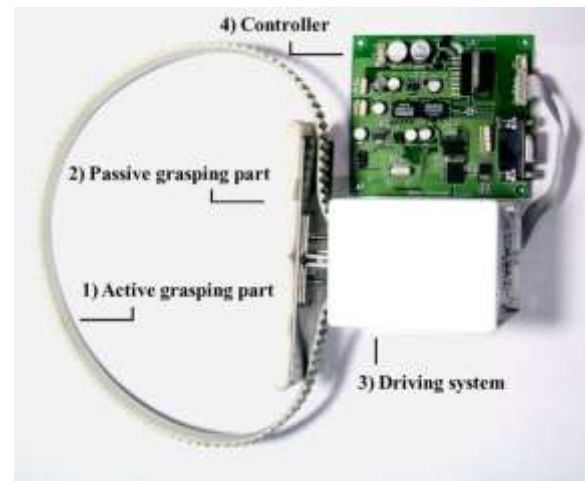


Fig. 2. Four major components of the minimal grasper: AGP, PGP, driving system, and controller

i) AGP

The AGP that actively makes contact with the work piece, which is a common rubber timing belt made of polychloroprene rubber and fiber glass. It is being squeezed by a dc geared motor through two identical spur gears. This timing belt features excellent flexibility, stable transmission, high durability, and high strength. So we can make it is an excellent material with which to meet the flexibility requirement and demonstrates a high level of energy transmission efficiency to firmly grasp various objects in real-world environments. The intrinsic merit of a flexible AGP over conventional finger-based robotic hands is that sensing joint torques and positions of the fingers and finding appropriate forces and wrenches to control each joint become unnecessary. In addition, this part adapts itself to

the shape of the object, thus enabling a successful grip of an unknown object of arbitrary shape.

ii)PGP

The PGP in which it like as the palm of a human hand and consists of an aluminium plate covered with widely used foam rubber, also having with two FSRs as force sensors (FSR406, Digi-Key Corporation), similar to those in [33]. The PGP consists of three major functions. First, the PGP works as a base plate which generates a retention force the force should be in the opposite direction of squeezing. In particular, by the virtue of the sponge characteristic of foam rubber, a stable grip can be implemented. Second, large fluctuations of the AGP, which could make the insertion of the loop into an object to fail, can be prevented by the PGP. Finally, by the aid of the FSR, a force feedback control can be implemented which enables the grasper to hold an object stably.

iii)Driving System

A dc servomotor, a pair of spur gears, a flange, and a main frame contains in a driving system . Their is a rotational motion into linear motion is performed by operating the motor the spur gear performs it . Similar designs have been widely used in rack and pin ion gears and industrial linear actuators. Here, two cylindrical supporters guide the belt to exit the casing without unnecessary contact.

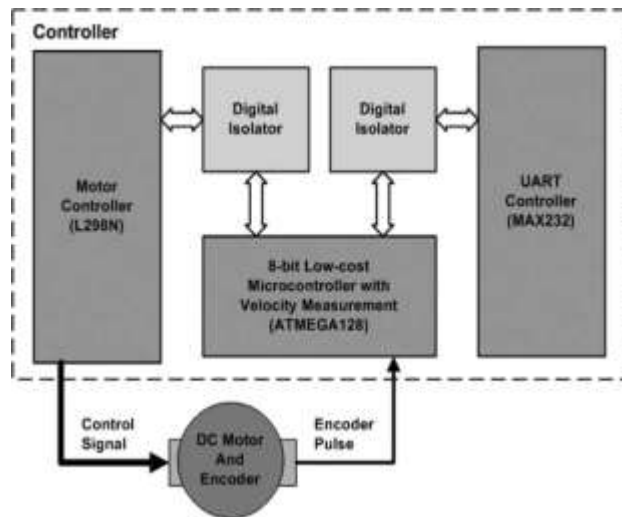


Fig. 3. Schematic diagram of the controller.

iv). Controller

A dc geared motor was controlled by a simple controller and measures the amount of rotation of the motor is designed. The grasps of an

object and release the object on a target location is correctly controlled by dc motor. To control the dc motor, a dual full-bridge dc motor driver circuit called L298N was used. In an effort to reduce the number of expensive sensors, only encoder output is measured. A schematic view of the controller is shown in Fig.3. In particular, to prevent signal and power noises these three circuits were isolated that could induce control failure.

Grasping Procedure

The grasping procedure in three phases: planning, enveloping, and lifting. As the minimal grasper also forms the enveloping grasp regardless of the shape of an object, the categorization was used for the grasping procedure as follows.

A.Planning Phase

In many cases the properties of an object are unknown ,and it also having an unstructured working environment has a high degree of uncertainty that can easily cause manipulation errors in positioning and force control .reach the goal of performing the grasping we have to eliminate these problems and many researchers have studied grasp planning. Here it described how the grasper simplifies grasp planning tasks to overcome uncertainties and accomplish a successful grasping task.to reach our goal in this study is to an alternative to optimal grasping with high-cost and well equipped robotic hands. Thus, as long as a gripping trial of a gripper shows stable grasping performance against uncertainties and disturbances and completes a given task, the grasp is considered successful.

In this for a feasibility measurement here the grasper approaches the objects in a downward direction from top to bottom of the object. Here measure the distance from the centre of the object to around the circumference of the object. After that it is compared with the grasper. Let us define object and ρ_{0grp} as the distances of the object at the virtual horizontal axis from its center point, as shown in Fig. 4(c). The superscript zero indicates the angle from the horizontal line in degrees. In some rare cases, there are multiple possible grasping locations are formed. Note that, as shown in Fig. 4(d) and (e), the orientation of the grasper with respect to the target object plays an important role in successful grasping. With all conditions the grasping is defined to be feasible only if the following condition is satisfied:

$$\rho_{i obj} > \rho_{igrp} \quad \text{for all } i \in [0, 360]. \quad (1)$$

A number of angles are formed here and any angles that satisfy (1) can be a candidate as an approaching angle of the grasper, as shown in Fig. 4(e). In this whether any angle which maximizes the

safety margin between the grasper the object we selected that desired orientation. This safety margin is the shortest distance between two log-polar profiles of ρ_{gr}^i and ρ_{obj}^j for two different angle sets of $i, j \in [0^\circ, 360^\circ]$. By this the maximum safety margin can be found by iteratively changing the angle of the grasper from 0° to 360° while checking the shortest distance we get the desired orientation or the angle which is more accurate for the grasping method. Fig. 5 shows these profiles before and after this process which indicates the desired orientation to be 76°

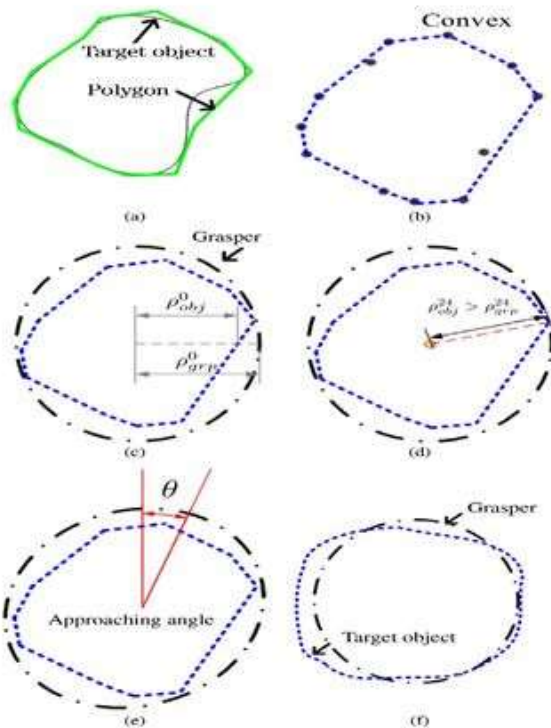


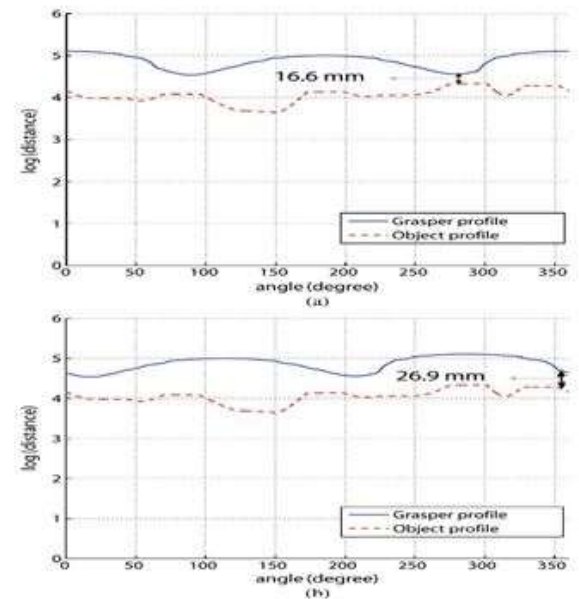
Fig.4.Workspace of the grasper. (a) Projection of grasped object and polygonization of the projection. (b) Constructing (dotted line) a convex hull using the convex hull algorithm. The vertex of the convex hull is shown by gray dots. (c) the feasibility of grasping with a given object. If feasible, calculate the approaching angle of the grasper. (d) Grasping is feasible. However, the orientation needs to be modified. (e) Possible approaching angle. (f) Infeasible case

The self-stability and self-adaptation of the grasper performs its task robustly against manipulation errors. Fully automated performance was allowed due to this robustness of the grasper. The grasping part always constructs a closed loop around the target; consequently, force closure is achieved in a planar space. Since an object grasped

by an enveloping grasp stays robust with respect to any rotational and translational disturbances in the planar direction, the only concern for pick and place tasks by this grasper disturbances in the vertical direction, particularly in the lifting phase. This means that considerable computational effort needed to search appropriate finger positions to achieve the force closure grasp would be saved in the task planning stage. This is a great advantage performed here over other anthropomorphic robotic hands that work with fingers.

B. Enveloping Phase

The squeezing and sensing of a construction of the force closure are the two main tasks in the enveloping tasks. The grasper adapts itself to an object and is being stabilized at some location, at the time of squeezing as shown in Fig. 7. This action is attributed to the flexible and compliant materials of the grasper skin and palm. Regardless of



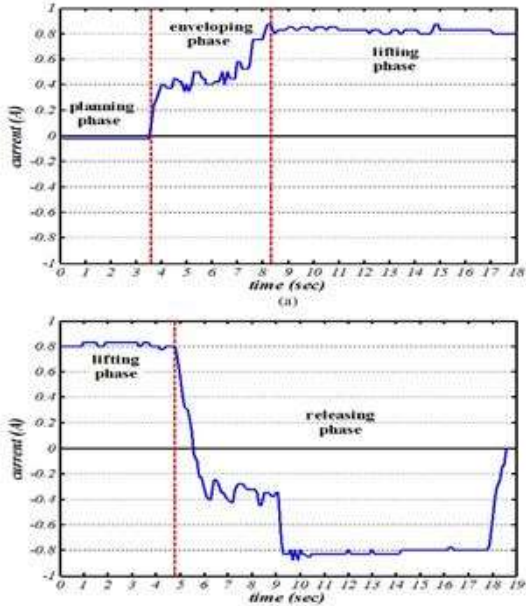
LogFig. 5 Log polar profiles for the grasper and the object. Initially, the safety margin was 16.6 mm as in (a). By shifting the angle of the grasper the maximum margin was found to be 26.9 mm as in (b). From these figures, the desired orientation can be easily found to be 74° .

whether the curvature of the surface has contact with the PGP, the object is reoriented in a way that maximizes the contact surface with the grasper. Here, the self-stabilization accounts for the fact that a controlling scheme does not need to work out a solution of the corresponding

We get a force signal from the two FSRs which is attached on PGP is used to determine whether the force closure is being constructed. Here a

force higher than the detected threshold is formed when a simple force control scheme is detected also the input current of the motor increases. In Fig. 8(a), the motor current increases during the enveloping phase. Once the phase is turned over to the lifting phase, the current is being kept so that the force exerted to the object can be maintained and that the object is stably held. The current value of releasing an object is shown in Fig. 8(b), which reverses the pattern of the enveloping phase.

C. Lifting Phase



A successful enveloping grasp was performed when squeezing is completed as in the fig.(6). Then, a robotic having the grasper is attached begins its manipulation to properly locate the grasped object, as planned previously

Experiments

Three stages are performed here for the validation of the grasper of the proposed grasper : a manual stand-alone experiment, a semiautomatic humanoid experiment, and a fully automatic test-bed experiment. All the objects were manually placed on the AGP prior to enveloping is shown in the manual method. The grasper can be used in real-life application is shown by the semiautomatic experiment. Here, the term “semiautomatic” means that the fact that all the procedures were automatically conducted except the object location it was calculated by a laser spot. In our experiment, a human operator emitted a laser spot on the surface of the object so that the humanoid robot could estimate the location of the object using stereo vision system. Finally, a test-bed experiment is conducted for the fully automatic pick-and-place task execution.

For those experiments, ten commonly used objects were selected with different shapes, sizes, and weights, as shown in Table II. To calculate a quantitative success rate, a scoring rule was set in a way that adds one credit whenever the system successfully conducts the following sub goals, as shown in Fig. 10: insertion of AGP downward to the object, enveloping, lifting, swinging, and releasing the object

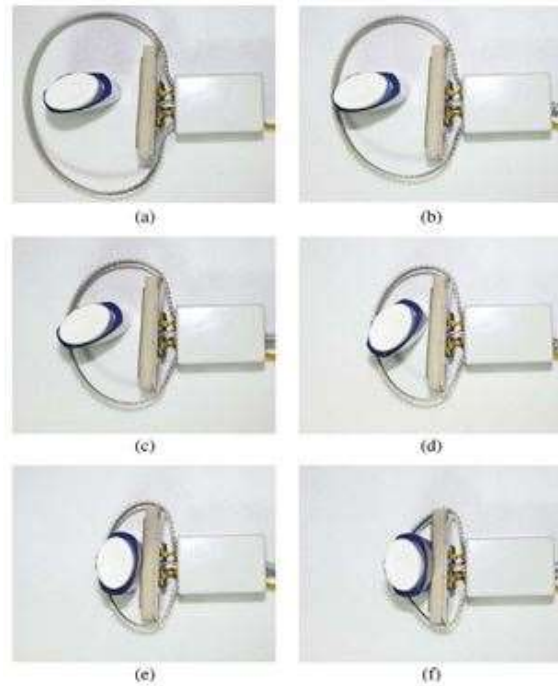


Fig 7. Motor current input during (a) the developing and (b) the releasing phase.

TABLE II Object Description

Object	Size(mm) (WxLxH)	WEIGHT (g)	SHAPE PRIMITIVE
Shuttlecock	84x67x67	4	Cone
Lotion	55x30x154	112	Cylinder
Paper cup	75x75x94	8	Cylinder
Symmetric can	50x50x133	261	Cylinder
Ergonomic mouse	73x101x80	84	Cylinder
Cotton doll	115x108x147	86	Arbitrary
Tennis ball	70x70x70	58	Sphere

by $\delta x = 25 \text{ mm}$ and $\delta y = 50 \text{ mm}$. (f) Grasping success for $\delta x = 25 \text{ mm}$ and $\delta y = 50 \text{ mm}$.

A. Manual Stand-Alone Experiment

In this experiment a total of 50 tests were conducted and get a success rate of 97.6%. in this experiment the failure is formed only for ergonomic mouse which is mentioned in the table III . Here we placed the grasper position slightly different from the ideal position. Due to this no displacement occurs during the enveloping phase for the object. The experiment was performed in a graph paper it shows more than 60% of errors in the y-direction and 30% of the size in the z-direction. The fig.(8) shows it.

Table III Result for Manual stand Experiment

no	Object	A	B	C	D	E	Success %
1	Shuttlecock	5	5	5	5	5	100%
2	Lotion	5	5	5	5	5	100%
3	Paper roll	5	5	5	5	5	100%
4	Paper cup	5	5	5	5	5	100%
5	Symmetric can	5	5	5	5	5	100%
6	Ergonomic mouse	5	5	1	3	5	76%

B. semiautomatic Humanoid Experiment

In this experiment the grasper is attached to a humanoid robot called “MAHRU”. While staring the semiautomatic pick and place grasping it having no prior knowledge about the object. The location of the object is identified by using a laser spot which is given by the human operator. Here the 3D location was found by using a stereo camera. The robot arm which contains the grasper was moved above the object and lowering the object downwards of the object. The arm consists of seven joints , three for the shoulder, one for the elbow, and three for the wrist. The seven joint angles of the redundant arm are determined by a humanlike arm motion generation method.

Here a total of 50 tests are conducted and we get a success rate of 86.4%. the success rate was relatively lower for the complex –shaped objects such as ergonomic mouse and cotton doll.

C) Fully Automatic Test-Bed Experiment

In the fully experiment, a test bed is designed for the experiment. In this the system has 4 DOF in (x,y,z) position and orientation (®) and is equipped with two cameras. Here the ceiling camera automatically extracts the desired 2-d position and orientation (x,y,0) and the side camera calculates the height shown in fig (9) . in this also 50 tests are conducted and we get a success rate of 95.6%.

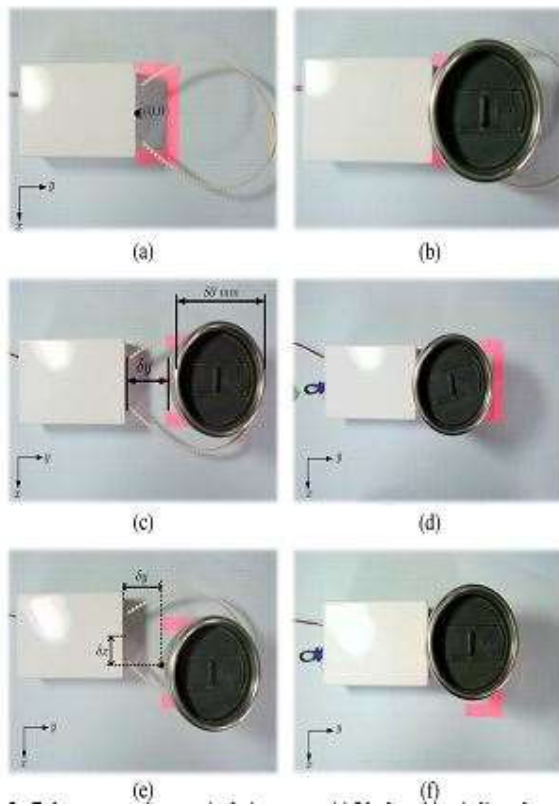


Fig.8 . Robustness against manipulation errors. (a) Ideal position indicated by the origin. (b) Ideal position with an object. (c) Manipulation error by $\delta y = 50 \text{ mm}$. (d) Grasping success for $\delta y = 50 \text{ mm}$. (e) Manipulation error

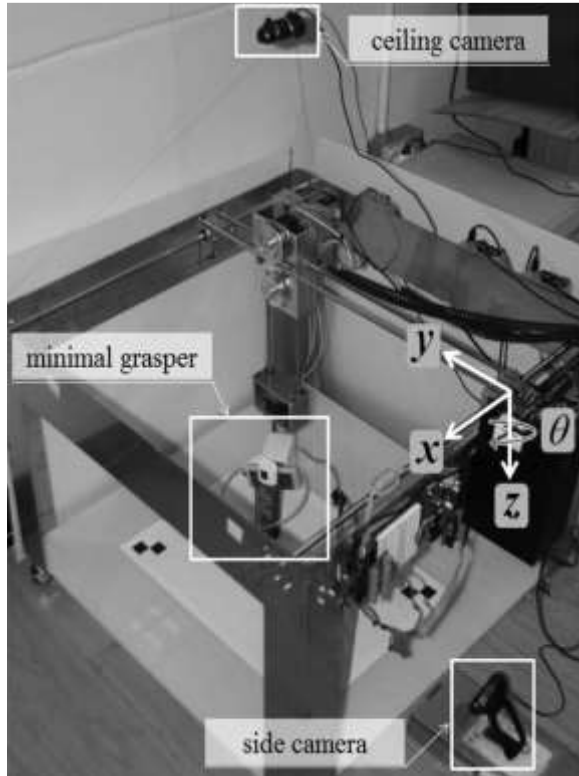


Fig. 9 . Test bed for the fully automatic experiment. This system has 4 DOF in position (x, y, z) and orientation θ . There are two vision cameras. One is on the ceiling for the extraction of the desired value in (x, y, θ) coordinate, and the other is on the side for the extraction of the desired value in z -direction.

Discussion

From the three experiments we get a overall success rate of 97.6% ,86.4% ,95.6% .The major reason of this achievement lies on its basic idea of squeezing the object using a flexible loop.Here other procedures also made contribution. For an example by planning to get the desired orientation of a headphone the grasper enable to take the envelop of the headphone because whose maximum length is larger than that of the minimal grasper. By the aid of FSR sensor the grasper successfully lifted the object. Through these extensive experiments it was found that there are two failures one is when the contact surfaces of the AGP and the object are not in parallel. Second one is the location errors of the grasper which is shown in the fig: (10).

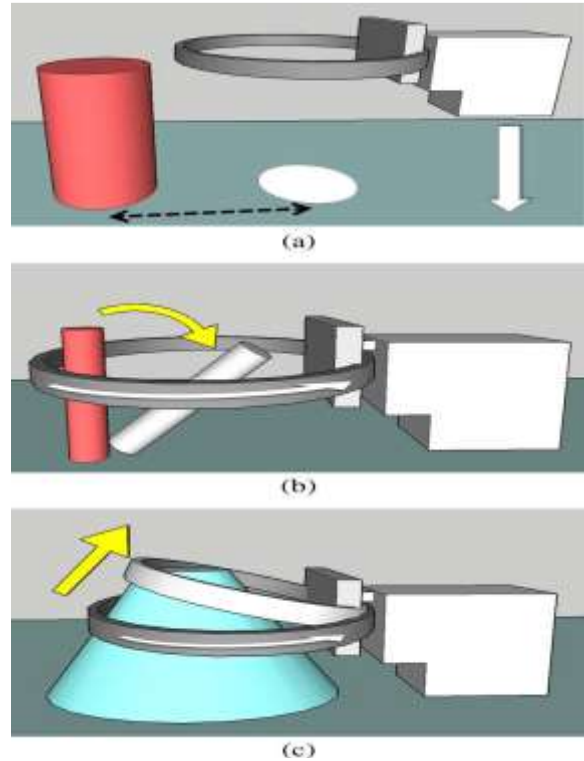


Fig. 10. Two failure cases. One is the failure induced when the contact surfaces of the AGP and the object are not in parallel as in (a). The other is the failure by significant location errors of the grasper as in (b) and (c)

Conclusion

By using this minimal grasper we can prevent current robotic hands from being commercialized and have considered the various approaches taken by many researches to overcome these difficulties. The grasper gives a success rates of 93.2% by performed in various real time objects with two features self -adaptivity and flexibility. In industrial fields every mechanical part in the proposed grasper is used. This is a advantage over other robotic hand with respect to mass production, with considerable reduction in manufacturing cost. In this it has many merits about its size, light weight and also simple hardware implementation and control algorithms at very less cost compared to the anthropomorphic robotic hands.

Further improvements will be done for the following two issues in future. First one is enhanced planning that minimize the change of the object orientation. Currently the orientation of the object is formed during the enveloping stage. The second one is the improvement in the control method by adopting a tension control scheme which can improve the success rate.

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