International Journal of
Scientific Engineering and Technology Research

ISSN 2319-8885
Vol.04,Issue.34,
August-2015,
Pages:6736-6739

www.ijsetr.com

Modified Design & Fabrication of Robotic Gripper using 3D Printing Technology

S. CHANDRA SEKHAR[1], CH. LAKSHMI SRINIVAS[2], M. VENKATESWARA RAO[3]

[1]PG Scholar, Dept of ME, Bapatla Engineering College, Bapatla, Guntur, AP, India.
[2]Assocaite Professor, Dept of ME, Bapatla Engineering College, Bapatla, Guntur, AP, India.
[3]Professor, Dept of ME, Bapatla Engineering College, Bapatla, Guntur, AP, India.

Abstract: Commercially available robotic hands are often expensive, customized for specific platforms, and difficult to modify. In this paper, we present the design of an open source, low cost, single actuator under actuated gripper that can be created through fast and commonly accessible through rapid prototyping techniques and simple off the shelf components. This project establishes the design of an adaptive, three fingered griper utilizing simple 3D printed components and readily obtainable off the self parts, modular and adjustable finger designs are provided. An under actuated finger, gear train mechanisms and an overall gripper assembly design are described in details.

Keywords: 3D Printed Component, Adjustable Finger Designs, Gear Train Mechanisms, Rapid Prototyping.

I. INTRODUCTION

Development of robotic end effectors that are employed for grasping of a variety of objects is an active research area. Various robotic end effectors were developed for wide range of applications where reproducing the human hand functionality is required. However, in most of industrial and service applications manipulation of objects with anthropomorphic robotic hands is not required and three fingered grasping devices are more sufficient. Usage of multiple actuators in each finger mechanism results in high cost of the device and control complexity. A number of designs utilize pulley/tendon driven mechanisms for wide range of robotic systems. They have many advantages such as low weight, less number of actuators and high degree of adaptability. Among disadvantages are limitations in load carrying capacity and low wear resistance. Therefore, as an alternative, mechanical linkage system are utilized for different designs of underactuated artificial fingers. There are many simple designs of commercially available grippers for grasping cylindrical and spherical shape objects. For example, a 3-fingered concentric gripper is designed for relatively high payload industrial applications, but it is not able to perform enveloping grasping.

The reconfigurable gripper with convex shape thin fingers is designed for picking round objects and placing them in a tray with little space for movement. In general, many of the commercially available hands do not accommodate extensive customization of the design features for attachment to different robotic arm platforms or integration of additional sensors for research purposes. To address such problems 3D printing rapid prototyping technology is actively applied for manufacturing of low-cost robotic hands. Aiming to provide a basic robotic platform with minimal number of 3D printed components and off-the-shelf actuator for facilitating robotic research efforts, a 3D printed open source tendon driven hand is proposed. In this paper the authors utilize a linkage based finger system and present an open source 3D printed underactuated three fingered robotic gripper with a simple design and relatively higher payload property comparing to similar size tendon driven mechanisms. The 3D model of the gripper is created using the SolidWorks CAD software. Robotic hands often fall onto two categories: simple and highly specialized grippers often used in manufacturing, and general and highly complicated grippers designed for a variety of tasks.

II. LITERATURE REVIEW

Robot end effectors are generally classified as any device attached to a robotic system that is used to physically interact with the robot ’ s environment. Some propose a further classification into two general groupings: robotic hands and robotic grippers. Hands are said to be designed with the intent of being anthropomorphic and fully actuated and as a result are typically more complex. Grippers, on the other hand, tend to be simpler, more utilitarian and tend to take the shape of whatever the design requires. Another method of differentiating is to compare the number of actuators, n_{act}, an end effector contains to its number of DOF, n_{DOF}.

- If $n_{DOF} = n_{act}$ the end effector is said to be fully actuated,
- If $n_{DOF} > n_{act}$, it is said to be underactuated.

Commercially available robotic hands are often expensive, customized for specific platforms, and difficult to modify. an open source, low cost, single actuator under actuated gripper that can be created through fast and commonly accessible through rapid prototyping techniques and simple off the shelf components. In this paper the authors utilize a linkage based finger system and present an open source 3D printed underactuated three fingered robotic gripper with a simple design and relatively higher payload property comparing to similar size tendon driven mechanisms. The 3D model of the gripper is created using the SolidWorks CAD software.

III. DESIGN AND FABRICATION OF 3D PRINTEDTHREE FINGERED ROBOTIC GRIPPER

A. Under actuated Finger Mechanism

Under actuated fingers have less number of actuators than total DOFs and are widely utilized in design of various. Robotic hands for industrial and service robotics. This is largely attributed to the relatively simple design of such mechanisms comparing with fully actuated dexterous artificial fingers. At the same time, an underactuated finger mechanism should ensure close wrapping of different shape objects due. to its adaptive grasping capability with one DOF actuation. In this work, the underactuated linkage mechanism is employed for finger design described in This design ensures a simple low-cost mechanical system which was one of the principles for finger design requirements Consider a 2-DOF and one degree-of-actuation (1-DOA) finger mechanism shown in Fig.1.

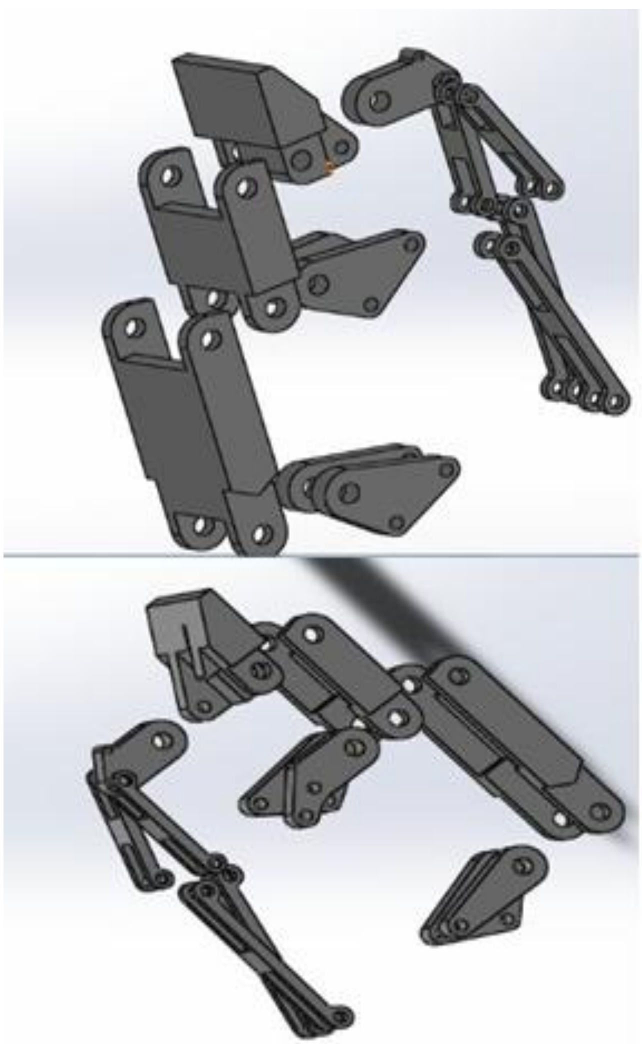

Fig.1. exploded views of finger.

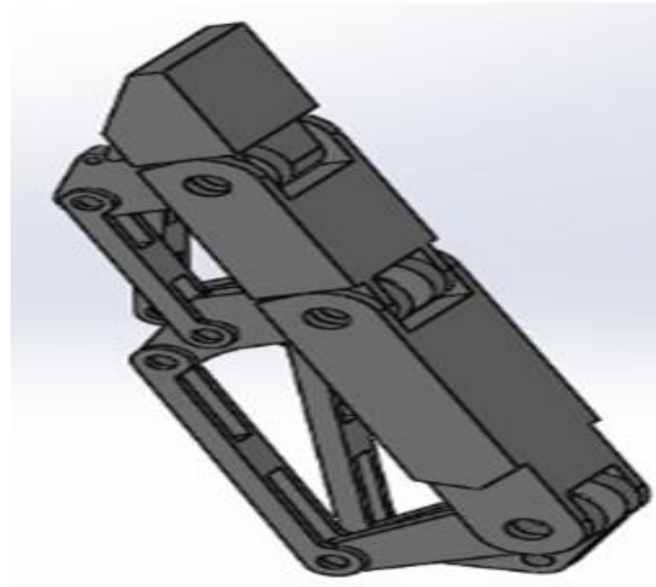

Fig.2. Assembled view of finger.

The first four bar link is providing actuation of the first DOF and second four bar link is for second degree of freedom of the finger. the closing sequence of the under actuated finger is described as follows, Firstly the finger moves as a rigid body from its initial position since no initial force is acting on it. When the first phalanx of the finger is in contact with an object, the second phalanx starts movement around a pivot point, and the third phalanx starts movement around a pivot point to complete a full wrapping. Same method can be applied to n-phalanx fingers. Utilizing this principle, an under actuated finger mechanism is designed and presented in Fig. 2. The finger consists of three phalanges, nine links and a worm wheel. Note that the worm wheel and link 1 are rigidly connected The worm wheel transmits rotary motion to link 1 around its pivot point; subsequently link 1 transfers the motion to link 2and link3 The second five links allows the finger to behave as a single rigid body during rotary motion around the fixed pivot.

When the first phalanx touches an object, the force produced by an actuator moves the five links which starts transferring motion to the second phalanx similarly the motion is transferring to the third phalanx. Finally, all the phalanges contact an object that concludes a finger closing sequence. Grasping characteristics of the gripper can be modified by setting various geometries of three actuation links of the fingers. For instance, changing the length of two actuation links of the finger can result in various dynamic outputs of the first and second phalanges. The surfaces of the finger components are flat so that the printer support material can be removed manually with little effort. All rotational joints of the finger are connected via pivots with retaining rings at both sides, as shown in Fig.2. The pivot 3D models are supplied with the gripper CAD model and can be used for manufacturing metal pivots using standard machine shop facilities.

B. The Gear Train Design

The three fingers in the gripper are actuated by a single actuator using a gear train transmission system. A servo actuator is fixed on the base and drives the directly connected worm gear. The worm transfers rotational to the set of worm wheels, which are connected to each finger. All three fingers are driven simultaneously from their initial position. Usage of the worm gear ensures non backdriveability of the finger actuation mechanism. The set of worm wheels are placed in a way that allows adjustment of the rotational speed and torque transferred to a finger.

C. Three Fingered Robotic Gripper

The three fingered robotic gripper consists of the three 2-DOFs underactuated fingers, a base, a palm, a gear train set and an actuator. The fingers are attached in a circular way with 120 degrees between each other. This allows the worm wheels of the fingers to be driven from a single actuator via the actuating worm as illustrated in Fig. 3. This type of layout of the fingers is preferable for grasping spherical or cylindrical objects of different sizes. The prototype is manufactured using 3D printing technology with ABS plastic and rubber materials. ABS is a strong, durable production grade thermoplastic used across many industries, and it is an ideal material for conceptual prototyping. An additional off-the-shelf component, a servomotor, is used as an actuator for robotic gripper prototype that eliminates necessary for complex electronic circuits and encoders for motor position control.

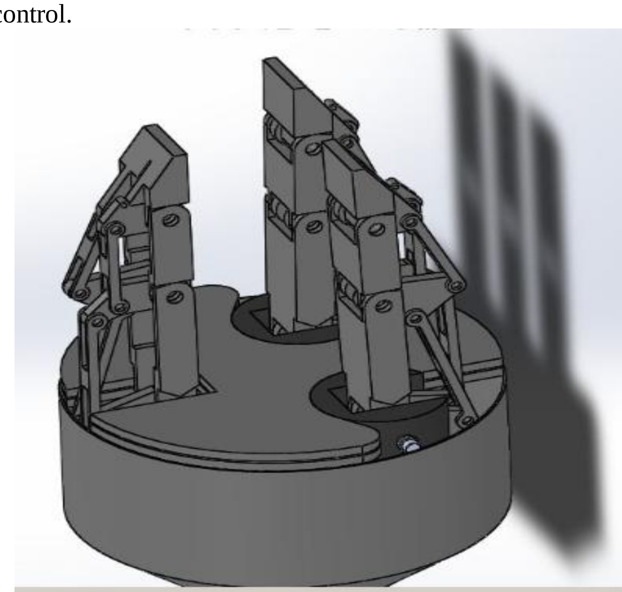

Fig.3. three fingered robotic gripper.

IV. CONCLUSION

This paper presents authors design of an open source 3D printed under actuated robotic gripper. The gripper design model and an experimental prototype are introduced and discussed in detail. It is shown that the presented robotic gripper with one actuator meets design objectives in terms of:

- A simple mechanical structure of the gripper due to usage of a four-bar linkage mechanical system for finger design and a single actuation;
- A low cost due to utilizing of a single off-the-shelf actuator and 3D printing technologies;
- Relatively high payload comparable with similar size tendon driven robotic end effectors.

The 3D model of the gripper is created using the SolidWorks CAD software, the open source gripper design aims to overcome constraint of the rigid, closed designs of existing robotic hands. The simple three fingered robotic gripper design released open-source for public use would allow researchers modifying the design for both research and educational purposes. Future work includes design and implementation of the presented end effectors prototype with embedded sensing elements such as tactile sensors for force feedback capabilities and a depth camera for object recognition to facilitate research on autonomous grasping of different shape objects. The gripper prototype will also be mounted on an industrial robot manipulator for evaluating grasping performance in real-life scenarios.

V. REFERENCES

[1] A.M. Dollar, R. Howe, “The Highly Adaptive SDM Hand: Design and Performance Evaluation,” International Journal of Robotics Research, 29 (5), pp. 585-597, 2010.

[2] L. Birglen, C. Gosselin, T. Laliberte, Under actuated Robotic Hands. Springer Tracts in Advanced Robotics, 2008.

[3]J. Won, K. DeLaurentis, C. Mavroidis, “Rapid Prototyping of Robotic Systems,” Proc. of Intern. Conf. on Robotics and Automation, San Francisco, CA, 2000.

[4] Z. Xu, E. Todorov, B. Dellon, Y. Matsuoka, “Design and analysis of an artificial finger joint for anthropomorphic robotic hands,” Proc. Intern. Conf. on Robotics and Automation, Shanghai, China, 2011.

[5] A.M. Dollar, R. Howe, “A Robust Compliant Grasper via Shape Deposition Manufacturing,” IEEE/ASME Transactions on Mechatronics, 11 (2), pp. 154-161, 2006.

[6] Townsend, W., “The BarrettHand grasper - programmably flexible part handling and assembly,” Industrial Robot: An International Journal, 27 (3), 2000, pp. 181-88.

[7] Ottobock, “Electric Greifer,” 2011. [Online]. Available: http://www.ottobock.com/cps/rde/xchg/ob_com_en/hs.xsl/3359.html.

[8] K. Wyrobek, E. Berger, H. der Loos, and J. Salisbury, “Towards a personal robotics development platform: Rationale and design of an intrinsically safe personal robot,” in Proc. IEEE Int. Conf. on Robotics and Automation, 2008, pp. 2165-2170.

[9] Robotiq, “Two-Finger Adaptive Robot Gripper,” 2011. [Online]. Available: robotiq.com/media/Robotiq-2-Finger-Adaptive-Gripper- Specifications.pdf.

[10] Rubinger, B. et al., “Self-Adapting Robotic Auxiliary Hand (SARAH) for SPDM Operations on the International Space Station,” Proc. I-SAIRAS, Quebec, Canada, 2001.

[11] Meka, “H2 Compliant Hand,” 2011. [Online]. http://mekabot.com/products/compliant-hand/

[12] Meka, “G2 Compliant Gripper,” 2011. [Online]. Available: http://mekabot.com/products/compliant-gripper/

[13] Schunk, “Schunk SDH Hand,” [Online], http://www.schunk-modularrobotics.com/

[14] L. Birglen, C. Gosselin, “Force Analysis of Connected Differential Mechanisms: Application to Grasping,” International Journal of Robotics Research, 25 (10), pp. 1033-1046, 2006.

[15] Gosselin, Clement, Frederic Pelletier, and Thierry Laliberte. "An anthropomorphic underactuated robotic hand with 15 Dofs and a single actuator." Robotics and

Automation, 2008. ICRA 2008. IEEE International Conference on. IEEE, 2008.

[16] Robotis, “Dynamixel RS-28,” 2012. [Online]. Available: http://support.robotis.com/en/product/dynamixel/rx_series/rx-28.htm

[17] L.U. Odhner, R. Ma, A.M. Dollar, “Precision Grasping and Manipulation of Small Objects from Flat Surfaces Using Underactuated Fingers,” Proc. of Intern. Conf. on Robotics and Automation, Minneapolis, MN, 2012.

[18] M. Quigley, A. Asbeck, A. Ng, “A Low-cost Compliant 7-DOF Robotic Manipulator,” Proc. of Intern. Conf. on Robotics and Automation, Shanghai, China, 2011.

[19] Laliberte, Thierry, Clement M. Gosselin, and Gabriel Cote. "Practical prototyping." Robotics & Automation Magazine, IEEE 8.3 (2001): 43-52.

[20] Stratasys, “uPrint SE,” 2012. [Online]. Available:http://www.uprint3dprinting.com/uprint-affordable-3d-printer/

[21] Odhner, L.U., Ma, R.R., and Dollar, A.M., “Open-Loop Precision Grasping with Under actuated Hands Inspired by a Human Manipulation Strategy,” IEEE Transactions on Automation Science and Engineering, 2013 (in press)

[22] Bruno Siciliano and Oussama Khatib. Handbook of Robotics, chapter 1 Introduction, pages 1–4. Springer, 2008.

[23] Antonio Bicchi and Vijay Kumar. Robotic grasping and contanct: A review. In IEEE International Conference on Robotics and Automation, volume 1, pages 348–353, 2000.

[24] H. Asada. Studies on prehension and handling by robot hands with elastic fingers. Ph.d. dissertation, Kyoto University, Kyoto, Japan, Apr 1979.

[25] Mason M.T and Salisbury J.K. Jr. Robot hands and the mechanics of manipulation. The MIT Press, Cambridge, MA, USA, 1985.

[26] Jeffrey Coates Trinkle. The Mechanics and Panning of Enveloping Grasps. a dissertation, University of Pennsylvania, Jan 1987.

[27] Makoto Kaneko, Yutaka Hino, and Toshio Tsuji. On three phases for achieving enveloping grasps - inspired by human grasping. In IEEE International Conference on Robotics and Automation, pages 385–390, 1997.

[28] Van-Duc Nguyen. Constructing force-closure grasps. In IEEE International Conference on Robotics and Automation., volume 3, pages 1368–1373, 1986.

[29] Yun-Hui Liu. Computing n-finger form-closure grasps on polygonal objects. The International Journal of Robotics Research, 19(2):149–158, Feb 2000.

[30] Kensuke Harada and Makoto Kaneko. Enveloping grasp for multiple obj’ects. In International Conference on Robotics & Automation, volume 3, pages 2409 – 2415, 1998.

[31] Farzad Cheraghpour, S. Ali A. Moosavian, and Ali Nahvi. Multiple aspect grasp performance index for cooperative object manipulation tasks. In International Conference on Advanced Intelligent Mechatronics, pages 386 – 391, 2009.

[32] Robotiq inc. Robotiq adaptive gripper instruction manual, 111031 edition, 2011.

[33] Implementing the singleton pattern in c#, http://csharpindepth.com/articles/general/singleton.aspx,Retrieved 21.08.2012.

[34] Daniel Robbins. Posix threads explained, http://www.ibm.com/developerworks/linux/library/l-osix1/index.html, Retrieved 21.08.2012. 32

[35] Max Felser. Real-time ethernet - industry prospective. PROCEEDINGS OF THE IEEE, 93(6):1118–1129, June 2005.

[36] libmodbus, http://libmodbus.org, Retrieved 19.08.2012.

Author’s Profile:

S. Chandra Sekhar received his b. tech degree. he is currently working towards m. tech degree in the department of mechanical engineering in bapatla engineering college. His research interest in CAD/CAM.

Mr.Ch.Lakshmi Srinivas, M.tech., (Ph.D**).** he is currently working as Associate Professor in the Department of Mechanical Engineering.

Dr. M. Venkateswara Rao, M.tech., Ph.D, he is currently working as Professor and Head of The Department of Mechanical Engineering.