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# Robotic End of Arm Tooling for Handling and Assembly Operation

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***Abstract***

*Robotics and Automation, the art of remote controlling machines have been a subject of research since the early 1900's. But the studies based on automated machines have witnessed booming growth and appreciating the support from MNCs, due to the resources available and the advancement in today's hardware system, enforcing a cutting-edge technology in industries. This research field has made the multi-cultural approach of mechanical and electronics & telecommunication possible. The upcoming advancement in automation has gained a lot of attention in making industrial work easy. The aim and objective of this research article is to methodically study the various Robotic functions used in industrial application. This could help in developing new automated systems to completely make the controlling of the robot more interactive by providing more virtual human interface in complicated job handling and assembly.*

***Keywords:*** *End of Arm Tooling (EOAT), Electronic Control Unit (ECU),* Robot Operating System (ROS).

## 1. Introduction

A Robot is a machine coming under automation system built to help in industries and make humans to put in less effort. But we also happen to see that controlling these sophisticated machines is not easy as, well, which were in fact made to make the work of mankind better, which is again possible by again making it more interactive like the way a person in a driver seat of the car. For this to be possible, it is deeply necessary not just for electronics or mechanics, but also the software to play an important role in building a System with an interface easy to understand and control by any person. This technology can also be seen as a stepping stone for further such technologies.

Designing and manufacturing very important in the field of aesthetics and ergonomics of a robot. The application possibilities of working activity (handling, assembly, welding, etc.) of a robot are determined by its EOAT which is analogous to the human hand (R. Shah, A.B. Pandey et al, 2018). In case of the handling robots, various grippers, suction cups, etc. are used at the end effector. In all this, the crucial role of performance and success of work cell is played by the robot fingers as gripper fingers are the only medium for a robot to come in contact with the physical working model and are responsible for clamping and shifting workpieces without dropping or deforming them (M. Honarpardaz et al, 2017).

A handling and assembly robot needs to constitute all the important aspects such as simplicity of the algorithm, reduced need for maintenance, which also means low cost after one-time investment, but things such as the fast and effective identification still seems to be constituted unsolved issues. Various studies have been made regarding ergonomics and proper functioning of a robot to go hand in hand. The processing speed still fails to meet the modern manufacturing requirements, even after all the adequately efficient and accurate algorithms have been developed (J. Kodagali & S. Balaji et al, 2012). Of all this motion devices are usually controlled by the robot's control system which is also known as an electronic control unit that is supplied together with the robot. The ECU consists of an open source platform known as Robot Operating System (ROS) (FANUC Controls, Rexroth Controls, KUKA Controls) that provides a unitary environment for development of the robotic applications. It is a set of libraries, tools and drivers for a wide spectrum of devices which simplify and accelerate the development of the robotic application (Vladimir Tlach et al, 2017). One of the options of effectors and other robotic subsystems controlling through the platform ROS is to apply an interface in I/O boards form such as the Arduino, Raspberry Pi, Odroid, etc. The Arduino boards are powered by Atmel microcontrollers. The communication between I/O boards and PC is realized through the UART protocol.

The problem becomes complicated owning to the objects' factor such as material, shape, colour, and some other properties pertaining to a specific object. Moreover, the expectations or requirements of the end user regarding cost and its simplicity are also directly connected to the rate of production, which is indubitability expected to be increased with the introduction of robotic equipment in advanced production setups (P. Tsarouchi et al, 2016). This is where sensors come into play, multi-sensors interfaced with robots allow the EOAT to successfully perform and complete any specified handling or assembly task in stipulated work space with desired position and orientation. Part assemblies are one of the most time-consuming activities in the line of production of manufacturing and automation (Om Prakash Sahu et al, 2014). In assembly ECU makes sure whether the previous sent command is performed and whether the next function or process is to be carried out by the robot with the help of the feedback given by the sensors mounted on different working stations and EOAT as well.

This Paper is organized as follows:

Phase 2 talks about designing the EOAT with its fingers. Phase 3 talks about ECU and the Platform for programming Phase 4 later comes the Sensors giving the feedbacks. Phase 5 discusses about the concept of adding human interaction to the robot and its schematic working representation. Phase 6 finally tells the Conclusion of this research paper.

## 2. Study and Design of EOAT with its Fingers

2.1 ARM: The design of Arm is based on the type of joints and their degree of freedom of the arm. Various types of Arm design are as follows:

- Cartesian robot
- Cylindrical robot
- Spherical robot
- Articulated robot
- SCARA (Selective Compliance Assembly Robotic Arm)
- Anthropomorphic robot

2.2 BASE FRAME:

Base Frame is an integral part of the EOAT which also plays an important role of holding the grippers and fingers. The frame is directly connected with the robotic arm's end, and the grippers with its fingers are mounted on the frame. Frame indirectly acts as an intermediate part which mainly does the part of supporting the grippers, but apart from this frame should also give a provision to let through the electronic and pneumatic controls to the grippers for their function. It is to be kept in mind that the frame should as light as possible, but strong enough to hold the grippers.

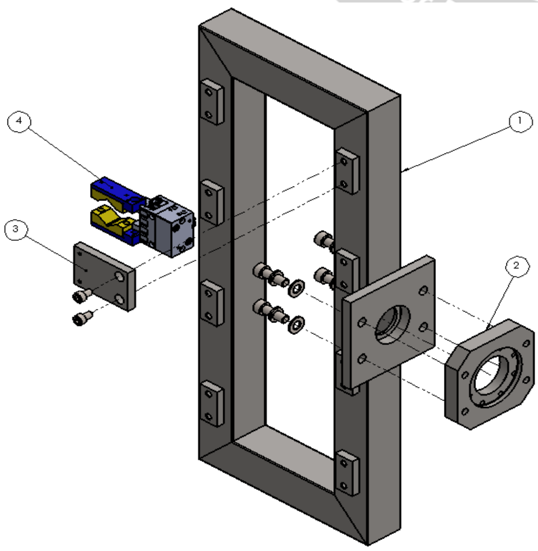


**Fig.1** Base Frame with Gripper and it's Mounting system

**Table 1** Experimental procedure parameters

| Balloon No. | Particulars | Description |
|---|---|---|
| 1 | Base Frame | To help holding the grippers in an arranged manner and give provisions of the pneumatics |
| 2 | Robot Arm End Connector | A sandwich plate on the robotic arm end to connect to the frame |
| 3 | Mounting Plate | To mount the gripper to the base frame with the help of a plate |
| 4 | Gripper (SCHUNK) | Procured from store and is available in different models |

2.3 GRIPPER:

A gripper which acts as an end effector of a robot arm, does the work of human hand, which allows one to pick and place the workpiece or job. Areas where hazardous tasks such as space high-temperature welding, defusing bombs, handling radioactive materials, exploration, mines and exploring shipwrecks, and other such human life endangering tasks are taken care of by the grippers (Rituparna Datta et al). Accordingly, the force to be applied to the component or the object to hold also matters. It is important for the gripper to exert enough gripping force in order to grasp the object, but sometimes it also necessary to keep it low as to the object is not damaged (plastic material). Sufficient amount of research on this particular subject has been done.

2.3.1 CONCEPTUAL DESIGN OF THE GRIPPER

- It should be able to grasp and hold objects of varied shape and size.
- It should accommodate different loads and loading systems.
- There should be stability during handling and assembling process.
- Synchronization is very important when it comes to simultaneous finger motion.
- Employment of minimum number of actuators.
- It should provide an interlocking, for the workpiece to not slip or fall.
- It should simulate the human hand.
- It should be precisely controlled (through computer or manually).
- It should be lightweight.
- It should be easily fabricated with readily available resources.
- It should be of low cost.

2.3.2 DESIGN OF THE GRIPPER

To hold any object at least three points are required. In this work, a three-fingered gripper each with two limbs have been designed and fabricated to hold irregular objects as this can be used for both force and form closure purpose. Single limb gripping is never possible and hence the presence of the second limb will

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augment the friction force and will assist in securely gripping the work-piece.

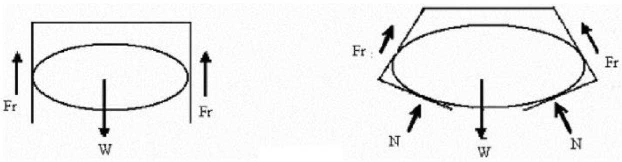


**Fig.2** (a) Fingers with single limb (b) Fingers With two limbs
(Ashish Singh, Guwahati)

The grippers are again classified on the basis of:

2.3.3 On the Basis of no. of Jaws

A) 2 Jaw Gripper: Usually used when the shape of the specimen is more like a rectangle or any parallel shaped object.

B) 3Jaw gripper: 3 Jaw gripper is used for holding a circular object as it is difficult for a 2 Jaw grip to hold it and also there might be a tendency of slipping.

2.3.4 Actuating Medium

A) Electronics Controlled: In order to expand and contract the gripper finger, electronic drive such as servo motor is used in this kind of gripping system. Assuming a constant actuating force, P and the manipulator displacement, Z vary independently of P. The assumed force delivered by the actuator is proportional to the voltage applied across it and the actuator-stiffness. In most of the cases spring of a certain stiffness is used to maintain a minimum grasping force, so the electronic drive has to only overcome the spring force while expanding the gripper fingers. The relationship between the force delivered to the current supplied is given in the equation below:

$$\boldsymbol{P = \frac{k\ x\ B\ x\ L\ x\ V\ x\ N}{R}}$$

Here $k$ is a constant, $B$ is the strength of the magnetic field, $L$ is the length of the coil, $N$ is the no. conductors, and $V$ is the current flowing through the coil.

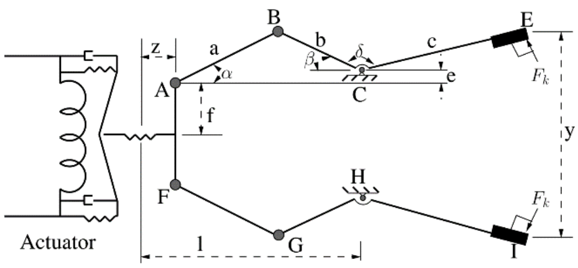


**Fig.4** Sketch of gripper links and mechanism
(Rituparna Datta et al, 2015)

B) Pneumatic Controlled: Air pressurized at 6 Bar-pressure is used in the gripping control. When compressed air from the regulator is entered into the cylinder pushes the piston and thus the piston rods undergoes a power-stroke to outwards which increases the distance between the gripper surfaces. Pneumatically controlled grippers may sometimes consist of spring in case the pneumatic system fails. The spring helps in pushing the surface outwards. On the other hand two way grippers are used to get the exact stroke length required by maintaining the pressure as per the gripping force which is required.

2.4 FINGERS:

Fingers are the components that are in direct contact with object, fingers in some cases may the integrated part of the gripper. The variables like length, diameter, width, strength, etc. must be properly, accurately calculated to provide efficient data for the purpose of serving the needy.

2.4.1 Designing phase

This phase includes the following steps:

1. Designing experiments that conclude the defined response parameter.
2. Selecting the most appropriate designs for experiments.
3. Defining a design database which contains a list of equipment, settings, order of running, etc.
4. Determining the principle of replication or iterations of the experiment. Iterations of the experiment may eliminate certain deviations in the data that are caused by external parameters. By performing iterations, deviations in the data that are caused by external parameters may be eliminated and a statistical verification is achieved.

2.4.2 Conclude and Analyze

After the experiments, the results are gathered. Costa et al recommends documenting a test plan initially in order to prepare for every essential step in actual experiments. Antony mentions several significant considerations prior executing an experiment, such as availability of material, environmental conditions, etc.

The later part is analyzing and interpreting the results so a valid correct conclusion may be made.

Grasp Stability verification:

(M. Honarpardaz et al, 2017) conducted two experiments (i.e. Force and torque), which are intended to measure the stability of three different sets of designing fingers. Each set of fingers is examined with X, Y and Z direction to measure the stability of the fingers in the three-dimensional space.

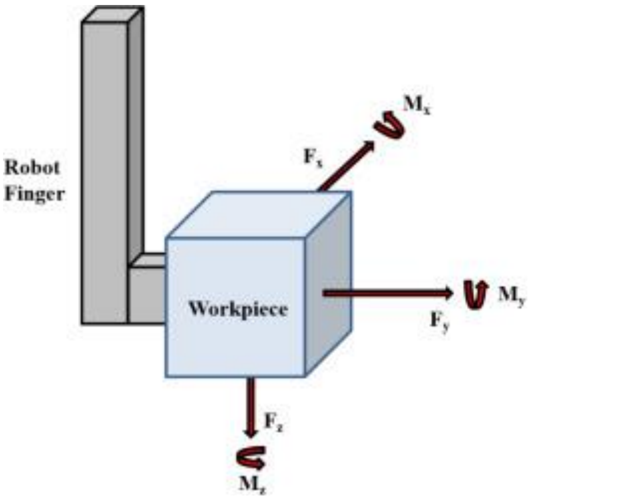


**Fig.4** Schematic diagram of the reference coordinates system

(M. Honarpardaz et al, 2017)

## 3. ECU with its Robot Operating System

3.1 Electronic Control Unit:

It is a hardware containing a microcontroller like Arduino, Raspberry Pi or Odroid, etc. on which we can install ROS on it. The control unit for robots is commonly known as the Teach Pendant, which is a handheld robot control terminal that provides a convenient means to move the robot, teach locations, and run robot programs.

Many of the pendant keys are multi-purpose, invoking their labeled functions only from certain screens. When the key's labeled function is not activated, the alphanumeric value of the key is assumed.

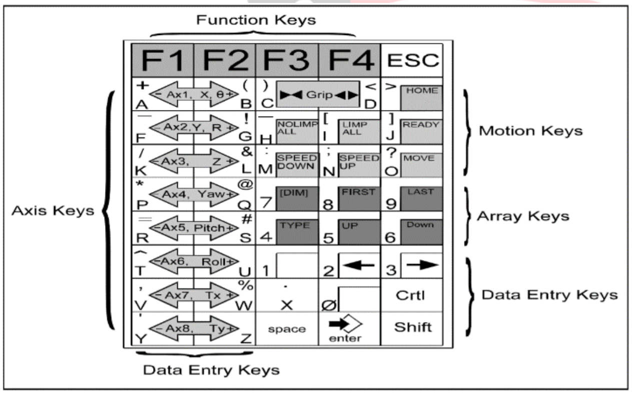


**Fig.5** Teach Pendant Interface

(Teach pendant manual)

Teach Pendant consists of Various types of keys like:

1. Function Keys'
2. Axis Keys
3. Motion Keys
4. Array Keys
5. Data Entry Keys

3.2 Robot Operating System:

The Teach Pendant requires an operating system to run and give in the interface for controlling a robot, for which a ROS is used. In a standard ROS application several calculating operations are always running simultaneously. A user can develop his/her own application consisting of a particular set of functions and they can use the formulae already created within the research activities of other research institutes. This is the benefit of using an open - source platform because by this way it achieves a reduction of a developmental time. Many of the top robot companies prefer having their own operating software with their own interface and also create their own libraries and Robo-guides.

## 4. Sensors

Sensor- improved 'intelligent' system is the state-of-the-art of present day robotics research study. The primary objective of the sensor is to detect the presence of any object.

## 5. Easy controlling of robot arm

5.1 Background:

As of now, we have observed and understand some of the advancement in robot technology. A small survey carried out in December 2017 in the industries in Belgaum (India) and Pune (India), showed that most of the industrial labours are losing their job with the arrival of automation in industries. The competition in the market has made engineer to come up with smart working rather than hard-working. To satisfy and attract customers the use of Mechatronics in manufacturing industry and in the product is predictability for entrepreneurs. As a contribution to the society, this paper is being written. The main idea of a robot is to make the work easy which it is doing very well, but understanding how to operate is not that easy for any person unless the instruction is received the manufacturers.

5.2 Discussion:

The proposed study combined the advantages of new and compact automation system. Currently, some minor issues such as controlling of EOAT by mean of the computer is a bit tedious. The proposed method can help in applications where the robot working is not in a loop and gives ease of controlling and skill required is also not high. Additionally, it is quite flexible and allows to handle random objects in the working area.

5.3 Methodology:

In this method, we are going to control the EOAT with our own hand like virtual reality play (master-slave control). Considering a Schunk SVH 5-finger hand as our EOAT mounted on the robot, which acts analogous to human hand, can be perfect to perform all the tasks a human can do. These robots can operate under the situation where a human cannot, like in nuclear power-plant, bomb diffusing, and hazardous areas, sewage cleaning, etc. Controlling this arm can be done by computer, but to make it feel more real to control, we have proposed a Robo-generous glove consisting flex sensors on its finger and a gyroscopic sensor on the wrist. As the fingers bend or our wrist is rotated, these sensors transmit analogous signals to the ECU (Arduino). The magnitude of the signals received by the ECU is converted to voltage, which is taken care by the ECU. The signals are then sent to the EOAT electrical drives (servo motor) placed in it. The magnitude of the angle to be rotated is directly proportional to the value sent by the flex sensors and a gyroscopic sensor on the glove. Additionally, we can also have camera and other detection sensors like load cell at the EOAT to give more a real feel with Virtual-Reality setup and vibrating feedback and user-end. Further, many other developments over this concept can achieve such virtual fell and the ambient temperature if required in and particular application.

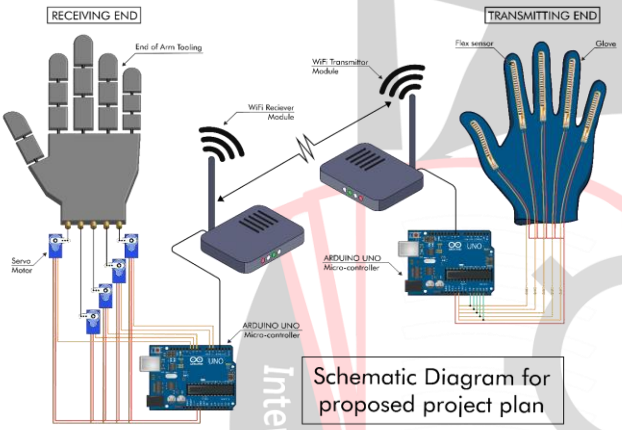


**Fig.6** Schematic Diagram of Transmitting and Receiving End

**Conclusions:**

The main objective of this work is to propose a more realistic approach to control the EOAT of a robot. This approach has contributed towards the progress already made in manufacturing automation and aims to enhance further of robotic systems. It attempts to imitate human behavior for manipulation. The main intention of writing this research article is to utilize such kind of technology where tedious tasks take place but still ensures the safety of the human.

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