End effector & sensors

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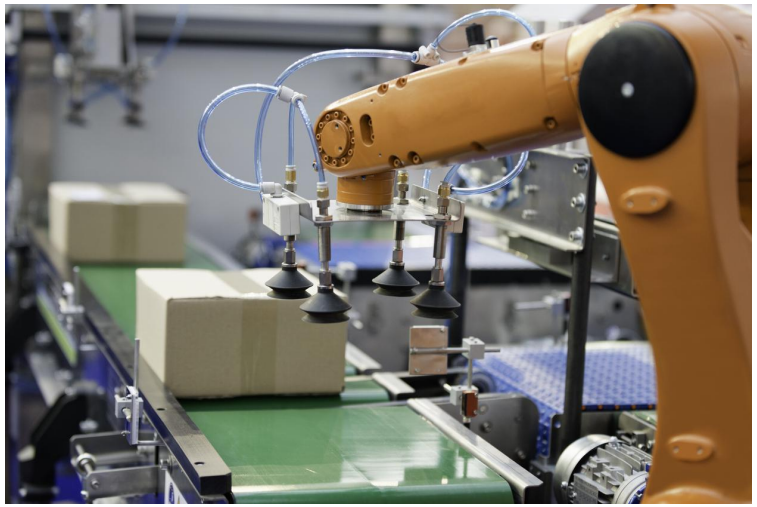
Overview

- End effector
- Classification
  - mechanical
  - magnetic
  - Vacuum
  - Adhesive gripper
- Grip force design and analysis
- Sensors
  - Types of sesnors
- Contact , position & Displacement sensors
- Proximity & Range sensors
- Force & torque sensors
- acoustic sensors



End effectors

Device that attaches to the wrist of the robot arm and enables the general-purpose robot to perform a specific task.

Two types:

Grippers – to grasp and manipulate objects (e.g., parts) during work cycle

Tools – to perform a process, e.g., spot welding, spray painting

Classifications of Grippers

- Mechanical
- magnetic
- Vacuum
- Adhesive

Mechanical gripper

- We can think of a mechanical gripper as a robot hand. A basic robot hand will have only two or three fingers
- A mechanical hand that wraps around an object will rely on friction in order to secure the object it is holding.
- Friction between the gripper and the object will depend on two things, First is the type of surface whether it be metal on metal, rubber on metal, smooth surfaces or rough surfaces and the second is the force which is pressing the surfaces together.
- Mechanical grippers are often fitted with some type of pad usually made from polyurethane as this provides greater friction. Pads are less likely to damage the work piece. Pads are also used so to have a better grip as the polyurethane will make contact with all parts of the surface when the gripper is closed

Magnetic gripper

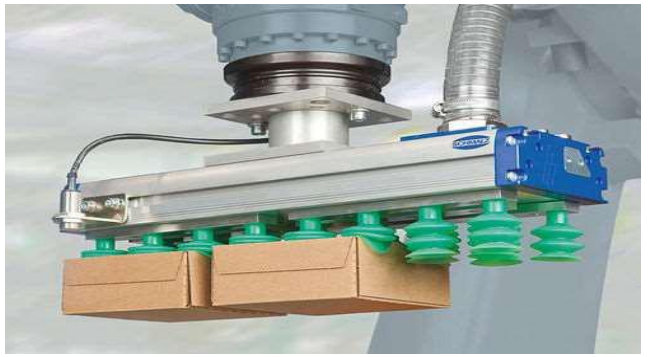
- Magnetic grippers obviously only work on magnetic objects and therefore are limited in working with certain metals.
- For maximum effect the magnet needs to have complete contact with the surface of the metal to be gripped. Any air gaps will reduce the strength of the magnetic force, therefore flat sheets of metal are best suited to magnetic grippers.
- If the magnet is strong enough, a magnetic gripper can pick up an irregular shaped object. In some cases the shape of the magnet matches the shape of the object
- A disadvantage of using magnetic grippers is the temperature. Permanent magnets tend to become demagnetized when heated and so there is the danger that prolonged contact with a hot work piece will weaken them to the point where they can no longer be used. The effect of heat will depend on the time the magnet spends in contact with the hot part. Most magnetic materials are relatively unaffected by temperatures up to around 100 degrees.

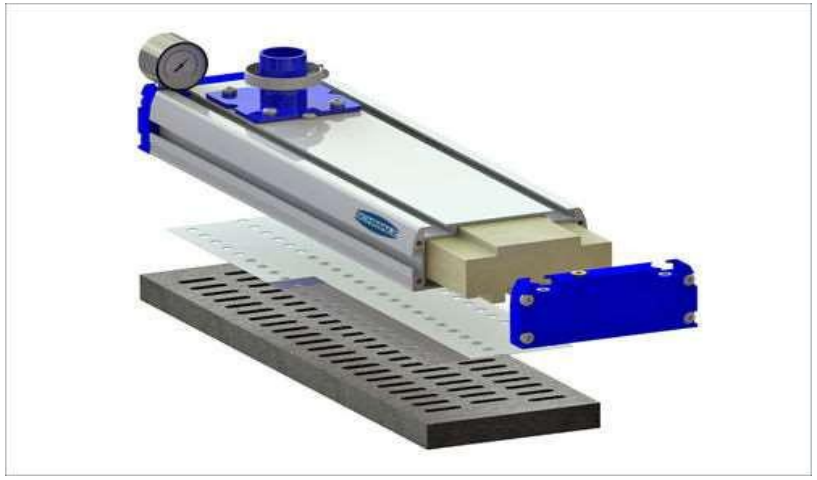
Vacuum gripper

There are two types of suction grippers:

1. Devices operated by a vacuum – the vacuum may be provided by a vacuum pump or by compressed air
2. Devices with a flexible suction cup – this cup presses on the work piece. Compressed air is blown into the suction cup to release the work piece. The advantage of the suction cup is that if there is a power failure it will still work as the work piece will not fall down. The disadvantage of the suction cup is that they only work on clean, smooth surfaces.

   There are many more advantages for using a suction cup rather than a mechanical grip including: there is no danger of crushing fragile objects, the exact shape and size does not matter and the suction cup does not have to be precisely positioned on the object





Adhesive gripper

Adhesive Substance can be used for grasping action in adhesive grippers.

In adhesive grippers, the adhesive substance losses its tackiness due to repeated usage. This reduces the reliability of the gripper. In order to overcome this difficulty, the adhesive material is continuously fed to the gripper in the form of ribbon by feeding mechanism.

A major asset of the adhesive gripper is the fact that it is simple. As long as the adhesive keep its stickiness it will continue to function without maintenance, however, there are certain limitations, the most significant is the fact that the adhesive cannot readily be disabled in order to release the grasp on an object. Some other means, such as devices that lock the gripped object into place, must be used.

Grip Force analysis and Design

- **In a mechanical gripper, the holding of an object can be done by two different methods such as:**

1) Using the finger pads as like the shape of the work part.
2) Using soft material finger pads.

In the first method, the contact surfaces of the fingers are designed according to the work part for achieving the *estimated shape*. It will help the fingers to hold the work part for some extent.

In the second method, the fingers must be capable of supplying sufficient force to hold the work part. To avoid scratches on the work part, *soft type pads* are fabricated on the fingers. As a result, the contact surface of the finger and co – efficient of friction are improved. This method is very simple and as well as *less expensive*. It may cause slippage if the force applied against the work part is in the parallel direction. The slippage can be avoided by designing the gripper based on the force exerted.

$$\mu\, n_f F_g = w \qquad \ldots\ldots\ldots\ldots\ldots\ldots \qquad 1$$

Grip Force analysis and Design

μ => co – efficient of friction between the work part and fingers n_f => no. of fingers contacting
F_g => Force of the gripper
w => weight of the grasped object

The equation 1 must be *changed* if the weight of a work part is more than the force applied to cause the slippage.

$$\mu\, n_f F_g = w\, g \qquad \text{..... 2}$$

g => g factor

During rapid grasping operation, the work part will get *twice* the weight. To get rid out of it, the modified equation 1 is put forward by *Engel Berger*. The g factor in the equation 2 is used to calculate the acceleration and gravity.

The *values of g factor* for several operations are given below:

g = 1 – acceleration supplied in the opposite direction. g = 2 – acceleration supplied in the horizontal direction.
g = 3 – acceleration and gravity supplied in the same direction.

Sensors & Transducers

• Sensor is a device that produces an output signal for the purpose of sensing of a physical phenomenon

• This signal must be produced by some type of energy, such as heat, light, motion, or chemical reaction.

Sensor:

– converts a physical parameter to an electrical output (a type of transducer, e.g. a microphone)

Transducer:

– a device that converts energy from one form to another

Actuator:

• converts an electrical signal to a physical output (opposite of a sensor, e.g. a speaker)

Types of Sensors

- Classification of Sensors

1. Active and Passive Sensors
2. Analog and Digital Sensors

- The sensors are also classified into the following criteria:

1. Primary Input quantity (Measurand)
2. Transduction principles (Using physical and chemical effects)
3. Material and Technology
4. Property
5. Application

Types of Sensors

- **Active Sensors**: The type of sensors that produces output signal without the help of external excitation supply. The own physical properties of the sensor vary with respect to the applied external effect. Therefore, it is also called as Self Generating Sensors. Any sensor which requires to input energy to the environment in order to retrieve the measurement is active.
- Examples: Photovoltaic cells, Thermocouples, Piezoelectric device.

- **Passive Sensors**: The type of sensors that produces output signal with the help of external excitation supply. They need any extra stimulus or voltage. Sensors are able to retrieve a measurement without actively interacting with the environment.
- Example: Strain Gauge, Magnetometer, Barometer.

Types of Sensors

- **Analog Sensors**: The sensor that produces continuous signal with respect to time with analog output is called as Analog sensors. The analog output generated is proportional to the measured or the input given to the system. Generally, analog voltage in the range of 0 to 5 V or current is produced as the output. The various physical parameters like temperature, stress, pressure, displacement, etc. are examples for continuous signals.

- **Digital Sensors**: When data is converted and transmitted digitally, it is called as Digital sensors. Digital sensors produce discrete output signals. Discrete signals will be non- continuous with time and it can be represented in “bits” for serial transmission and in “bytes” for parallel transmission. Digital output can be in form of Logic 1 or Logic 0 (ON or OFF). A digital sensor consists of sensor, cable and a transmitter. The measured signal is converted into a digital signal inside the sensor itself without any external component. Cable is used for long distance transmission.

List of sensors

- Light Sensor
  1. IR Sensor (IR Transmitter / IR LED)
  2. Photodiode (IR Receiver)
  3. Light Dependent Resistor
- Temperature Sensor
  1. Thermistor
  2. Thermocouple
- Pressure/Force/Weight Sensor
  1. Strain Gauge (Pressure Sensor)
  2. Load Cells (Weight Sensor)
- Bio-Sensor
- Chemical Sensor

Applications of sensors in Industry

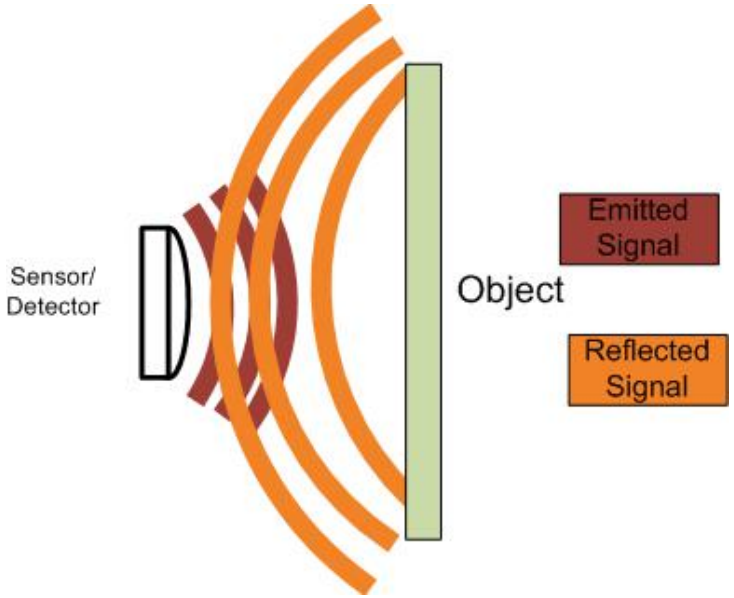
Laser rangefinders
Laser scanners/LIDAR
Laser alignment systems
Encoders
Spectrometers
Container scanners
Baggage scanners
Radiation detectors
Passenger counters
Volumetric flow controllers
Filter monitoring
Condition monitoring
Leak detection
Level sensing
Industrial printers
Cabin air pressure

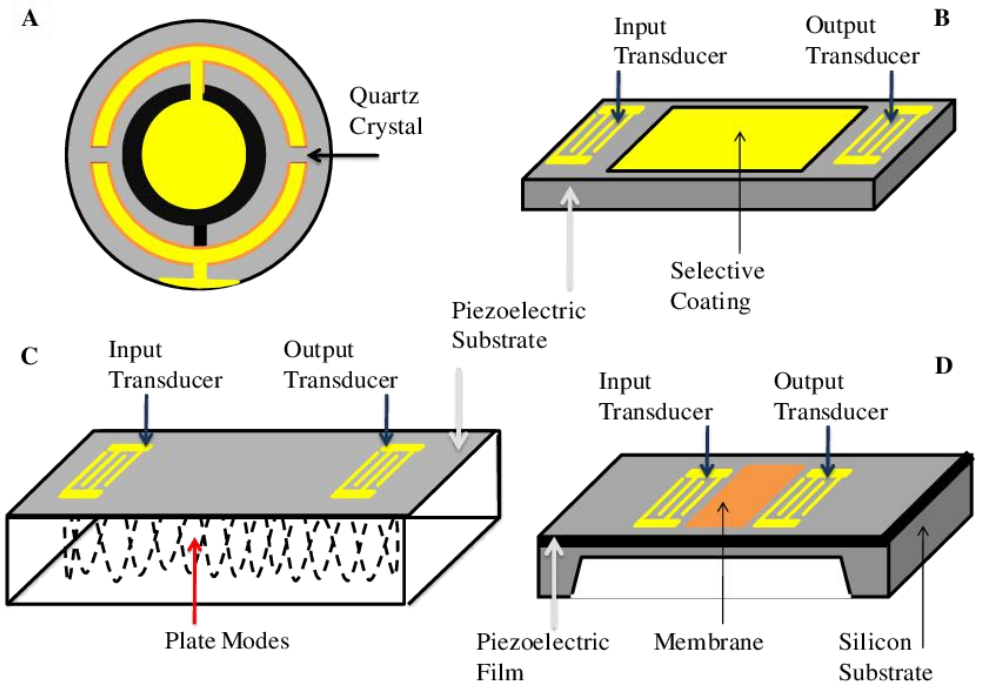
Proximity Sensors

A proximity sensor is a sensor able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation, and looks for changes in the field or return signal.

Acoustic Sensors

Surface acoustic wave sensors are a class of microelectromechanical systems which rely on the modulation of surface acoustic waves to sense a physical phenomenon. The sensor transduces an input electrical signal into a mechanical wave which, unlike an electrical signal, can be easily influenced by physical phenomena.





Force & Torque Sensors

Force sensors are responsible for measuring the force acting on an object. As a golden rule, both tensile and pressure forces, as well as elastic deformations are measured. Moreover, there are different variants in which force may be measured and determined through the sensors

A torque sensor, torque transducer or torque meter is a device for measuring and recording the torque on a rotating system, such as an engine, crankshaft, gearbox, transmission, rotor, a bicycle crank or cap torque tester. Static torque is relatively easy to measure.