CHAPTER-1

INTRODUCTION

Every human being's in this world needed three things necessarily they are, food, clothing and shelter. Here, food is the main resource, where every living being's is needed. Without food and water living organisms can't survey in this world i.e. without cloth and shelter they can live but no food there is no soul."Food is the one and only resource that helps us to balance the nutritional paradigms in our body". Food is a needed substance that is been consumed to provide a sufficient nutritional support for an organisms. The food things are usually of green plants or meats of animal origins that contain nutrients, such as minerals, proteins, vitamins, or carbohydrates. These substances are ingested by an organism and assimilated by the organism's cells to provide energy, maintain life and growth. A nice quote is said by the Thirumoolar in Thirumandhiram as follows, *"Udambar azhiyil uyirar azhivar…"***.** Many plants and their specimens are eaten as food and nearly 20,000 plant resources are cultivated for food, many of these plant species have several unique cultivars. Vegetables are parts of plants that are consumed by humans or other animals as food. And it is collectively termed as plants to refer to all edible plant matter, including the flowers, leaves, roots and the meaning is still commonly used. In some culinary and cultural traditions, the definition for the term *vegetable* would be arbitrary. Initially, the gatherers used to collect the fruits and vegetables from forests, later they started to cultivate on their own in several parts of the world, which was probably during the period 10,000 BC to 7,000 BC, then a new agricultural way of life is developed. Nowadays, most vegetables are grown all over the world as climate permits, and crops may be cultivated in protected environments in less suitable locations. Cooking is a kind of art and craft for preparing food for consumption. The basic need to prepare a food is "fire and plant resources". Plant resources are vegetables which are usually

added to the dishes which are been preparing. By including this vegetables into the dishes it will gives us a healthy food. Some of the people who involved in cooking are, Chef, Home makers and so on. Vegetables are needed to prepare the dish. The toughest job in the art of cooking is 'Chopping the vegetables'. So we need to chop the vegetables into different shapes based upon the dish is being prepared. To chop the vegetables basically we need a knife, by using knife the masters will the chop the vegetables into different shapes. By chopping the vegetables by using hand it takes more time and man power. So, to overcome this problem we need to automate this chopping work by applying some latest technologies. This will be helpful for them to make the work very fast and more efficient.

1.1 INTRODUCTION TO IoT in MECHATRONICS

1.1.1 MECHATRONICS

Mechatronics, which is also called mechatronic engineering, is a multidisciplinary branch of engineering that focuses on the engineering of both electrical and mechanical systems, and also includes a combination of robotics, electronics, computer, telecommunications, systems, control, and product engineering. As a relatively new branch in the engineering field, Mechatronics was first introduced by the Japanese. It is safe to say that that it is a multidiscipline and a combination of various systems. It is a key to the next generation of machine and robots. The intention of mechatronics is to produce a design solution that unifies each of these various subfields. Engineering cybernetics deals with the question of control engineering of mechatronic systems. It is used to control or regulate such a system (see control theory). Through collaboration, the mechatronic modules perform the production goals and inherit flexible and agile manufacturing properties in the production scheme. Modern production equipment consists of mechatronic modules that are integrated according to control architecture. The most known architectures

involve hierarchy, polyarchy, heterarchy, and hybrid. The methods for achieving a technical effect are described by control algorithms, which might or might not utilize formal methods in their design. Hybrid systems important to mechatronics include production systems, synergy drives, planetary exploration rovers, automotive subsystems such as anti-lock braking systems and spin-assist, and everyday equipment such as autofocus cameras, video, hard disks, and CD players.

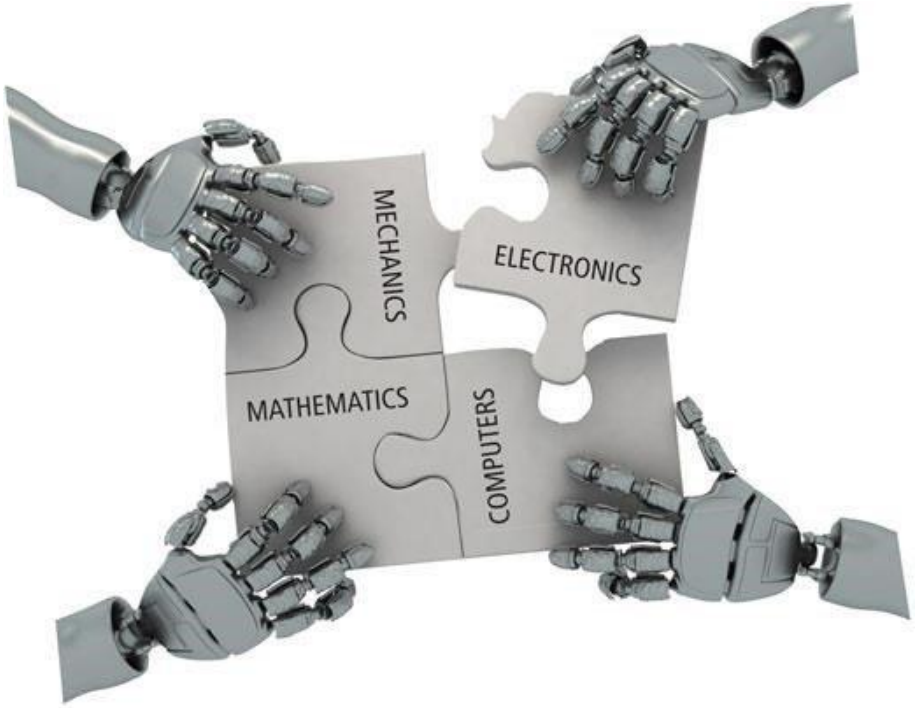

Figure 1.1 Mechatronics

COURTESY: MECHATRONICS BY NORMAN MEDI

Mechanical modeling calls for modeling and simulating physical complex phenomena in the scope of a multi-scale and multi-physical approach. This implies to implement and to manage modeling and optimization methods and tools, which are integrated in a systemic approach. The specialty is aimed for students in mechanics who want to open their mind to systems engineering, and able to integrate different physics or technologies, as well as students in mechatronics who want to increase their knowledge in optimization and

multidisciplinary simulation techniques. The specialty educates students in robust and/or optimized conception methods for structures or many technological systems, and to the main modeling and simulation tools used in R&D. Special courses are also proposed for original applications (multi-materials composites, innovating transducers and actuators, integrated systems, to prepare the students to the coming breakthrough in the domains covering the materials and the systems. For some mechatronic systems, the main issue is no longer how to implement a control system, but how to implement actuators. Within the mechatronic field, mainly two technologies are used to produce movement/motion.

1.1.1.1 ELEMENTS OF MECHATRONICS

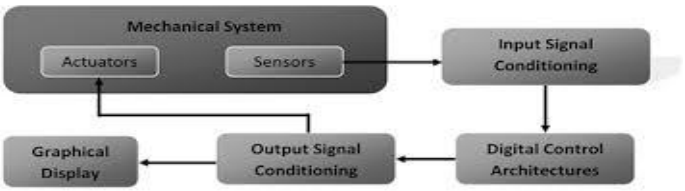

Figure 1.2 Elements of Mechatronics

COURTESY: ELEMENTS OF MECHATRONICS BY MAMILLA

The elements of mechatronics system are,

- **Mechanical**

  Mechanical elements refer to mechanical structure, mechanism, thermo-fluid, and hydraulic aspects of a mechatronics system. The mechanical element may include static/dynamic characteristics and it interacts with its environment purposefully. The mechanical elements of mechatronics systems require physical power to produce motion, force, heat, etc.

- **Electro-mechanical**

  Electromechanical elements refer to sensors and actuators. A variety of physical variables can be measured using sensors, e.g., light using photo-resistor, level and displacement using potentiometer, direction/tilt using magnetic sensor, sound using microphone, stress and pressure using strain gauge, touch using micro-switch, temperature using thermistor and humidity using conductivity sensor. Actuators such as light emitting diode (LED), DC servomotor, stepper motor, relay, solenoid, speaker, shape memory alloy, electromagnet, and pump apply commanded action on the physical process.

- **Electrical and Electronics**

  Electrical elements refer to electrical components (e.g., resistor (R), capacitor (C), inductor (L), transformer, etc.), circuits, and analog signals. Electronic elements refer to analog/digital electronics, transistors, thyristors, opto-isolators, operational amplifiers, power electronics, and signal conditioning. The electrical/electronic elements are used to interface electro-mechanical sensors and actuators to the control interface hardware elements.

- **Control interfacing and computing hardware**

  Control interface/computing hardware elements refer to analog-to-digital (A2D) converter, digital-to-analog (D2A) converter, digital input/output (I/O), counters, timers, microprocessor, microcontroller, data acquisition and control (DAC) board, and digital signal processing (DSP) board. The control interface hardware allows analog/digital interfacing, i.e., communication of sensor signal to the control computer and communication of control signal from the control computer to the

actuator. The control computing hardware implements a control algorithm, which uses sensor measurements, to compute control actions to be applied by the actuator.

1.1.1.2 MECHATRONICS APPLIED FIELDS

Mechatronics is a field of very vast scope and can be used in various fields and such as:

- **The Medical field:** such as surgery, Radiology, Emergency Medicine…
- **Robotics Industry:** basically the manufacture and designing of robots and robotic systems such as industrial robots
- **Automotive/Automobile engineering:** This branch of engineering refers to the integration of such technologies as mechanical, electrical, electronic, software and safety engineering to design and manufacture of motorcycles, automobiles, and trucks.
- **Research Organizations:** such as Instrumentation and Sensors, Micro fluidics and MEMS, Energy Conversion
- **Mechanical Industry:** This branch of mechanical engineering refers to the application of engineering, physics, and materials science principles for the designing, analyzing, manufacturing, and maintaining mechanical systems. Mechanical Industry is one of the oldest and broadest branches of the engineering field.
- **Computer-Aided Designing (CAD):** In simplest term, CAD is the use of computer systems (or workstations) to aid in the creating, modifying, analyzing, or optimizing of a mechanical design.
- **Manufacturing Industry:** This scope of engineering is utilized in the production of merchandise for use or sale using labour and machines or tools.

- **Mining:** It refers to the extraction of valuable minerals or other geological materials from the earth.
- **Inspection:** such as oil and gas pipeline inspection via drones.

1.1.1.3 EXAMPLES OF MECHATRONICS

Below are some examples of mechatronic systems:

- **Robots:** Robots are now well known for their wide applications in different segments. A robot is a device that is capable of independently moving either by walking or rolling on its wheels. They have been designed to perform complex actions such as grasping and moving objects. Some robots even resemble the behaviour of living creatures such as animals or even humans.
- **Washing machine:** a washing machine is a device that is used to wash laundry, it is composed of 4 components: sensors, actuators, a microprocessor and the mechanical parts.
- **The DA VINCI Surgical System:** This is a surgical robotic device that was made by the American company Intuitive Surgical. It was approved by the US FDA (Food and Drug Administration) in the year 2000 to be used in surgeries. This revolutionary surgical device has made surgeons capable of performing the most complicated and delicate surgical procedures through very small cuts with high accuracy.

1.2 INTERNET OF THINGS (IoT)

Today**, Internet application development demand is very high**. So **IoT is a major technology** by which we can produce various useful internet applications. Basically**, IoT is a network in which all physical objects are connected to the internet** through network devices or routers and exchange data. IoT allows objects to be controlled remotely across existing network

infrastructure. IoT is a very good and intelligent technique which reduces human effort as well as easy access to physical devices. This technique also has autonomous control feature by which any device can control without any human interaction. **“Things” in the IoT sense, is the mixture of hardware, software, data, and services**.

The convergence has helped to tear down the silo walls between Operational Technology (OT) and Information Technology (IT), allowing unstructured machine-generated data to be analyzed for insights that will drive improvements.

The Figure 1.3 represents how all the web-enabled devices collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware. These devices, often called "connected" or "smart" devices, can sometimes talk to other related devices, which is called machine-to-machine (M2M) communication, and act on the information they get from one another. Humans can interact with the gadgets to set them up, give them instructions or access the data, but the devices do most of the work on their own without human intervention.

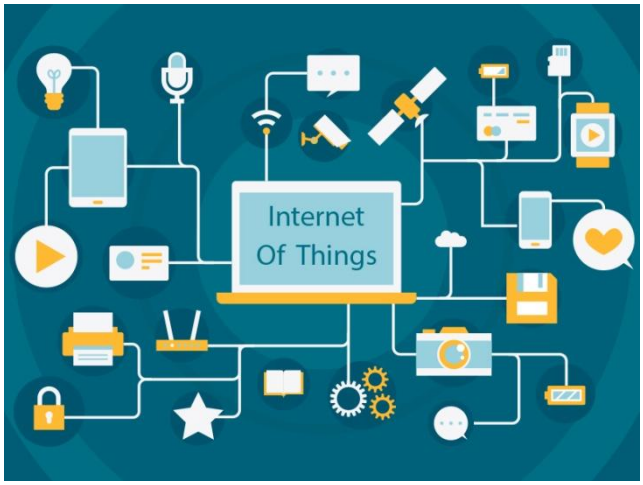

Figure 1.3 Internet of Things

COURTESY: IoT BY COSERVIT

Connected devices also generate massive amounts of Internet traffic, including loads of data that can be used to make the devices useful, but can also be mined for other purposes. Gadgets out in the open can monitor for changing environmental conditions and warn us of impending disasters. These devices are popping up everywhere, and these abilities can be used to enhance nearly any physical object.

1.2.1 WORKING OF INTERNET OF THINGS (IoT)

The Figure 1.4 represents how the things in IoT coordinate and work as a single entity. Sensor being the significant component, it can be used for various purposes like; sensing of vibration, pressure, movement of an object etc. Sensors can be directly linked with the cloud via a gateway. From the cloud, the data can be sent to various forms of devices like mobile, tablets, laptops or to any PDA.

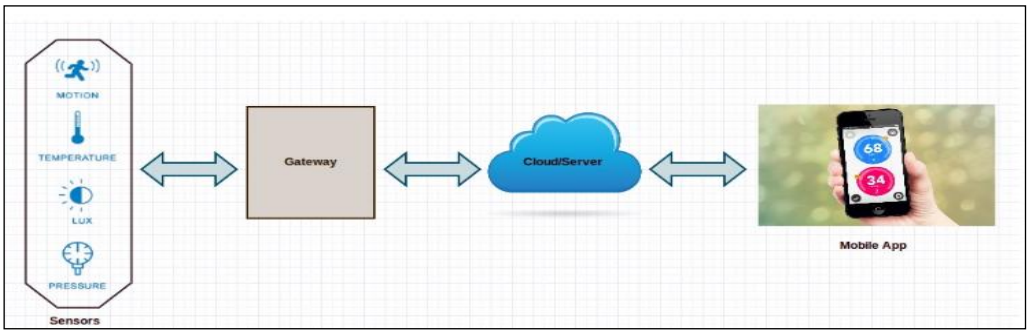

Figure 1.4 Working of Internet of Things

COURTESY: HOW IoT WORKS BY EMBITEL

Here, are four fundamental components of an IoT system:

1) Sensors/Devices: Sensors or devices are a key component that helps you to collect live data from the surrounding environment. All this data may have various levels of complexities. It could be a simple temperature monitoring sensor, or it may be in the form of the video feed.

A device may have various types of sensors which performs multiple tasks **apart** from sensing. Example, A mobile phone is a device which has multiple sensors like GPS, camera but your Smartphone is not able to sense these things.

2) Connectivity: All the collected data is sent to a cloud infrastructure. The sensors should be connected to the cloud using various mediums of communications. These communication mediums include mobile or satellite networks, Bluetooth, WI-FI, WAN, etc.

3) Data Processing: Once that data is collected, and it gets to the cloud, the software performs processing on the gathered data. This process can be just checking the temperature, reading on devices like AC or heaters. However, it can sometimes also be very complex like identifying objects, using computer vision on video.

4) User Interface: The information needs to be available to the end-user in some way which can be achieved by triggering alarms on their phones or sending them notification through email or text message. The user sometimes might need an interface which actively checks their IoT system. For example, the user has a camera installed in his home. He wants to access video recording and all the feeds with the help of a web server.

1.2.3 END-USER MOBILE APPS

The intuitive mobile apps will help end users to control & monitor their devices from remote locations. These apps push the important information on your hand-held devices & help to send commands to your Smart Devices. These mobile applications more helpful, since it is present in the hand-held devices it can be easily accessible and controlled by the end-users. These apps contains an

interactive UI, which is easily understandable to the users and it is also contains the functionalities which is requested by the users.

1.2.4 BENEFITS OF IOT ENABLED MECHATRONICS

1. Lower cost and better function

Each component must have a positive impact on the financial bottom line. Less wiring and connectors, fewer components and sensors, less labor invested, reduced time spent in setup and maintenance and maximized operational uptime all substantially reduce the overall cost of ownership and operation.

Figure 1.5 IoT enabled Mechatronic system

COURTESY: MECHATRONICS BY NORMAN MEDI

2. Less space: By building the driver, controller and amplifier into a smart motor, less panel space is needed, which saves material, time, labor and overall cost.

3. Simplified Wiring: Combining the driver, controller and amplifier means fewer sensors are needed, especially when an encoder is used, fewer I/O connections, and less complicated wiring schemes.

4. Reduced troubleshooting: With fewer components and less wire connections, the job of tracing down problems that may arise is greatly reduced.

5. Streamlined commissioning: Machine installation and start up is made easier with pre-programmed homing routines and with the ability to make changes at an individual axis without working through the PLC. This distributed control model frees the installation team to work on multiple axes simultaneously, and report progress through Internet connectivity. It also allows an operator to make in-process adjustments at an individual axis without affecting the PLC or entire production line.

6. Modular integration
Standardized smart robot modules make integration into multiple axes or multiple machines a natural and easy process.

7. Automated adjustment: Switching a packaging or assembly line to a different size or part can become automated and "recipe driven," increasing manufacturing flexibility and speed. Such adjustments eliminate time consuming manual changes.

8. Maximized uptime: Real-time monitoring of temperatures, friction, motor torque and other performance related data can be routed to a mobile device allowing operators, maintenance or engineers to proactively handle issues related to maximizing machine uptime.

1.3 PROBLEM DEFINITION

Food is the main resource, where every living being's is needed. It is the one and only resource that helps us to balance the nutritional paradigms in our

body. There are many vegetation resources are available in this world to eat and survey. We can't have these vegetations directly, so we have to cook the vegetables. To cook the vegetables we need to chop the vegetables, chopping of vegetables is a difficult task for homemakers and the chefs who are involved in cooking as a need or profession. Many machines are there as shown in Figure 1.6 and Figure 1.7 for cutting the vegetables but the only difficulty is user need to change the blade manually as and when required. At every change it takes time to change the blade and the procedure to change the blade is also difficult. Therefore to overcome this problem, an automated slicer is designed in such a way that the user can choose the type of blade from the user interface(Mobile App), in order to cut the vegetables in their preferred shapes.

Figure 1.6 Slicer Dicer

COURTESY: SLICER DICER BY DEALSNBUY

Figure 1.7 Vegetable cutting Machine

1.4 OBJECTIVE

The main objective of this system is to make the cooking process easier, faster and to reduce the man power and time. This system helps the user to chop the vegetables in their preferable shapes available in the system. The difficulty in the existing system is to change the blades manually by the user and the process to change is tedious, so to overcome this difficulty the blade changing process is been automated by applying the concepts of Mechatronics and IoT technologies and then, there is no need of having the knowledge about the blade changing process. This automation process uses the IoT and Mechatronics technologies make the process “SMARTER”.

1.5 KEYWORDS

The following are the keywords used in this document, they are,

- Arduino UNO.
- A4988 Stepper Driver.
- HC-05 Bluetooth Module.
- Pneumatic Cylinder.
- Direction Control Valve(DCV).

1.5.1 ARDUINO

The Figure 1.8 represents the Arduino UNO board. Arduino is a prototype platform (open-source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programmed (referred to as a microcontroller) and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Arduino provides a standard form factor that breaks the functions of the micro-controller into a more accessible package.

Figure 1.8 Arduino UNO

COURTESY: ARDUINO UNO BY BEN

The key features are,

- Arduino boards are able to read analog or digital input signals from different sensors and turn it into an output such as activating a motor, turning LED on/off, connect to the cloud and many other actions.
- You can control your board functions by sending a set of instructions to the microcontroller on the board via Arduino IDE (referred to as uploading software).
- Unlike most previous programmable circuit boards, Arduino does not need an extra piece of hardware (called a programmer) in order to load a new code onto the board. You can simply use a USB cable.
- Additionally, the Arduino IDE uses a simplified version of C++, making it easier to learn to program.
- Finally, Arduino provides a standard form factor that breaks the functions of the micro-controller into a more accessible package.

1.5.2 STEPPER MOTOR

The Figure 1.9 represents the Stepper Motor. A **stepper motor** is a brushless, synchronous electric motor that converts digital pulses into

mechanical shaft rotation. Every revolution of the stepper motor is divided into a discrete number of steps, in many cases 200 steps, and the motor must be sent a separate pulse for each step. The stepper motor can only take one step at a time and each step is the same size. Since each pulse causes the motor to rotate a precise angle, typically 1.8°, the motor's position can be controlled without any feedback mechanism. As the digital pulses increase in frequency, the step movement changes into continuous rotation, with the speed of rotation directly proportional to the frequency of the pulses. Step motors are used every day in both industrial and commercial applications because of their low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment.

Figure 1.9 Stepper Motor

COURTESY: STEPPER MOTOR FUNCTIONS BY T-KUHN

1.5.3 BLUETOOTH MODULE (HC-05)

The Figure 1.10 represents the Bluetooth Module HC-05. HC-05 is a Bluetooth module which is designed for wireless communication. This module can be used in a master or slave configuration.

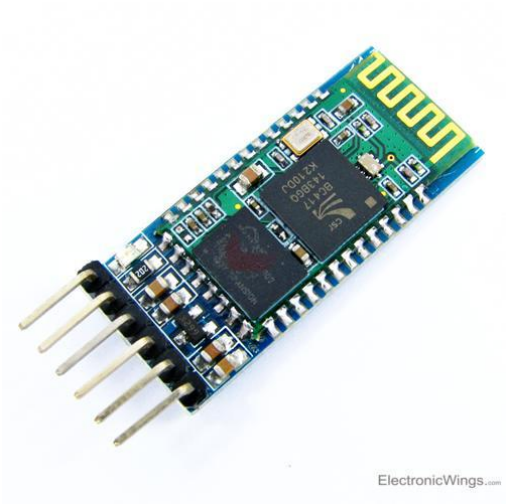

Figure 1.10 HC-05 Bluetooth Module

COURTESY: HC-05 BLUETOOTH BY DEJAN

Pin Description,

Figure 1.11 HC-05 Pin Description

COURTESY: HC-05 PIN DESCRIPTION BY BASSAMA

The Figure 1.11 represents the HC-05 Bluetooth module pins description. Bluetooth serial modules allow all serial enabled devices to communicate with each other using Bluetooth.

It has 6 pins,

1. Key/EN: It is used to bring Bluetooth module in AT commands mode. If Key/EN pin is set to high, then this module will work in command mode.

Otherwise by default it is in data mode. The default baud rate of HC-05 in command mode is 38400bps and 9600 in data mode.

HC-05 module has two modes,

- **Data mode:** Exchange of data between devices.
- **Command mode:** It uses AT commands which are used to change setting of HC-05. To send these commands to module serial (USART) port is used.

2. VCC: Connect 5 V or 3.3 V to this Pin.

3. GND: Ground Pin of module.

4. TXD: Transmit Serial data (wirelessly received data by Bluetooth module transmitted out serially on TXD pin)

5. RXD: Receive data serially (received data will be transmitted wirelessly by Bluetooth module).

6. State: It tells whether module is connected or not.

1.5.4 A4988 DRIVER

Figure 1.12 A4988 Stepper Driver

COURTESY: A4988 DRIVER DESCRIPTION BY DEJAN

The Figure 1.12 represents the A4988 stepper motor driver. The A4988 is a micro-striding driver for governing the stepper motors, it is incorporated with the interpreter for the tranquil process. This motor driver offers five, unlike step tenacities which are, 1. Complete Step 2. Half (1/2) Step 3. A quarter (1/4) Step 4. Eight (8th) Step and 5. 16-Step. It also has a potentiometer which regulates the output current, over temperature updraft stoppage and crossover current safety.

The interpreter of this driver is fundamental to the stress-free employment of the A4988. Only entering one pulse on the stride input drives the motor one micro-step. There is no need for phase classification tables, higher frequency outlines, or multifaceted borders to plug-in. The interfacing of this module is suitable for such applications where a composite microprocessor is inaccessible or is overloaded. During the stepping process, the cutting governer in this module robotically chooses the current falling-off way, sluggish or diversified. In diversified decay style, the expedient is set firstly to a fast deterioration for a magnitude of the steady off-time, then to a slow deterioration for the remains of the off-time. In this module, interior synchronous modify integrated circuit is connected to mend power indulgence during the PWM process.

This special integrated circuit consists of thermal cessation with hysteresis, under voltage lockout (UVLO), and crossover-current fortification. It is available in superficial mounted QFN cascading (ET), with the dimensions of 5mm x 5mm, having a cascading height of 0.90mm and an uncovered wad for boosted thermal indulgence.

1.5.5 PNEUMATIC CYLINDER

A pneumatic cylinder is a cylindrical metal machine that guides a piston in a straight-line reciprocating movement in a cylinder. The air converts heat energy into mechanical energy through expansion in the engine cylinder, and the gas

receives piston compression in the compressor cylinder to increase the pressure.

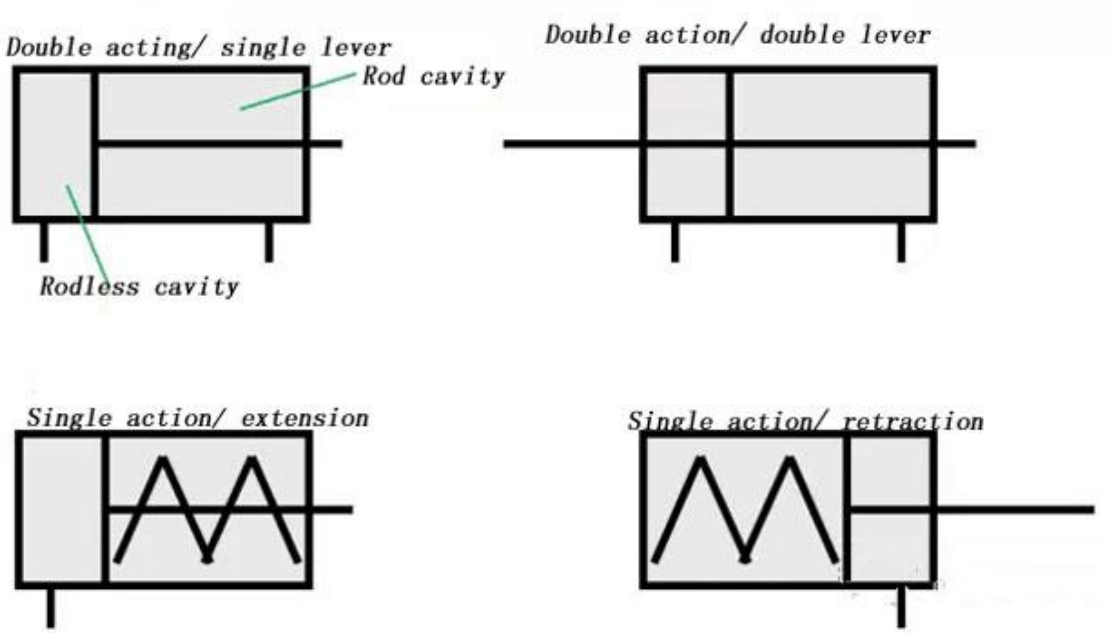

Figure 1.13 Pneumatic Cylinder Functions

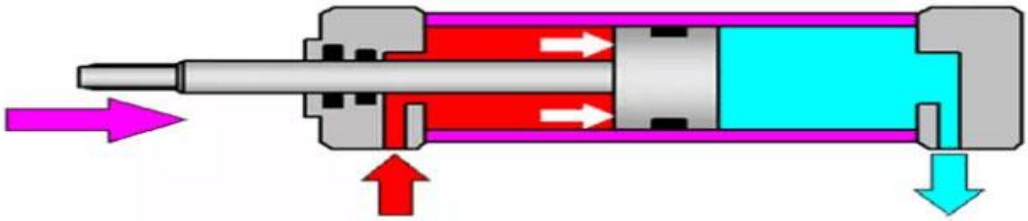

Figure 1.14 Pneumatic Cylinder retracts

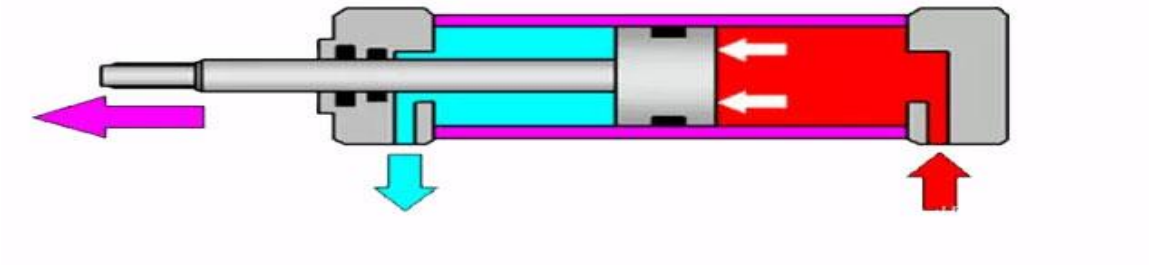

Figure 1.15 Pneumatic Cylinder Extracts

COURTESY: PNEUMATIC WORKING PRINCIPLE BY ATO

Figure 1.13, 1.14 and 1.15 represents the functionalities of the pneumatic cylinder. When the compressed air is input from the rod-less cavity, there is a rod-cavity exhaust, the pressure difference between the two Chambers of the cylinder ACTS on the piston to push the piston movement, so that the piston rod extends. When there is a rod-cavity air intake, no rod-cavity exhaust, make the piston rod retraction, if there is a rod-cavity and rod-cavity alternate air intake and exhaust, the piston reciprocating linear movement.

1.5.6 DIRECTIONAL CONTROL VALVE (DCV)

Figure 1.16 DCV

The Figure 1.16 represents the Direction Control Valve. Directional control valves (DCVs) are one of the most fundamental parts of hydraulic and pneumatic systems. DCVs allow air flow (hydraulic oil or water) into different paths from one or more sources. DCVs will usually consist of a spool inside a cylinder which is mechanically or electrically actuated. The position of the spool restricts or permits flow, thus it controls the air flow. Directional control valves perform only three functions: stop air flow, allow air flow, and change direction of air flow.

These three functions usually operate in combination. The simplest directional control valve is the 2-way valve. A 2-way valve stops flow or allows flow. A water faucet is a good example of a 2-way valve. A water faucet allows flow or stops flow by manual control. A single-acting cylinder needs supply to and

exhaust from its port to operate. This requires a 3-way valve. A 3-way valve allows air flow to an actuator in one position and exhausts the air from it in the other position. Some 3-way valves have a third position that blocks flow at all ports. A double-acting actuator requires a 4-way valve. A 4-way valve pressurizes and exhausts two ports interdependently. A 3-position, 4-way valve stops an actuator or allows it to float. The 4-way function is a common type of directional control valve for both air and hydraulic circuits. A 3-position, 4-way valve is more common in hydraulic circuits.

1.6 AN OUTLINE OF EXISTING SYSTEM

Today different types of vegetable cutting machine are there as an existing system, that are used to chop the any kind of vegetables. These machines are medium in size, mostly body and blades are made up of stainless steel, fixed motor to operate the blade, hollow opening to load the vegetables, and a switch to control. It also contains different type of blades such as large, small and vertical grids, etc, where to chop the vegetables into the desired shapes as the user preferred. If the user needs to change the blade, every time he/she have to open the machine's top and have to change the blade.

1.6.1 LIMITATIONS OF EXISTING SYSTEM

- The existing system consumes more time and man power.
- Changing the different types of blades is a difficult process.
- It can't be used for the home needs. And it is difficult to handle the existing device for the home makers.
- It consumes more electric power and uses high power motors.

1.7 SUMMARY

In this chapter we discussed about the domain of the project “Internet of Things (IoT) in Mechatronics”. Mechatronics, which is also called mechatronic engineering, is a multidisciplinary branch of engineering that focuses on the engineering of both electrical and mechanical systems, and also includes a combination of robotics, electronics, computer, telecommunications, systems, control, and product engineering. The elements or components of mechatronics system represent the overall architecture. The examples provides a clear understanding of the applications where mechatronics is applied. Since, IoT plays a vital role and makes the overall processes smarter, the IoT and mechatronics functionalities are integrated and applied in this project to make the process easier, time efficient and more productive. All the components that are needed to design the “digital vegetable cutter” are explained in detail. By applying the concept of “Internet of Things” and the components which are specified has been involved in the development of product and gives an innovative output as a product.