# Robotic systems

The process of robot construction is divided in nine steps: defining a task of robot, choose a robotic platform, selection of actuators, selecting microcontroller, motor controller, the human-machine interface, power supply, additional tools, and programming.

## Defining a task of robot

It is clever to enhance all the required knowledge about how to prepare a robot before starting up. First step is to think about few questions such as, what will be the task of the robot? What kind of robotic competition it will be? What is the good resource to get knowledge about robotics and robotic competition? This material will help one to build customized land type robot, by combining the different tools explained in the following part. The first thing is to understand the task. A robot can perform various tasks depending on the design and programming (Nehmzow, 2009).

The factors explained bellow can help students to get an initial idea to design the robot. Such factors are maximum and minimum speed of a robot, total weight a robot will lifting or carrying, if any kind of accuracy is required, in how many directions a robot will require to travel, program length and a memory capacity of a microcontroller, initial cost, maintenance cost, and environmental factors such as what kind of land a robot will travel on (Newman, 2006).

## Choose a robotic platform

A design of the robot starts with vision, needs and specifications. The possibility of how many types of custom robots can be made is large. The understanding of the robotic platform helps to simplify the mission of an individual to make a robot (Colestock, 2005). Following are few basic platforms a robot, one can choose from. By enhancing good knowledge of different robotic platforms, one can change his or her robot from land type to the water or air type robot (D’azzo, & Houpis, 1995).

### Land type robots.

The land robots have the significance to provide the best exposer of the robotics systems at low cost. Commonly, the land robots are less complex in comparison with air and water type robots. The focus of the robotic competitions are land type robots. The land type of robots can be further classified in four types: Wheeled type, tracked type, arm and gripper type, and leg type (Nocks, 2007).

###### Wheeled robot.

To provide a mobility to the robot whiles are the best solution, because wheels are easy to mount, least complex, and low cost. One can use any size of wheels available in the market, according to specifications provided for competition. One can design two, three, four or more wheeled robots according to the need. Four wheeled robots are most popular, stable, and easy to control. Two wheeled robots can be prepared using the gyroscopic sensor, which provides the stability to the robot. Adding such kind of tools makes robotic function complex. Hence, it is good idea to use four wheels. Use of multiple drive motors can decrease the slip and provides more grip and traction control, which means each motor drives individual wheel. (Colestock, 2005).

###### Tracked robot.

Continuous track, also called tank tread or caterpillar track, is a system of vehicle propulsion in which a continuous band of treads or track plates is driven by two or more wheels. In simple words, tracks are what tanks use as a wheel. Tracks distributes the weight of the robot on the surface, and increases the grip on the slippery surface such as sand, and mud. Tracks can be used to increase the ground clearance. Moreover, one can decrease the amount of motors used in tacked robot propulsion system. On the other hand, tacks increase the mechanical complexity of the robot. A tracked robot can provide excellent grip in a robotics competition, especially in robot-war (Perkowitz, 2004).

###### Legs type robot.

The legs type robots are complicated in comparison with the wheeled robots and the tracked robots. To make the robot balanced is the difficult task with the leg type robot. Six legs can make the balancing task easy. The only advantage of the leg type robot is that it can navigate through the large obstacles, because the motion of the robot is closer to the organic natural motion. The legs type of robots can be more reliable in obstacle type robot race. On the other hand, this kind of robot can significantly increase the mechanical, electrical and codding complexity (Tadokoro, 2009).

###### Arm and gripper type robots.

The factories use the arm or gripper type robots in larger amount. The arm and gripper type robots can be used where the movement of the robot is limited. However, one can fix the arm on the mobile platform according to the need. One can easily build an arm type robot with as less as three or four degrees of freedom (DOF). In simple words, DOF is number of directions an arm can move. A cost of the robot can go higher with the higher lifting capacity, and higher number of DOF. By adding more DOF to an arm, one can get complex motion for an arm. The design process requires three basic things a hierarchy (in terms of DOF), number of arms, and a purpose of end effect. An arm can have maximum six degrees of freedom for each linear, and rotational movement as shown in figure 1 (Philipe, 1983, pp. 19-34).

### Air type robots.

Air robots are also called as UAV (Unmanned Aerial Vehicle). One can choose to build wing type or copter type UAV. An air robot which can perform a task autonomously is called as AUAV (Autonomous Unmanned Aerial Vehicle). One can build the copter type robot to reduce the cost, complexity and risk. One needs to understand that entire investment can be lost in just one crash of the robot (Mason, 2001).

### Water type robot.

The water type robots can be divided further in two types: Floating type and Diving type. The floating type robots can have very restricted use. The diving type robots may provide more advantages over the floating type robots. The major drawback is that the robot can be lost in many ways such as sinking, internal leakage of the robot or due to lost communication. The electronic parts must be covered in the water tight case, because electronic parts do not like water, and can stop working after contact of a water. As a robot gets deep in the water, due to the water pressure and the wireless communication problems can arise. Hence, powerful and long-range communication system is required for diving type robots. A cable communication and on-board power supply are preferable for diving type robots (Mathia, 2010).

## Selection of actuators

An “actuator” can be defined as a device that converts energy into physical motion. In robotics, the energy tends to be electrical. The actuators make a rotational or linear motion. The AC/DC motor is most commonly used actuator in robotics. Torque is a mechanical parameter to measure the force generated by an actuator, and the speed is a mechanical parameter to measure motion. Rotational speed is measured in RPM (rotation per minute), linear speed is measured in m/s (meter/second), and torque is measured in N•m (Newton•meter). Encoder is a device which provides a feedback to the processor about the position of the rotating shaft of the motor. Encoder can be connected to the motor through the feedback mechanism or one can buy a motor with internal encoder. A Potentiometer is simple feedback mechanism which can be used instead of encoder when the budget is limited. The mobile robot requires an encoder in case only if the application requires a higher accuracy for a movement of a robot. Generally, robots for robotics competition do not require encoders. Picture bellow shows the encoder for AC motors (Smith, Mcgrath, & Jason, 2013).

Is **the actuator being used to move a wheeled robot?** Is the motor being used to lift or turn a heavyweight? In degrees, how much is the range of motion? What is the specific angle to turn the robotic arm? Is the motion linear or rotational? Above questions can help one to choose the right actuator. Few different types of actuators are as below (Masterson, Poe, & Fardo, 1985).

### AC motors.

The AC motors come in wide range of torque ratings, RPM ratings, and sizes. AC motors can be used when the higher torque is required and, the application is stationary. AC motors can produce higher torque in comparison with DC motors. The motor producing higher torque may produce limited amount of rotational speed. AC motor can act as a generator while free spinning. In such a case, one can add flywheel or another electrical equipment which can absorb extra electricity. One can convert the DC power in to the AC power using DC to AC power converter and vice versa for on board use (Smith et al., 2013).

### DC motors.

In the most cases, the mobile robots use DC motors and electronic components such as microcontroller use DC power. Hence, to use DC power supply is advisable. Choosing a DC motor is easy task. DC motors are available in verity of shapes, size, Torque ratings and, RPM ratings. DC motors can provide very high range of RPM, up to 10,000 and, usually produces low torque in comparison with AC motors. One can add gear to increase the torque, on the other hand it will decrease the speed (Menzel, & D’Aluisio, 2000).

### Geared DC motor.

A geared DC motor is a DC motor with internal gearbox. A gearbox controls the speed of the DC motor to increase or decrease the torque. For example, if a gearbox is 200:1 type, and a maximum torque and speed of a motor is 0.01 N•m (Newton • Meter) and 1000 RPM respectively. In such case, at speed of 1000 RPM a motor is producing 0.01 N•m torque. Adding a gear down would reduce a speed 200 times and increase a torque 200 times. A mathematical explanation is provided in following calculation.

* Before adding gear:

Speed of a motor: 1000 RPM

Torque of a motor: 0.01 N•m

* After adding a gear down (200:1)

Speed of a motor: 1000/200 = 5 RPM

Torque of a motor: 0.01•200 = 2 N•m

 The most popular type of gearbox is spur, planetary, and worm. Out of the above three spur is the simplest and most popular gearbox (Colestock, 2005). The planetary gearbox allows the higher ratio with minimum gear down at higher efficiency. Worm gear boxes are expensive in comparison with other gear boxes, but worm provides higher ratio with single gear stage down.

### R/C servo motors.

When the precise angular moment is required such as, controlling a steering wheel or controlling a radar of the UAV, the servo motors can be good option. A servo motor comes with an internal encoder, which provides a feedback of the angular moment. With use of an internal encoder a servo motor can provide a precise feedback of motion to the microcontroller.

The use of encoder is significant in some robotic applications. The significance of an encoder is explained in following example. One can use different servo motors to drive different wheels. For example, all the wheels are driven by different servo motors, the robot is four-wheel drive, and the robot is using two batteries. One battery is providing power to two servos on the left side and another battery is providing power to two servos on the right side. In such case it is possible that one battery with same electrical ratings is more electrically charged than other. Hence, one side of servos will get more electrical power than other side. In the above condition the robot will not move in straight line. Hence, the coordination between all four servos is necessary. If the servos are not coordinating with each other in proper way, there is a chance the robot will not move in straight line. The feedback of the motion is very important in order to keep robot moving at same speed in desired direction. The encoder will provide the feedback of the servo speed, and the shaft position which will help all four servos to keep operating at same speed (McComb, 2011).

The servo motor with an internal break helps in speed control. The servo motor running at high speed can be precisely stopped at the desired set point with the help of the internal encoder and break. Moreover, the internal break can be used to generate the drag, so the wheel will not free spin. To stop a servo motor at desired set point, the break and encoder work in union. The price of the servo motor is comparatively higher than other types of motors because of its advantages (Smith et al., 2013). The servos have two wires, one for the power, and a second for encoder. The servo motors are useful in arm or gripper type robots, where precise angular moment of the motor plays an important part in the movement of the robot. AC powered servo motors are useful for industrial use and a DC powered servo motors are useful for mobile applications.

### Linear actuator.

The linear actuator moves in straight line. The linear actuator works the same as a stroke of a gasoline engine. The linear actuator has three characteristics: the stroke, the force and the speed. Stroke is measured in millimeter, and linear speed in m/s. Use of a linear actuator is good option to fire a hammer as weapon, for a robotic-war competition (Moallen, Patel, & Khorasani, 2000). An example of a hammer as a weapon in mobile robotic application is shown in figure 4.

### Computing the motor requirement.

The questions and answers bellow are designed to help individuals to understand the motor requirements. One can determine the motor requirements for the robot competition by answering the following questions (Rahimi, & Karwowski, 1992).

1. What will be the function (direct use) of the motor?

The motor can be used to do different things such as, to propel the robot, to move the arm, or as a steering mechanism to turn the robot. If the motor is being used to move the wheels or tracks, the motor must be capable to move the entire mobile robot with maximum weight. Moreover, one should keep in mind that the driving motor should have extra capacity to handle an extended weight or slope. DC motor is the good option for propulsion application. The servo motor or linear actuator can be the good option for arm or gripper type robot depending on the specific application.

 Providing the power only to the one side of track or wheels can turn the position of the robot. For example, providing the power only to the wheels on the right side of the robot, will turn the robot left. This is the simplest steering mechanism called as “Skid steering”, which provide good control to turn the robot. The servo motor is good choice for steering operations. Moreover, by turning one side of wheel pairs at different speed, the robot turns by skidding. That means, one side of wheel pairs do not have to be fully stopped during the steering operation.

1. Will robot be caring or turning heavy weight?

One should consider using high torque motors when it comes to move or lift heavy weight. The robot needs more power in lifting a weight, in comparison with moving the same amount of weight. If one is making a robot which will lift the weight through arm or ripper, one need to make sure that arm will not drop a weight in case of power cut. Arm should stay in the current position while lifting procedure is paused or stopped. Any motor with internal break is good option.

1. What is the range (in degrees) of the motion of the motor shaft, and dose operation require a precise angular moment?

The servo motor can provide good feedback when precise angular or linear moment is required.

1. What is the type of motion, linear or angular?

For angular moment one can choose from DC motor, AC motor, Servo motor, geared motor, or stepper motor. For linear moment one can choose linear actuator. One should consider looking in the market for latest motors.

The consideration of the following factors can be good practice to determine the motor requirement: Total mass of robot (g), number of driver motors, radius of drive while (in), velocity of robot (m/s), maximum incline (degree), Supply voltage (V), desired acceleration (m/s2), Desired operating time (s), velocity of motor(rpm), torque (N•m), total power (W), maximum current (A), and battery pack (AH) (Hunt, 1985).

## Selecting Microcontroller

 The microcontroller is the brain of the robot. A microcontroller is responsible for decision making, communications, and computations. Arduino Uno R3 USB Microcontroller, Arduino Due 32bit ARM Microcontroller, Intel 8051, are popular microcontrollers. (Dumouchel, & Damiano, 2017). The microcontroller possesses set of pins (legs), which can be turned high (1) or low (0), by a set of instructions (program). The microcontroller can be used to control electrical devices such as actuators, storage devices, WiFi or Bluetooth. Home appliances such as TV, refrigerator, remote controller, and digital watch are few examples which uses the microcontroller. An advance computer uses the microprocessor as CPU (central processing unit). The microprocessors are more advance than the microcontrollers in many ways. Advance microcontroller comes with on board storage, RAM, internal BUSs to transfer a data from, clock, contour, timer, and frequency generator.

A microcontroller can be programed for simple to very complex tasks. Few things to consider about choosing microcontroller are budget, speed of the microcontroller, how many devices the microcontroller will be handling, and how many tasks each device will execute. For example, consider an LED (light emitting diode) connected to the microcontroller. A simple program can be created to toggle an LED. The programmer can set a specific pin of the microcontroller high or low for a specific time, which connected to an LED. For the time of period a pin is set high an LED will glow. When a pin is set to low, an LED will not glow. It is important to know how much voltage and current are associated with each pin of the microcontroller before connecting any device directly to the microcontroller. In the above case an LED is directly is connected to the microcontroller. One should refer to the manufacturer’s manual to know how much current and voltage are associated with each pin of the microcontroller. The task of creating a program for time delay may vary for different microcontrollers, internal clock of the microcontroller, an operating frequency of the microcontroller, and if controller is 8-bit, 16-bit or 32-bit type. Some microcontrollers provide a facility to connect external clock to the controller. Consider that microcontroller has very low output voltage and current, which is not enough to drive the devices such as a motor. Hence, microcontroller requires additional system (motor controller) which can drive a motor according to the program or live control (Nehaniv , & Dautenhahn, 2007).

The advance microcontroller can perform advance tasks such as communicate with other microcontrollers, and computers because of in-built hardware support system called as UART. UART is universal asynchronous receiver-transmitter. RS232 cable is an example of UART serial communication system. The microcontroller understands only binary language also called as binary bits. The microcontroller comes with inbuilt complier which converts the programing language in binary bits. The microcontroller converts binary bit in to the nearest equivalent voltage or current (Launius, & Mccurdy, 2008).

 One can choose to use computers for the stationary robotic systems. For the mobile robotic application computers are not much helpful, because computers are more expensive, heavy weight, needs external peripherals, and need more power in comparison with the microcontrollers. Hence, the microcontroller is better choice to use in mobile robot application in comparison with the computer (microprocessor) (Kalften, Chmielewski, & Negin, 1989). The comparison of a microcontroller and a computer is in the following table.

Selecting the microcontroller is not an easy task. It is wise to keep the combined cost of the microcontroller and development board as low as possible. With the use of “pulse width modulation” (PWM), it is possible to control the speed of a motor. Understanding and answering the following questions will help to choose the appropriate microcontroller (Astolfo, Ferrari, Ferrari, 2007).

1. What is the application of robot, mobile or stationary? And what type of robot it is, land, water or air?

For the stationary robotic system, one can use the computer or microprocessor instead microcontroller.

1. Which and how many peripherals will robot use? Such as Number of motors, weapons, sensors.
2. Will a microcontroller support all the possible future upgrades? Is it possible to include more motors in the future, or replace the motor with higher torque or RPM?
3. Are guidelines and related documents easily available? Since the programing is an important task, it is necessary to make sure that there are enough documents available from the manufacture to use the microcontroller efficiently.
4. Is it possible to use specific microcontroller with development board? Testing the microcontroller on the development board is good idea before use it with the robot.

## Motor Controller

The microcontroller decides the speed and direction of a motor. A motor cannot be connected directly to the microcontroller. A microcontroller operates on low power, which is not enough to drive a motor. It is necessary to connect a device between microcontroller and motor, which can understand the commands of the microcontroller and drive power from the battery and deliver it to the motor. Such device is the motor controller (Engelberger, 1989).

There are variety of motors available in the market which operates on wide voltage range. A motor needs minimum amount of power to rotate continually at maximum load. It is necessary to select right motor controller which should be able to supply the minimum amount of power to all the motor to make the continues rotation at maximum load. The important thing to consider is that different motor may operate at different power. It is vised to use minimum number of motor controller for the mobile robot. Hence, it is necessary to choose right motor controller which can power as many motors as possible according to the operation (Selig, 2000).

There are few control methods one should aware of to control the motor speed such as, PWD, voltage control, I2C, R/C, and UART. Before considering above control methods, it is necessary to make sure which type of pin is available on the microcontroller. For PWD method, each motor requires a separate channel. A motor controller should be able to control the direction and a speed of a motor. One requires to consider that not all the motor controller provides this facility (Wilson, 2008).

## The human-machine interface

The robot can be controlled by wired or wireless human-machine interface systems. Wired remote-control and wired computer-control are two types of wired human-machine interfaces. Wifi, bluetooth, infrared, and radiofrequency (RF) are examples of wireless human-machine interfaces.

### Wired.

###### Wired remote-control.

A wired remote control is the simplest way to control the mobile robot. By the use of wired remote-control motors can be connected directly to the remote-control switches, and the switches can be connected to power source. By using such mechanism one can avoid the use of microcontroller and motor controller. Avoiding the use of microcontroller, and motor controller decrease the complexity of robot design (Hartley, 1983). Wired remote-control interface system is good option for individuals who wants to build the robot for the first time. The moving robot can cause a loose connection of wire. Hence, with wired remote-control system, it is important to make sure that wires are properly connected with motors, remote-control switches, and power source. With the use of wired remote-control system, it is possible to use off-board power supply. The off-board power supply helps to reduce the weight of the robot, and provides an option to use AC power supply. The use of AC power supply opens the door to use high power AC motors. The wired remote-control is good option if range of the robot operation is within few meters. (Hall, & Hall, 1985).

###### Wired computer-control.

“Tera team” is the software to control the robot. The website ([www.instructables.com/id/DIY-Laptop-Controlled-Robot/](http://www.instructables.com/id/DIY-Laptop-Controlled-Robot/)) has an example of the computer controlled robot. The website mentioned above provides an example to make a simple robot, and write a program to control the robot. It also provides the guidelines to connect the robot with the computer or laptop. Tera team provides an option to connect the robot with computer by using bluetooth. The computer-based robot control system may cost higher in comparison with remote-control system. Tera team is open source, free software which provides C++ programing language platform (Klancar et al., 2017).

### Wireless.

###### Infrared.

An infrared remote control is low cost option of robotics control system. The robot requires to stay in the visible sight of a remote control. An infrared remote cannot transmit or receive data if a reviver is not within visible sight (Cook, 2010).

###### Radio frequency (RF).

There are many different types of RF remote-controls available in the market. RF remote-control is divided in two parts, a transmitter and a receiver unit. A transmitter unit goes to the remote-control, and a receiver goes to the robot. A transmitter encodes a data and transmits through a RF channel. On the other hand, a receiver receives an encoded RF signal and decodes the signal. A receiver communicates with the microcontroller through I/O port. Some RF controllers are available with the trans-receivers. The trans-receiver can transmit and receive signal with the same antenna. The trans-receiver provides a feature of receiving a feedback from robot, such as the position of the robot. An RF remote-control system can transmit over few kilometers range (Cook, 2010).

###### Bluetooth.

A bluetooth uses microwaves to transmit a signal. A function of a bluetooth control system is same as RF control system. A Bluetooth has very short range (about 25 meters) which is a disadvantage of use of the bluetooth control system. Moreover, bluetooth devices uses a specific protocol through which a robot requires to “paired” with the remote-control (Gerdes, 2014).

###### WiFi.

With a use of WiFi control system, one can control the robot from anywhere the internet connectivity is available. The robot requires to stay connected with WiFi all the time if robot operator is at distance place. With a WiFi control system, the robot can connect with a WiFi router, and a router requires an internet connection. A WiFi control system will require the computer-based robot control system to control the robot as explained under the section “wired computer-control”. With use of Wifi, this system will work as wireless computer-control system. (Gerdes, 2014).

## Power supply

On board rechargeable battery is good option for a mobile robot power supply. Different peripherals of the robot may operate at different power ratings. Hence, proving a power supply to all the peripherals of a robot with single battery may not be a good idea. Selecting multiple batteries can solve the above problem. Consider that, different batteries may stop working at different time. The microcontrollers and actuators usually operate at 9V-12V range, and the most sensors operate at 5V depending upon the brand of the component (Colestock, 2005). One can choose battery for a motor according to the task of the robot. For robot race high RPM motors are useful. For robot war high RPM and high torque motors are useful, and the robot may have weapons. Hence, high power battery may be good option for robotic war.

## Additional tools

 Wires, soldering connecters, diodes, resisters, switches, and capacitors, are important additional components. The robot may require more components according to the requirement. The following sections explains about more tools. Screwdrivers, wrenches, pliers, wire strippers/cutters, rotatory tools, drill, breadboard, jumper wires, power supply, soldering tools, multimeter, computer and programming software are some additional tools individual may require building the robot (Selig, 2005).

### Sensors.

Using sensors, the robot can sense the surrounding environment and make decisions accordingly. An ultrasonic sensor, an infrared sensor, a laser sensor, a stretch and bend sensors, and a stereo camera system are some examples of sensors which can help the robot to measure the distance. GPS can sense the location, and the potentiometer, and the gyroscope can sense the rotation. The light sensor, the sound sensor, the thermal sensor, the humidity sensor, the pressure sensor, a gas sensor, and a magnetometer can sense the surrounding environment (Vukobratovic, & Potkonjak, 1982).

### Assembly

One can use existing commercial products such as robo-board. A frame can be made by using traditional tools or by using metal/plastic cutting machines or 3D printer. 3D printing and similar processes may cost high (Srinivas, Dukkipati, & Ramji, 2009). Assembly process may vary according to the complexity and the design of a robot but can be divided into few common steps listed below:

1. Putting different parts together inside the frame
2. Connecting motors to motor controller
3. Connecting power supply
4. Connecting motor controller, sensors, and communication device to microcontroller
5. Add additional parts according to the design and use of a robot

### Materials.

Wood, metal, synthetic material, and composite materials are few materials that can be used to build the robot frame. Steel, aluminum, copper, brass, and bronze are basic metals that can be used to make the robot. Polyvinyl chloride (PVC), and plexiglass are composite materials and foam core and cardboard are other materials that can be used to make a robot (Wright, & Bourne, 1988).

## Programming

The microcontroller only understands the binary language, which works in form of “1s” and “0s”. On the other hand, programmer understands the programming . Many programming software widely recognized as programming langue, available in market, such as Java, C, C++, Assembly, .NET, Processing, Basic, and Python. These programming languages convert the command of a person in a language the microcontroller can understand (binary). After successful completion of a program, a program can be burned into the microcontroller’s memory. Beginner can focus learning one programming language, depending upon which microcontroller one is using, and which is the supporting language of a microcontroller defended by the manufacturer (Srinivas et al., 2009).

 One can use microcontroller development board, to program a microcontroller which are easy to use and provides USB interface, so a programmer can connect a microcontroller directly to the computer. A microcontroller development board is a circuit board and it is equipped with voltage regulator, oscillator, resisters and USB plug which provides support to the microcontroller to be programmed. After connecting a microcontroller to a computer through a USB or RS-232 port, a computer requires drivers to communicate with a microcontroller. The drivers can be found on the manufacturer’s website or according to the user manual provided by the manufacturer. The manufacturer of a microcontroller kit usually provides a sample codes to program a microcontroller. A documentation of code is a key part, as a programmer develops more cods and knowledge of programming of a microcontroller (Srinivas et al., 2009).

# Mobile Land Robots

As name states “Mobile Land Robot” is kind of robot which is locomotive and uses platform of “land robot”. (See section “choosing a robotic platform” for more details). “Locomotion is a process of moving an autonomous system from one place to another” (Klancar, Zdesar, Blazic & Skrjanc, 2017, pp. 13). A robot can be autonomous or non-autonomous. A non-autonomous robot is one which is fully or partially controlled by an operator. An autonomous robot can take decisions autonomously. An autonomous robot may require calculate velocity, angular velocity, travel path, trajectory, obstacles, environmental factors, and targeted mission. An autonomous robot requires sensors, and combination of electrical and technical parts to make decisions.It is important to have an idea about relationship between input parameters of robot and how a robot will react on those inputs for different surrounding conditions. (Klancar, et all, 2017).

The actuators, manipulators, control systems, appropriate sensors enough power supply, and well-designed software are the necessary parts to build the basic mobile land robot. A right blend of all the systems explained above needs to fit appropriately together to make the mobile land robot work successfully. Instead of controlling a robot by a remote controller all the time, a robot should have a small amount of artificial intelligence. A robot competition such as an obstacle robot race require a robot to be artificially intelligent, identify obstacles, pass them and finish the race. For the autonomous mobile land robot, an intelligence is a sense of surrounding sensed by sensors and appropriate automated reaction. (Jones, Flynn & Seiger 1999).

Generally, competitor is not allowed to control the robot during the obstacle race type robot competition. Hence, the robot must be autonomous for obstacle race. The rule of the competition may vary from competition to competition. It may sound difficult to make artificially intelligent mobile land robot for obstacle race type robot competitions, but it is simple. By implementing an electrical circuit explained as following, one can tell robot when to turn, how far to turn, when to move forward and when to reverse. A robot is equipped with a bump sensor which detects the collision. An electrical circuit with microcontroller moves all the wheels in forward direction until a bump sensor detects collision. Once the sensor detects the collision, the circuits moves the wheels in reverse direction and then robot backs up. One can choose to make the robot with four wheel-two drive motors (one on each side) or four wheel-four drive motors (one on each wheel). A resistor-capacitor (RC) circuit is connected with each side of motor/s. RC circuit works on the base of a state of an element or timing which makes robot to turn. If the one of the RC circuit is set for the different amount of period then other in that case one side of wheels will move more than other side of wheels, which will make robot to turn. Then after the robot resumes the forward motion, and repeats the same task until it crosses all the obstacles (Fjermedal, 1986).

## Parts

As shown in figure 5 a robot can be program to move forward in linear and arc motion. During the forward motion if one side of wheel/wheels can move little faster than other side, one can enhance the arc motion for the robot. In this section of the material practical example to build an obstacle race type robot is explained. A function of the such robot is to escape from the obstacles, and follow along the wall if there is any. There are two wheels used to build the robot. Trailing caster wheel maintains the stability of the robot. One can choose where he or she wants to put all other parts on robot such battery, and circuits. This robot is designed with all analog circuits only to eliminate the codding part (Christensen, Bunke, & Noltemeier, 1999).

One requires motor, gears, axles, wheels, switches, connectors, wire cutters, wire stripers, soldering iron, soldering machine, chassis, and collision sensors. One may require more components according to change in design. An oscilloscope along with multimeter could be more helpful for debugging purpose. Figure 6 shows the functional block diagram of the robot, and how information passes from collision sensor to motors.