LECTURE-7

Motors

Introduction:-

You have to make it go somehow. I don't think there are any serious alternatives to a robot that uses batteries for stored energy and some kind of electric motor for the driving force.

There are some basic physics to look at and then the choice between two common types of electric motor. I have only bothered with stuff on steppers and DC motors as these will do the job and present enough complexity to keep anyone happy

Essentially, while making a robot all we want is a driving unit which one can easily and accurately control in terms of acceleration, speed and position. It must be light, small and use as little energy as possible. A minimum of ancillary electronics would be good and it should preferably be easy to mount and cheap.

For convenience, you might want to choose stepper motors. They are heavy and power hungry, not always good for speed and will need relatively heavy duty driving electronics. However, control is a doodle and mounting could hardly be easier. Usable steppers can be recovered from old disk drives

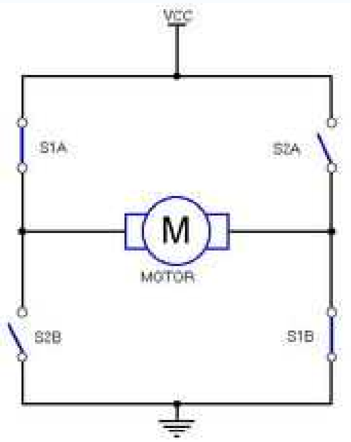
For performance, DC motors are the way to go. They can be small and light, the electronics are fairly simple and the power requirements quite modest. But to control the motion properly, we need good programming skills and a clever processor with fast mathematical calculation speed. Mounting and finding suitable gearboxes can be a pain. High quality, small DC motors are not cheap if purchased new.

DC Motors:-

DC motors will almost certainly give you the best combination of power to weight ratio and top speed.

A DC motor is intended to work from a direct current supply. Voltage is applied to the motor terminals and the motor begins to rotate. As the armature picks up speed, a voltage is induced in the windings that try to oppose the current flowing in them. Quite quickly, a speed is reached where a balance is established and the motor speed stabilizes. The speed at which this occurs is a function of the applied voltage and the motor characteristics. The amount of turning force, torque that the motor can produce is a function of the current through the windings. As load is applied to the motor, the speed drops and the current increases. A load just sufficient to stop the motor is the stall torque and will correspond to some particular (and fairly high) current through the windings. The energy can only appear as heat must be avoided.

Direction:-



Changing which direction a DC-motor turns is very simple: simply reverse the polarity.

Both pairs of switches ((S1A, S1B) and (S2A, S2B))-see the picture above- will always switch together. This circuit is called an H-bridge.

This H-bridge can be made by using transistors but its better to be directly used from **IC-L293D or L298**

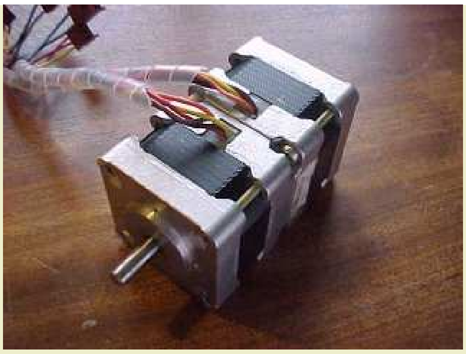
Speed:-

Speed is a little bit more complicated. slowing down a motor by reducing its voltage with a variable resistor or other ways does not work well, because it will not only reduce the motor's speed, it will also reduce a motor's strength, while also consuming a lot of electricity as large amounts of heat are generated by the resistor.

While these motors are expecting a direct current to drive them, so for control and speed it is much more efficient to use a supply that is switched on and off repeatedly. The width of the on pulses is varied so that the motor sees the average amount of energy flowing. Pulse width modulation (PWM) of the motors is not too complicated to achieve. You will need to select a pulse repetition rate that is quite high. A few hundred Hz is just not going to do it. However, a rate that is too high will be less efficient because of the inductance of the motor windings. Somewhere in the range 20 kHz - 40 kHz will probably be fine.

Stepper Motors:-

A defining characteristic of a stepper motor is that, under normal circumstances, it is made to take up and hold one of a number of fixed positions. Movement from one of these positions to another is only by stepping it through a series of intermediate positions. A typical stepper motor might have 200 such positions in a single, complete rotation of the drive shaft. With little effort, this can be increased, on the same motor, to 400 steps.



These motors are used on many robots and CNC machines, as their main advantage over DC motors, is that they can be easily specified for how much to turn, for more precise control, rather than a "spin and see where it went" approach.

So steppers are the motors that can be positioned to about 0.35mm as slowly as we want and yet might drive us forward at speeds approaching 2m/s.

But many times even if the motor can run that fast it may not have enough torque to push a robot at those high speeds. More drive voltage can help here and, of course, suitable drive electronics are available in the form of integrated circuits.

They are bulky and heavy. They also require relatively high capacity batteries - these are heavy too. Remember the need for higher voltages? More batteries. More weight.

There is no question about it, steppers are poor cousins in the power to weight contest. Nevertheless, they are worth looking at.

Competitive robots can certainly be built with steppers, they are very easy to control and there is no messing around with motor control feedback loops and tacky arithmetic.

Servo Motors:-

Servos are used in robotics for different uses: e.g. to move a sensor around, or to move the legs of a robot. Some users modify the servo so they can use it as a DC-motor with a gearbox.

Controlling a servo is done with Pulse-Width-Modulation. The length of the pulse is relative to the position the servo will turn to. The length of these pulses is usually located between 1ms and 2ms, if so 1.5ms would be the center position. This pulse needs to be repeated with small intervals (otherwise the servo might turn to a "save" position or it might simply stay at its current position. This depends on the type of servo used.

Calculations while Controlling Motors:-

If we are using DC motors, we need to create clever control loops to govern the velocity and position of the wheels. Our goal is to put the wheels into a known position. The constraints include the available acceleration and the desired velocity or acceleration profile.

Simple motion in a straight line requires accelerating the wheels as hard as dared. Both wheels will need the same acceleration if the robot is to go straight. Controlled deceleration will be needed at the end of the run to ensure that we come gently to a rest in the desired position without over or undershooting the target.

Rotation about the centre of the mouse is a similar operation except that the accelerations will be different and one of the motors will be driving backwards. The accelerations will be different because the rotational inertia of the chassis of robot will have a more pronounced effect when spinning on the spot compared to straight line motion.

Differential Turning is the simplest and hence the most commonly used mechanism for directing a robot. Consider the case when we want our robot to take a right-turn. Our robot must rotate about the point of contact of the right wheel and the ground. This can be achieved by stopping the right motor and hence allowing the to rotate about the point of contact with the left motor.

Thus, the robot would take a right-turn. Just remember that the motor in the direction in which we want our vehicle to turn must be switched off while the opposite motor remains on.

A common technique for creating this kind of control is to create a PID controller system. PID stands for Proportional, Integral, Derivative. All that means is that we want to know how far we are away from the goal (integral), how fast we are moving (proportional) and how much acceleration we are using (derivative). These control systems are common and can be quite simple to write. They need tuning for the actual device they are used in.