Chapter 6

6 Conclusion and Recommendation

The torque created by a motor is a good measurement to detect the external force applied to it. The motor torque of a DC servo motor can be changed by changing the duty cycle of the PWM waveform which drives the motor. A MR with two wheels attached to two DC servo motors, it is possible to detect the reaction on both wheels when it drives independently. If the MR moves in a horizontal plane with no obstacles, reaction on both wheels will be equal if the weight distribution of the robot is symmetrical. If there is an obstacle which creates the reaction force on the MR through the symmetrical axis then also equal reaction force creates on both wheels. Only difference is that the reaction force is having a higher value than the obstacle free motion. But when an object creates a reaction force on the MR breaking the above symmetry it will lead to a different reaction force on both wheels. It tends to different driving torques on both motors.

With the positive width of the motor driving PWM wave and the encoder pulses created by wheel rotation it is possible to detect the point of the pusher which the reaction of the pushing object passes through. Since this process is done using one motor at a time the robot creates a zigzag moment. This zigzag moment is helped to push the object towards the centre of the pusher and hence the object does not try to go away from the pusher. This is a great advantage when pushing an object.

The most important thing in this process is that it utilizes only the wheel encoder pulses and the properties of the motor driving PWM waveform. No other sensor is used in this technique and hence this is a very low cost effective solution for object pushing robots.

There is another very valuable output in this technique. This method can be used with any shaped object which can be moved either by rolling or sliding. Most of the previous researches were limited to either a box or a cylinder shaped object. It is hard to find the center of mass of an object using most of the other techniques, if the mass

distribution of the object is uneven. But in this method the object turns and pushed towards the centre of the pusher until the pusher gets the same reaction from both sides pushing in a zigzag motion. At this instance the geometrical centre of the object is not important. The reaction created through the centre of friction of the object is measured by this technique.

Since the friction of the terrain equally affects both the MR and the object the MR should have enough weight to create a sufficient friction when it pushes objects with larger weight. The wheels also should create sufficient friction to push the object. Hence the robot can designed with fairly thick tires.

There are some other ways to detect the force applied on the motor much accurately than the technique used in this research. Some other techniques like "Disturbance observer" will improve the bandwidth of the force detection created by the motor. Using this technique the motor driving force can be determined with higher accuracy. Then the COF of the object can be aligned with the centre of the pusher more accurately than the result obtained in this technique.

This robot is designed to push any object which contacts the pusher when it is moving. Using a camera or an ultrasound sensor the robot will be able to find the position of the objects and then the MR can move towards the object. If the sensors can identify the Geometrical center of the object then the center of the pusher and the geometrical center of the object can get aligned in it's first contact. This will help to minimize the number of zigzag movements to detect the COF.

The amount of rotation of the MR in this zigzag motion can be optimized. Hence it is possible to do the job faster and save the energy. This will be another research area in the future. At the end of the COF of the object and the center of the pusher alignment, MR need not undergo the zigzag movement. Then the robot can move the object to the target with the normal motion. If there is any movement of the object detected along the pusher while it is pushing with normal motion, the zigzag motion can apply to correct the COF and the center of pusher deviation.

By adding some robot navigation technique it is possible to develop this MR to push an object to a predefined target. GPS navigation techniques can be used for outdoor applications. Landmark-based, map-based, vision based positioning or localisation can

be used for indoor or outdoor navigations. Then the robot can be used for applications such as cleaning corridors, pushing granite blocks in a quarry etc.