Aim:

The major defect of an Industrial Manipulator or geometrically operated manipulation devices are their inability adjust to the environment and their deficiency in thinking. However, when a machine is taught the knowledge of their geometrical position in 3-dimensional space and position of their target, they can manipulate with utmost precision. The aim of this project is to test the ability of machines to think based on this geometric coordinates.

A manipulator fitted on the back of a mobile robot will be used for testing the experiments. The aim of this mobile robot manipulator is to locate their target in a cluttered space and pick their target avoiding collisions with environment using feedback data from required sensors.

However, achieving the required task requires the following tasks to be accomplished.

1. Development of an accurate localization scheme based on odometric data for a mobile robot who can position themselves in a 2D space
2. Development of an accurate IK scheme who can estimate the joint coordinates based on the geometrical location of their base and the target.
3. Detection of collision and recalculating Inverse Kinematics based on feedback from sensors.
4. Improving the accuracy of manipulation.

1. **Development of an accurate localization scheme based on odometric data for a mobile robot who can position themselves in a 2D space:**

   The theoretical formulas to estimate the current position of the dynamic system in a 2D workspace who has their knowledge of the starting position in 2D and orientation with reference to Z-axis is obtained from [1]. Calculations were made using the formulas presented in the research paper and a simulation model was developed to validate the calculations. The plot showing the actual trajectory against the calculated trajectory is as shown in *Figure 1*

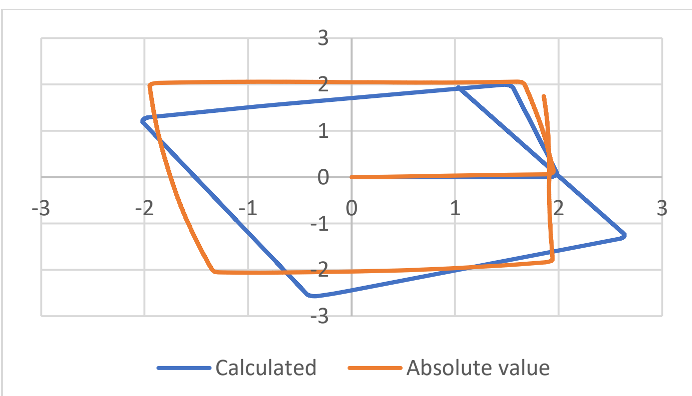

Figure 1:Plot: Uncorrected Position and Orientation of Trajectory

The reason for the huge variation in the calculations can be interpreted with a small analysis of the formulas.

$$X_{n+1} = X_n + d_{center}.Cos(\theta_n)$$

$$Y_{n+1} = Y_n + d_{center}.Sin(\theta_n) \qquad [1]$$

$$where\ \theta_n = \theta_{n-1} + d_{rot}$$

$$d_{center} = \frac{d_{right} - d_{left}}{2}$$

$$d_{rot} = \frac{d_{right} - d_{left}}{d_{base}}$$

here, X_{n+1}=*Increment in X - Direction*

Y_{n+1} = *Increment in Y – Direction and*

d_{rot} = *Rotation around the centre of the body (Orientation)*

d_{center} = *Relative movement of the centre of the wheel axle with reference to the wheel movement*

A closer analysis of the rotary to linear translation of the odometric formula shows

$$d_{right}/d_{left} = \frac{\pi d}{360} * \Delta\omega + \delta d + \delta\omega \qquad [2]$$

Where

$\Delta\omega = Change\ in\ angular\ position\ for\ wheel\ rotation(\ also\ from\ angular\ velocity)$
$d = Diameter\ of\ the\ wheel$
$\delta d = First\ order\ error\ due\ to\ the\ accuracy\ of\ the\ diameter\ of\ wheel$
$\delta\omega = First\ order\ error\ from\ the\ number\ of\ revolution$

The above stated errors are added for every time step thus leading to abnormal position tracking.

However, the calculations need to be improved to reduce the error caused due to the variation in the above calculations. From the plot, it is observed that major error factor contribution is due to the miscalculation in determining the orientation of the body.

Using the API of the simulation tool, the orientation of the body was obtained for every time step and the calculations were made with the orientation determined from the simulation tool against the calculations used in *Figure 1*. This method improved the quality of the calculations performed improving the accuracy of position determination. A plot of the calculated values against the absolute values are shown in *Figure 2.*

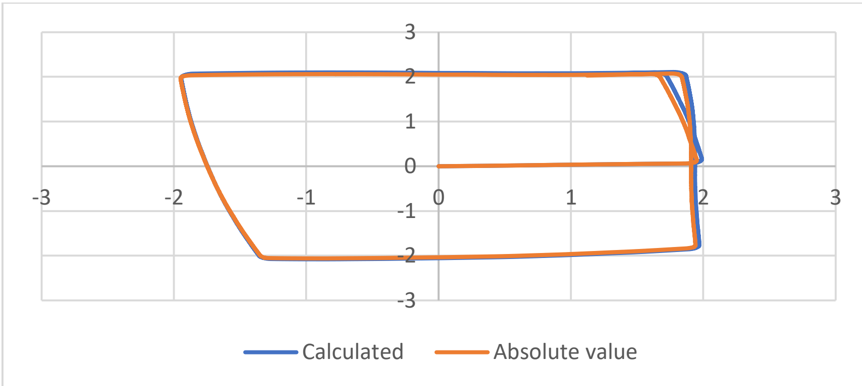

Figure 2: Plot Corrected Orientation and Uncorrected Position

From the figure, it is observed that the error has been minimized by correcting the orientation of the body. This enables us to understand that the major component of the error is contributed by the orientation calculation of the formulas. The orientation can be corrected by using simple magnetic compass fitted over the body of the rover. However, care should be taken to study the effect of external components on the determination of the orientation using the magnetic compass adding to the accuracy of the magnetic compass.

It is to be noted that there is a small variation in the position of the rover detected against the absolute value in *Figure 2.* This variation can be visualized in Figure 3.

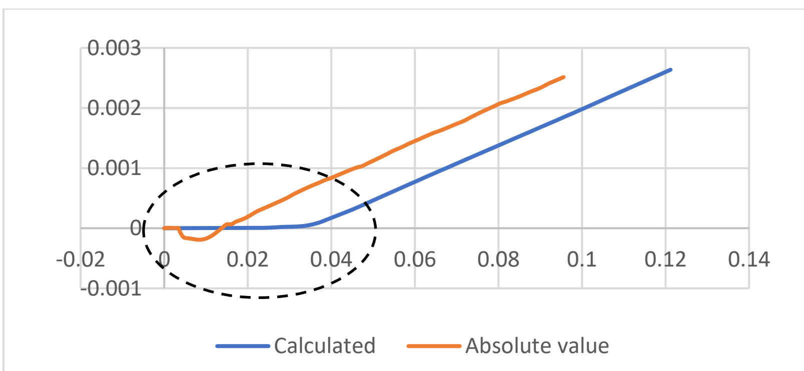

Figure 3: Error caused in the position determination using 2D localization formulas

During the beginning of the simulation, due to the shift of the center of mass (COM) there is a jerk in the body of the rover, which is neglected in the calculated localization values. This error along with the roundoff error added for every time step cause the variation in the 2D location values calculated. In order to study and minimize the effect of this jerk, a 4-wheeled model of the same is developed to study the above performed simulations and their accuracy respectively.