I. Introduction

This project aims to evaluate the three localisation algorithms Extended Kalman Filter (EKF), Markov Grid Localisation, and Adaptive Monte Carlo Localisation (AMCL with KLD-Sampling). This is because there are three distinctive approaches where EKF uses a continuous Gaussian, Markov Localisation is a grid-based approach and AMCL uses sampling based approach. This gives us an overall experiment of which of these algorithms can excel in handling different localisation problems and the trade-offs that are incurred in the process. Common examples to be tested are the noise and initial location. Experimenting this would result in a wide spectrum of comparison that will enlighten the roles and avenues of each of these algorithms whilst understanding the true limitations of each localisation method. Accurate localisation is a fundamental aspect of intelligent robot behaviour since navigation and decision-making heavily depend on it. The major part of this project would be the understanding of underlying concepts of how each method works and why certain algorithms are well preferred over another in robotics.

II. Methodology

For this project we will be performing a comparative analysis between all three algorithms within a controlled simulation environment. Noise is one factor that is very prevalent when it comes to localisation and it will be tested with all these three selected approaches to see how they perform under these changes given the same robot. We will be experimenting against a few other factors that are connected to be a primary challenge in the localisation arena to make sure that the outcome of the project is not only based on a singular variable but a few others. For a stronger basis for our experiments we have selected a few papers and we are using it as our reference for variable control settings like noise level, tracking issues, and sensor parameters. In this project we will be mainly focusing on how each algorithm's differences in architecture and concepts performs in these uncertainties and conditions. To ensure a fair and measurable comparison, we will assess each method’s accuracy and computational efficiency under varying noise and uncertainty levels. Our main contribution is developing a unified testing environment that allows fair and consistent comparison between different localisation algorithms.

III. Hypothesis and Experiment Design

Experiments will be conducted entirely in Webots using a single 3-D world with a derived 2-D occupancy map. The TurtleBot will follow predefined trajectories under varying noise and initial-uncertainty conditions. Each run will produce odometry, LiDAR, estimated pose, and supervisor ground-truth logs. Using the outcomes that have been logged we can compute the accuracy, robustness, and computational efficiency of each individual algorithm for the varying situation. In our project we also aim to make the experiment repeated with different seeds to make sure we are getting the true understanding and error values for each algorithm under the variables. Below are the initial hypotheses that guide our experimental evaluation

- All three localisation algorithms can operate on a known map but will differ in accuracy and efficiency under changing motion and noise conditions.
- The EKF is expected to perform well on smooth paths with low noise but lose accuracy as motion and sensor noise increase, while Grid Localisation stays more stable but requires greater computation.
- AMCL with KLD-Sampling should keep good accuracy even with noise and uncertain initial poses, offering better efficiency through adaptive particle use.

IV. Project Distribution

Hao Lin	: Implements EKF localisation and tuning under different noises
Rohit Sonar	: Builds grid-based localisation using LiDAR and 2-D occupancy map.
Herish Chaudhary	: Builds AMCL with adaptive particle filter (KLD-sampling).
All	: Create the map, set robot parameters, design trajectories, and analyse results.