# Localization in Unknown Environment

"Simultaneous Localization and Mapping" (SLAM). SLAM involves creating a map of the unknown environment then determining robot's location in this map.

There are many sensors used for it like:

Ultrasonic sensors: these sensors are mostly used for nearby objects by using sound wave.

Wireless Beacons: Placing beacons in unknown environment to emit signal for robot to help it for localize its place.

IMU: IMUs measure acceleration and angular velocity to know robot's movement.

Cameras: provides pictures for surrounding environment. Computer vision can be used for detecting edges, landmarks that helps in localization.

Some algorithms to solve these problems:

**Particle filter :** Particle Filter, also known as Monte Carlo Localization, is a probabilistic approach that represents the robot's position with a set of particles.

to start the algorithm, we need the initial belief state, p(x0 ). This is just our initial guess. For robot localization, if we have no idea, we can just scatter particles all over the map,. For each time step, we then loop with three phases: prediction, update, and resample.

$$p(x_t \mid d_{0\ldots t}) = \mu p(z_t \mid x_t) \int p(x_t \mid u_{t-1}, x_{t-1})\, p(x_{t-1} \mid d_{0\ldots t-1})\, dx_{t-1}$$

This equation consists of three party first part is Resample then update then Prediction.

Prediction: for each particle, sample and add random, noisy values from action model

Update: each particle's weight is the likelihood of getting the sensor readings from that particle's hypothesis

Resample: new set of particles are chosen such that each particle survives in proportion to its weight

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**EKF(Extended kalmain filter):** These are used for sensor fusion, combining noisy sensor measurements to estimate the robot's state and its covariance. They can be used for both mapping and localization.

In EKF-SLAM, the map is a large vector stacking sensors and landmarks states, and it is modeled by a Gaussian variable. This map, usually called the stochastic map, is maintained by the EKF through the processes of prediction (the sensors move) and correction (the sensors observe the landmarks in the environment that had been previously mapped). To achieve true exploration, the EKF machinery is enriched with an extra step of landmark initialization, where newly discovered landmarks are added to the map. Landmark initialization is performed by inverting the observation function and using it and its Jacobians to compute, from the sensor pose and the measurements, the observed landmark state and its necessary co- and cross-variances with the rest of the map. These relations are then appended to the state vector and the covariances matrix.

**Visual SLAM:** Visual simultaneous localization and mapping (vSLAM) algorithms use device camera to estimate agent's position and reconstruct structures in an unknown environment. As an essential part of augmented reality (AR) experience, vSLAM enhances the real-world environment through the addition of virtual objects, based on localization (location) and environment structure (mapping). From both technical and historical perspectives, this paper categorizes and summarizes some of the most recent visual SLAM algorithms proposed in research communities, while also discussing their applications in augmented reality, mapping, navigation, and localization.

In general, Visual SLAM algorithms have three basic modules: initialization tracking and mapping .The initialization consists of defining the global coordinate system of the environment to be mapped, as well as the reconstruction of part of its elements, which will be used as a reference for the beginning of the tracking and mapping. This step can be quite challenging for some visual SLAM applications. The next section of this paper is split into three categories: monocular based, stereo focused, and monocular and stereo focused vSLAM algorithms. In detail, each algorithm is described along with its advantages and disadvantages.