# I am a title (RO SLAM Methods/Implementation Survey)

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***Abstract*—This is my abstract, there are many like it, but this one is mine. Will fill this in once paper is written ******

**An survey of current the current implementations and methodologies used for solving the range only systematic and localization problem (RO-SLAM).**

## I. Introduction

## II. range only sensors/tech

## III. Methods...

### A. EKF

The Extended Kalman Filter (EKF) is one of the most popular and widespread methods used to solve the SLAM problem. It is used to overcome the assumption of linear state transitions and measurements, which are rarely seen in practical environments. [1]. The derivation of the EKF is very well documented, as such, detailed explanations can be viewed from a variety of sources such as: [1] [2] [3]. When used to solve SLAM the map applied to the EKF is a feature based map, meaning it is composed of observable features (landmarks) which can be distinguished between during re-observation.[1] This distinction becomes important when examining range only SLAM (RO-SLAM) where only the range to a landmark, or the range between landmarks, is known. This restriction means that landmarks need to be manufactured, such as those discussed in section II, and physically placed in an environment.

A system for robust range only localiztion was prosed by Olson [4]. The system utilized an Autonomous Underwater Vehicle (AUV) and beacons without carefully surveyed locations. A method for outliers rejection was accomplished via spectral graph partitioning. A voting scheme was implemented similar to a Hugh transform to get approximate beacon locations [5]. The approximate location was then incorporated into an EKF. The methodology was simulated using a dataset from the GOAT'02 experiment.

Multipathing and noise presents major obstacle to any radio frequency based RO-SLAM solutions. Research and experimentation has been conducted to determine how these effects can be mitigated without the use of specialized equipment. Fabreese presents a pre-filtering algorithm to be applied to range measurment before being used in the EKF in order to reduce these effects [6]. The author also validates and expands upon this method through indoor and outdoor experimentation with an Unmanned Aircraft System (UAS). [7].

Vallicrosa presents a solution utilizing a Sum of Gaussian (SOG) filter for a single range only beacon. The filter made use the EKF by representing each Gaussian in the SOG as a complete EKF [8]. Results are given from a simulated environment.

Several techniques have also been implemented that involve cooperative sensors. The sensors in these cases are able to determine the range between themselves and other sensors and or the robot. In scenarios where the location of the landmarks is unknown and each landmark can not communicate with all other landmarks, Djugash presents a solution. He proposes that a moving beacon be used to add edges to the network [9]. In addition, no external position sensing were required on the part of the moving beacon, but the option for it to be incorporated is open.

Torres-Gonzalez explains that methods utilizing inter beacon measurment should incorporate measurements with a configurable number of hops between beacons. This allows for the robot to gather range data from beyond the extent of the robots sensors [10]. Based on testing with an EKF, his results showed that the more hops that were added the greater the performance of the system.

One of the complications with RO-SLAM involves the issue of determining the location of landmarks when their initial placement is unknown, the EKF is especially sensitive to poorly initialized landmarks.

### B. Graph SLAM

### C. Particle

### D. Graph

### E. Fast

## IV. Conclusion

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