A Simple ultrasound GPS system for Indoor Mobile Robot System

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Problem Statement:

Abstract:

A GPS module available in the market can pin point its location on Earth by returning the coordinates of latitude & longitude by receiving determining its distance from GPS navigational satellites that stays in high altitudes, orbits around the Earth continuously streaming its position with respect to Earth.

Though these GPS modules have a lot of applications, they tend to have very low accuracy when considering small scale systems where more degree of precision is required, whereas GPS modules tend to have only (+/-) 5m of accuracy & most GPS signals fail to enter the roofs of indoor systems.

To counter this problem a specialized **indoor GPS system** is needed. In most cases this is done through image processing by having a camera at the top and recognizing the position of target(s). But this system requires the ground to be of an even texture, with optimal lighting conditions. So a GPS system which uses virtual indoor satellites which works by using ultrasound pulses as transmission medium can be chosen, as:

(i) Ultrasound is much slower than EM waves, as sound is much slower than light. This allows us to achieve more precision based on time taken for sound to travel b/w satellite & target (Time of Flight - TOF).

(ii) The signal is not affected by external lighting conditions, color/texture of target (or) ground & noises created in the audible frequencies.

Basic Task:

In the basic task I intend to make a simple ultrasound GPS system by getting distances of target from ultrasound satellites and calculating its position, by intersection of louses (circles) of target w.r.t. the satellites.

A system of ultrasound indoor satellites, is made by either having 3 satellites in the ceilings/ (raised height facing down) (or) placing 2 satellites on 2 corners of a room/ (region where bot is to be tracked), raised to some height.

A target module is placed on the floor which measures its distance from the satellites and calculates its distance from them at regular intervals, and determines the position (coordinates) of the target in the room.

-The coordinates of the stationary satellites will be hard coded.

-To calculate the distance of target from the satellites, either the satellite system can be made to transmit ultrasound pulse & target`s system to receive the pulse (or) vice versa. The time taken between transmission & reception will be used to calculate the distances.

-All the ultrasound satellites will be connected to a single microcontroller through wires. The target will have another microcontroller with an ultrasound transmitter/receiver.

-Calibration of clock time between the satellite microcontroller & the target`s microcontroller will be done with the use of IR transmitters & receivers (using TSOP protocol).

Advanced Task 1:

This task involves application of Kalman filter in code to minimize errors caused in ultrasound sensors to get a more precise location.

Due to the characteristics of ultrasonic sensors, noise occurs in sensor values by surrounding temperature or obstacle. Location error is minimized by prediction and correction of the noise with Linear Kalman Filter.

Advanced Task 2:

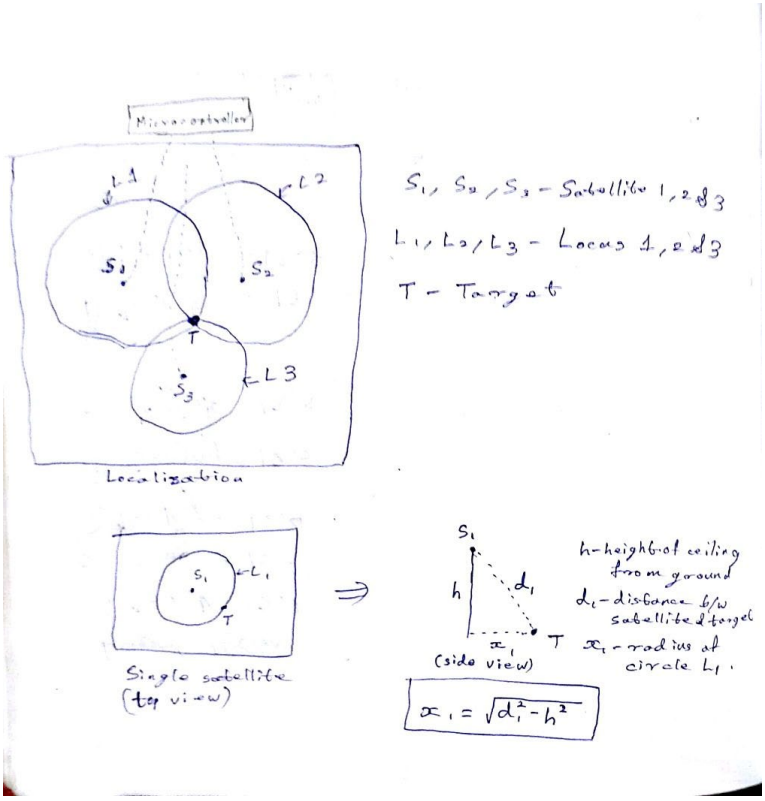
This task involves making a bot that traverses paths using the continuous coordinates received from the sensors.

If the “target module” created in the previous 2 tasks is enough accurate & consistent, it can be attached & integrated with a differential drive robot, and can made to travel along a line a reach a destination whose destination is specified by a user, from a mobile app via Bluetooth (or) the bot can also be made to travel along predefined paths.

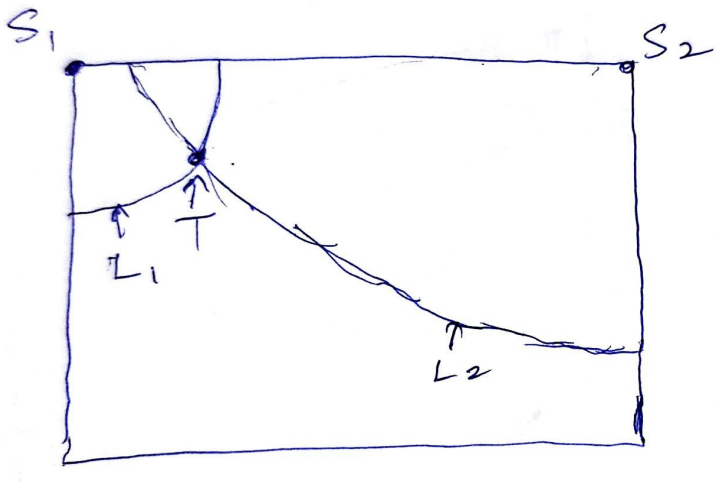
Time duration: 2 months

2 Possible plans of implementation:

(i) Localizing using 3 Satellites:



Localizing using 2 corner Satellites:



As intersection of 2 quarters of a non-consecutive circle gives a single point, 2 satellites are alone enough.

Things required:

- 2 Microcontrollers (mostly ATmega328p)
- Bright IR led(s)
- 1 x TSOP1738 IR Receiver
- 6 x HC-SR04 or any other ultrasound transmitter/receiver if better
- Bluetooth mode for advanced task
- Differential drive robot for the other advanced task, with Motor driver, battery, wheels, etc...

Main algorithms to implement:

- Communication between Target`s microcontroller & Satellite`s microcontroller with IR transmitter & receiver using **TSOP protocol**.
- Implementation of Linear **Kalman filter** to improve accuracy.

In case the tasks mentioned till now gets finished soon, the Advanced task 2 can be made more difficult, else another Advanced task could also be added.

-Thank You