Indoor Localization using TDOA technique

Meetha V Shenoy
Department of EEE/ENI
BITS-Pilani,K K Birla Goa Campus
NH-17B,Zuarinagar,Goa-India-403726
meetha@goa.bits-pilani.ac.in

Anupama K R.
Department of EEE/ENI
BITS-Pilani,K K Birla Goa Campus
NH-17B,Zuarinagar,Goa-India-403726
anupkr@goa.bits-pilani.ac.in

Ch.S.Sankhar Reddy
Department of EEE/ENI
BITS-Pilani,K K Birla Goa Campus
NH-17B,Zuarinagar,Goa-India-403726
sankhar@goa.bits-pilani.ac.in

ABSTRACT
The system which we propose to demonstrate for indoor localization competition is based on Time difference of arrival(TDOA) technique.Using our custom made hardware we could achieve localization of a mobile node by distance estimation from beacon nodes by using time difference of arrival between RF and ultrasonic signals and subsequent lateration operation. We also have developed a system for achieving localization of a mobile node using Odometry and TDOA technique which can achieve the localization with very few beacon nodes while ensuring large coverage of area.

General Terms
Localization Technique

Keywords
Ultrasonic,TDOA, Odometry,Dead Reckoning

1. LOCALIZATION TECHNIQUE
In this session we describe two approaches used by us for indoor localization. The primary criteria while developing both approaches was to develop a low cost localization system which is capable of achieving a reasonable trade off between the localization error and the time required for localization so that the same can be used for real time tracking of mobile objects.

Approach 1 : In this approach we use the well known method of TDOA or time difference of arrival technique to obtain the localization.We have designed the hardware which can function as mobile node or a beacon node.The custom built hardware unit(wireless mote) is equipped with ARM Cortex M4 based micro-controller as the processing unit.In-addition to providing low interrupt latency,the ARM Cortex-M4 processor,also provides fixed interrupt latency and near-zero jitter which is critical in achieving a precise localization.The hardware unit is also equipped with RF transceiver module .We have also desinged a 40Khz ultrasonic transmitter and receiver module with a range of approximately 10 meters.We designed a suitable arrangement of the ultrasonic transducer so as to obtain a near 360 degree propagation of ultrasonic signals. The mobile node will initially calculate its distance from the three beacon nodes using TDOA technique and then use trilateration is used to obtain the (x,y)position of the mobile node.

Approach 2: A modified version of the localization is developed for mobile robots using odometery and TDOA technique described in approach 1.In this technique we perform dead reckoning in which the robots estimate their position with the help of wheel encoders and compass module.However to reduce the accumulation of error when the robots travel a considerable distance we use the TDOA technique mentioned before . Thus information fusion is done on compass data,encoder data and the calculated TDOA.This method would allow the mobile robots to localize and achieve a real tracking system with very few beacon nodes.

2. DEPLOYMENT REQUIREMENTS
For the demonstration of Approach 1, a person will carry the mobile node and we would need tripods or suitable arrangement to mount the beacon nodes on walls, approximately at the same height as that of the mobile node. The number of beacon nodes will depend on the area to be covered.Currently we are working on improving the range of ultrasonic sensor so that the number of anchor nodes can be reduced as well and a better accuracy of localization can be obtained. As of now to obtain an average accuracy of .60 meter and to ensure coverage of an area of 2500 square feet we would require at least 8 anchor nodes.All devices used for localization are battery operated and hence we dont have any specific power supply requirements.

If the rules of the competition allow to use a mobile robot (miniature wheeled robot-diameter 15cm) to carry the mobile node we can demonstrate approach 2 which uses odometry and fusion of TDOA to obtain precise localization with less number of beacon nodes.This method was developed for the localization of a group of robots.

3. CONCLUSIONS
We are working on the performance improvement of approach 1 as with the current hardware platform(Microcontroller and RF circuits) a theoretical accuracy of less than 10cm can be achieved.More improvement is needed in filtering of the received Ultrasound signal.The focus is also on reducing the number of anchor nodes by improving the ultrasonic transducer board design. If the same is achieved,accuracy of approach 2 will also improve and we will require fewer beacon nodes for the same area of coverage as compared to approach 1.

4. REFERENCES

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