A Localization System for the Emergency Department

Jules Fakhoury, Quang Dung Ho, and Tho Le-Ngoc

McGill University, Department of Electrical and Computer Engineering, Broadband Communication Lab

Introduction

Interest in RFID or positioning systems for clinical applications has been growing recently. Specialized medical equipments have been successfully tracked using such positioning systems, thus reducing the time wasted by clinicians looking for them through hospital facilities. Extending the location and positioning technology from only equipment to clinicians and patients opens the door to a new set of applications, whose potential for time and cost savings are appealing.

In this research, we aim to deploy, improve, and use an ultra-wideband (UWB) based location system to carry out mainly workflow related studies in a clinical environment. In order to enable advanced location-assisted information technologies into a clinical facility, it is necessary to reach a certain level of reliability and precision on the location estimate. The focus of this work would be on the deployment of the location system in the emergency department (ED) of the Royal Victoria Hospital and the applications associated with this system.

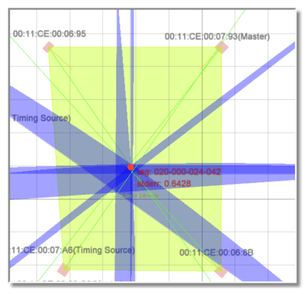
UWB Localization

•UWB systems are characterized by a very large bandwidth and short-time pulses.
•Short pulses provide time resolution, making UWB a good potential for ranging and localization.
•A large bandwidth improve the reliability as the signal contain different frequency components, which increases the probability that at least some of them can go through obstacles.
•Spreading the signal energy over a large bandwidth decreases the power spectral density, thus reducing interference to other systems in the hospital.

Methods

Combined AoA, TDoA technology:

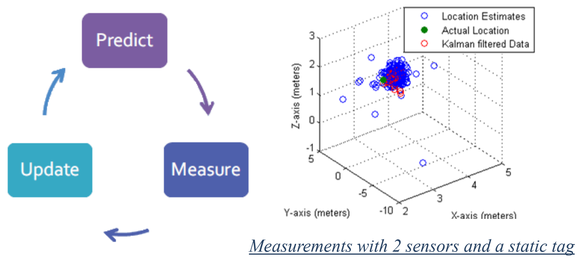
•The system performs measurement of both pseudorange (based on TDoA) and AoA
•More measurements per sensor make the system more robust
•Using both TDoA and AoA means that the location can be determined using fewer sensors



Green lines represent the AoA seen by each sensor, while blue curves represents the possible tag positions that would have generated the TDoA

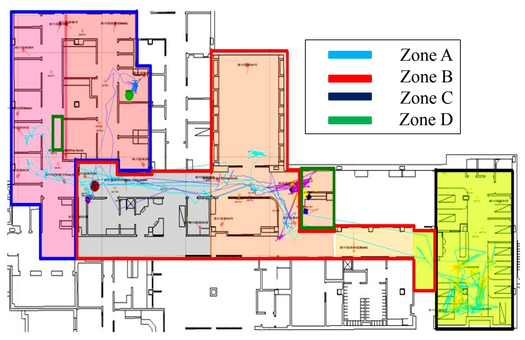
Filter-based location algorithm:

•Sensors include information filters algorithms that use models of object dynamics to enhance location accuracy of dynamic and static objects in a variety of environments, eliminating reflections and ambiguous data
•Algorithm works in an iterative manner by combining the previous estimate of the position with the current measurements



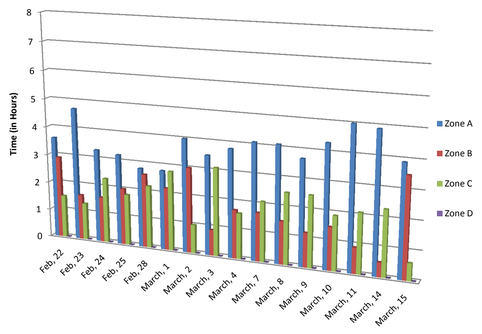
Measurements with 2 sensors and a static tag

Data Acquisition

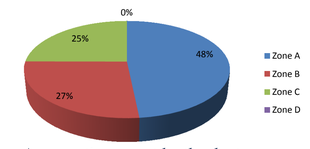


Tags in the Emergency Room of the Royal Victoria Hospital

•The system estimates the position of many doctors during their shift in real time.
•The information about the position of the doctors can be used to extract useful information such as the time spent in each zone and the number of transits between zones.
•Special attention must be taken at the boundaries since the position estimates can fluctuate between zones due to erroneous measurements.



Time spent by the doctor in each zone during the monitored days



Average time spent by the doctor

	Zone A	Zone B	Zone C	Zone D
Zone A	0	6	0	0
Zone B	6	0	4	0
Zone C	0	4	0	0
Zone D	0	0	0	0

Number of transits between zones for the doctor

Applications

Management of the Medical Staff

The location system can be used for offline studies of clinical workflow patterns, and for the non intrusive assessment of bottlenecks in clinical processes.

Healthcare Asset Tracking and Management

Tracking of specialized medical equipment would reduce the time wasted by clinicians looking for them throughout the ED facility.

Patient Monitoring

A precise location system in the ED would enable staff to track patients in a timely manner, ensuring accurate and consistent delivery of care.

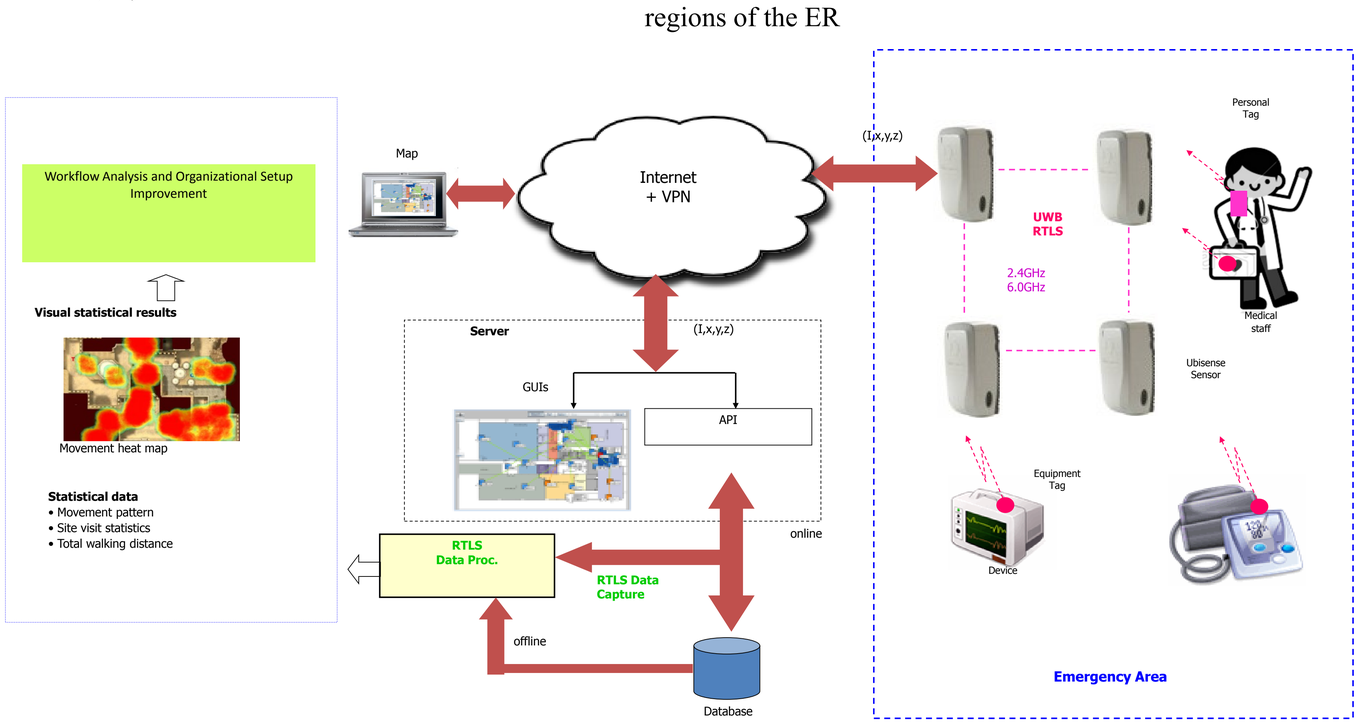
RTLS Architecture

Tags

•Transmits UWB radio pulses
•Flexible update rate
•Comes into 2 forms: slim and compact
•Slim tags are used for the medical staff and patients
•Compact tags are used for equipments (ECG monitor, mobile ultrasound, scanner,…)

Sensors

•Detects UWB pulses from tags
•Contain an array of antennas which can measure the Angle-of-Arrival (AoA) and Time-Difference-of-Arrival (TDoA) of tag signals.
•Multiple sensors are daisy-chained through a wired link
•26 sensors were used to cover most of the regions of the ER



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Conclusions

UWB Localization:

•Our UWB-based location system performs measurements of both AoA and TDoA.
•Information filtering uses the predicted position from the previous time step as well as the measurements from the current time step to compute the position estimate.
•The reported accuracy in 3D is 15 cm.

E-Health Applications:

With the burgeoning of health care technology, more and more systems throughout hospitals are becoming automated, including those in the ED. A localization system would open the door to a new set of applications and gives healthcare facilities better visibility into their processes.

References

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