Submission for the Microsoft Indoor Localisation Competition 2017

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ABSTRACT

We submit this extended abstract as an entry for the Microsoft Indoor Localisation Competition that will take place in April 2017. Our entry is for the category of *infrastructure-based modified Commercial off-the-shelf (COTS) Technologies*. Our approach will be based on Ultra-wideband (UWB) technology for making range measurements between our custom devices. This collaboration centres around the Automatic Control Lab (IfA, [1]) based at ETH Zürich where we research the localisation and control of robots swarms in a distributed manner, using a fleet of nano-quadcopters as one of our test-beds.

Deployment Requirements and Localisation Approach

Our deployment requires the placement of the fixed infrastructure, referred to as *anchors*, at various positions around the space to be covered by the localisation system, see Figure 1 for an example of our custom hardware. We will require a minimum of 6 anchors to be deployed, and our system will handle up to 20 anchors, where coverage and accuracy increases with the number of anchors. In order to localise the anchors and provide absolute position measurements, a ground truth measurement will be required for any three of the anchors. To provide relative position measurements, no external measurement device is required. The anchor self-localisation approach will be based on Two-Way-Ranging (TWR) measurements between anchors, and then using optimization-based techniques to compute the anchors' locations in 3D space. The developed self-localisation approach requires minimal user input and therefore reduces installation time, calibration costs, and deployment overhead.

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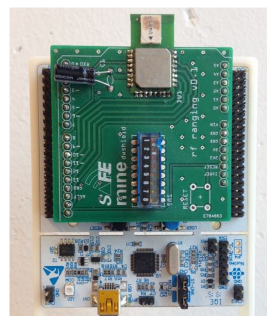

Figure 1: Custom biult hardware, the white board is a STM Nucleo F446RE, and the UWB chip is a Decawave DMW1000 moodule [2].

The position estimate of test locations in the space will be made with the use of an additional portable device, referred to as a *tag*. Once placed at a test location, the tag will perform a TWR measurement to each of the anchors and then use an optimization-based techniques to compute its position estimate in 3D space. A Non-line-of-sight (NLOS) detection method will be implemented so that such measurements can be taken into account without adversely affecting the accuracy of the position estimates. Auto detection of NLOS will significantly improve location accuracy in dynamic environments and in the presence of moving obstacles.

System features and current status

To address issues that commonly arise for UWB-based localisation systems similar to the ones described above [4], our implementation will include the following features:

- Scalability to deploy 6-20 anchors, and to localise multiple tags simultaneously,
- "One-click" automatic self-localisation of the field of anchors to allow for quick and flexible deployment,
- Detection of NLOS measurements to avoid large estimation errors arising from using invalid data,
- Internet-of-Things (IoT) applicability with all computations being performed on a Cortex M4 Micro-Controller Unit (MCU) and a laptop used only for display and interfacing purposes.

Testing indicates that our localisation system will be able to achieve a position estimation bias < 10cm when the tag has line-of-sight (LOS) to 6 or more of the anchors, with an update frequency of 10Hz achieved on our custom built IoT devices. Figure 2 shows experimental results for the localisation of a tag (black circle) within a field of 6 anchors (green squares). Each of the dots is a location estimate of the tag made from one set of distance measurements. The location estimates using a baseline triangulation approach are shown by the blue dots, while the optimisation-based location estimates are indicated with the red dots. This result typifies the improvements we have observed with optimisation-based localisation: reduced bias in the position estimates and smaller worst case errors. Our current work includes experimental investigation of the sources of bias in the position estimates, and developing hardware and software improvements to reduce the bias. We expect further improvements to the localisation accuracy for our competition deployment.

Team backgorund

The Distributed Flying and Localisation project at IfA has been running for almost 3 years, with our work summarised on our website [3]. We focus on resource-constrained devices for both flying and localisation so that the improvements we achieve through algorithmic development can be realised on the mobile robots of today and the future. Our medium term goal for localisation is to develop an UWB-based system that is readily deployed, wireless, and allows an arbitrary number of tags to self-localise via Time-Difference-of-Arrival (TDOA) measurements. On the flying side, we use the Crazyflie 2.0 nano quadcopter, which also runs a Cortex M4 MCU, and aim for collaborative lifting of objects with a distributed control architecture and UWB localisation.

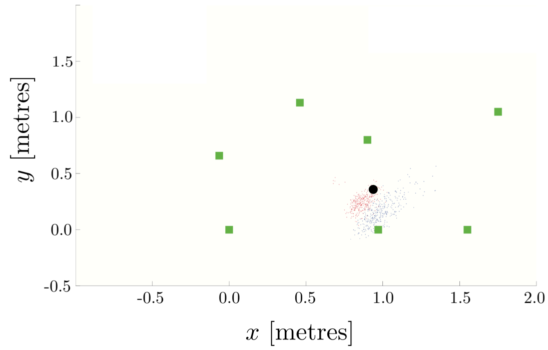

Figure 2: Experimental results for the localisation of a tag (black circle) within a field of 6 anchors (green squares). The dots represent position estimates of the tag via 2 different methods, triangulation (blue dots) and optimisation-based (red dots).

Summary

With a fast and reliable localisation accuracy in the decimetre range that accounts for NLOS situations, our scalable approach meets the precision requirements for a variety of indoor localisation scenarios. We demonstrate this for position estimation of mobile robots but the IoT nature of our technology makes it applicable to many of warehouse and factory specific problems such as people tracking, product placement, and advertising.

1. REFERENCES

[1] Automatic control laboratory (IfA) at ETH Zürich. http://control.ee.ethz.ch.

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[4] D. Lymberopoulos, J. Liu, X. Yang, R. R. Choudhury, V. Handziski, and S. Sen. A realistic evaluation and comparison of indoor location technologies: Experiences and lessons learned. In *Proceedings of the 14th international conference on information processing in sensor networks*, pages 178–189. ACM, 2015.