DESCRIPTION OF THE RESEARCH PROJECT FOR THE SUMMER 2020 RET SITE

Project 2: A Robust Positioning System Development and Its Applications

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Project Summary:

Global Positioning System, or GPS, is a line-of-sight positioning system that is used widely around the world for daily commuting by almost everyone. In the future, robots will be expected to carry out most of the laborious jobs like carrying stuff around in a factory or a supermarket, carrying food in a restaurant, etc. These applications have a basic requirement such as *location* information. One knows that GPS doesn't work so well in a closed environment as there are too many obstacles that keep it out from the line-of-sight of the GPS satellites. This reduces the accuracy of the estimated location and therefore calls for the need for something that can work in closed environments. For this purpose, the ***big idea*** is to develop a robust *positioning system* using cost-efficient sensors. This idea is being pursued by industry leaders like HID Global, Samsung, NXP, and Bosch in a Consortium called FiRa (short for Fine Ranging) [1]. Companies like iRobot [2] and LG have been pushing this technology for automation of home/outdoor appliances,

with Apple claiming to launch new iPhones with Ultra-Wide Band (UWB) sensors for indoor positioning and navigation capability [3].

Each object to be tracked is equipped with a range sensor and is defined as the *"Tag"*. The *"Anchor"* nodes, made by three or more range sensors, are at fixed points with specified coordinates in the environment around the tag. The tag then receives distance information from each of the anchors and uses that information to determine its position relative to the anchors. It is necessary that the tag receives information from at least three sensors in order to determine its two-dimensional position. Figure 1 shows a planned test environment to demonstrate the positioning system technology shown in Fig. 2.

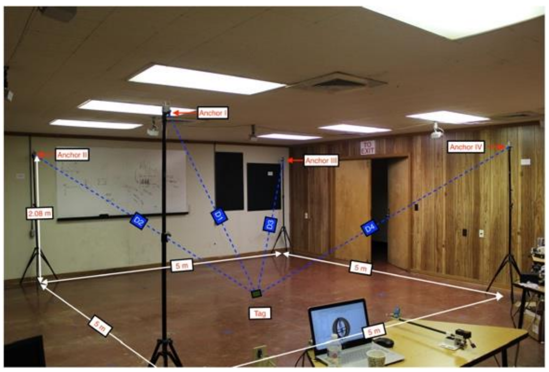

Figure 1: Test Environment Set-up

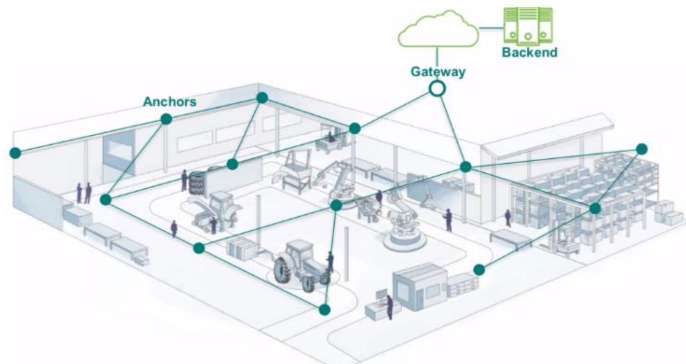

Figure 2: Indoor Positioning Concept [4]

The range sensors that will be used in this project are UWB sensors. The reason behind this choice is that the cost of these range sensors is low, which allows a cost-efficient implementation of this technology. Also, these are low-power sensors and operate over a large bandwidth (>500MHz) while offering very low latency and high data security.

The research ***challenges*** in this project are to: 1) design a technique to reduce noise effects in the received signal in order to improve location accuracy; 2) set up a reliable communication mechanism between the object to be tracked and the tag; and 3) develop an optimal sensor deployment strategy to maximize both coverage and accuracy.

The ***guiding questions*** necessary to address the aforementioned challenges can be summarized: 1) How can this new technology be successfully deployed in public environments?; 2) What are the various filtering techniques which can be employed to reduce the noise in the measurement signals?; and 3) What kind of applications and use-cases can this technology be targeted for?

Training Provided:

The training for the teachers will be provided for a duration of six weeks, and below is the tentative training structure:

1) Study and use digital I/O control, serial communication, and data parsing using a micro-controller unit to gather data from all systems.

2) Construct a positioning system using range sensors based on the knowledge gained and use it to determine the positions of static objects.

3) Understand the behavior of measurement noise and study the various techniques that can be used to filter this noise.

4) Design the filtering techniques and implement the finally selected technique onto the positioning system developed.

5) Perform experiments under various conditions and analyze results.

6) Study various applications of the positioning system developed.

Research Facilities:

The primary research facilities required for this project are the Autonomous Systems Research Laboratory (ASRL) and Robust, Intelligent, Sensing and Control (RISC) Laboratory. ASRL has heterogeneous sensor modules, actuators, a six-degree-of-freedom Stewart platform, micro-controllers, ground test platforms, and a high specification computer system for deep learning research. RISC lab has a state-of-the-art facility to conduct multi-vehicle tests. The facility includes a 16-camera motion capture system that provides millimeter level accuracy that is used to validate the accuracy of cooperative localization algorithms, several unmanned platforms (quadcopters, fixed-wing UAVs, and ground robots) equipped RTK GPS, cameras, and distance finding RF sensors.

Industrial Partner:

Our industrial partner Demeter, Inc. maintains a nearly 3,000 sq. ft. hangar adjacent to and with access to the UAS Test Range at Springfield Beckley Municipal Airport, allowing for 200 square miles of approved UAS testing area with support for Beyond Visual Line of Sight (BVLOS) operation of unmanned systems. This will be very helpful in experimentally validating GPS-denied environments.

Ideas for Classroom Implementation:

The range sensors chosen for this research project are Decawave DWM1001 UWB Sensor Modules. The main reason behind this selection is low cost and power consumption. Also, these modules are easily available to purchase. Therefore, these can be easily acquired for the purpose of classroom teaching and implementation for the demonstration to students. This will allow students to understand the basic principle behind the operation of GPS. The students can also undertake activities like understanding micro-controller units and creating a communication system to receive and parse the data from the range sensor. Another critical thinking activity for the students can be to identify various strategies that can be employed in environments devoid of location services.

References Cited:

[1] J. McGregor, "Ultra-Wideband (UWB) Gains Traction As A Sensing Technology Under New Industry Consortium," 01 August 2019. [Online]. Available: https://www.forbes.com/sites/tiriasresearch/2019/08/01/ultra-wideband-uwb-gains-traction-as-a-sensing-technology-under-new-industry-consortium/.

[2] iRobot Corporation, "Robotic lawn mowing boundary determination," 2016. [Online]. Available: https://patents.google.com/patent/US9516806B2/en.

[3] M. Owen, "AirDrop & device tracking only the beginning of Ultra Wideband in the iPhone," 17 October 2019. [Online]. Available: https://appleinsider.com/articles/19/10/17/airdrop-device-tracking-only-the-beginning-of-ultra-wideband-in-the-iphone.

[4] Ripples IOT, "Indoor positioning digital twin," October 2019. [Online]. Available: https://www.ripplesiot.com/indoor-positioning/.