UWB_Select

A UWB based IOT positioning & control system

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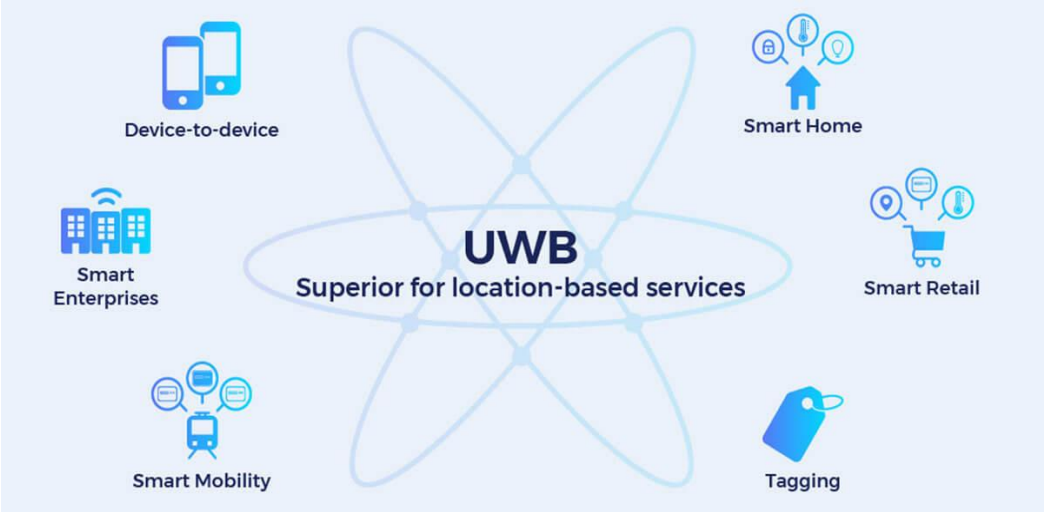
Intro

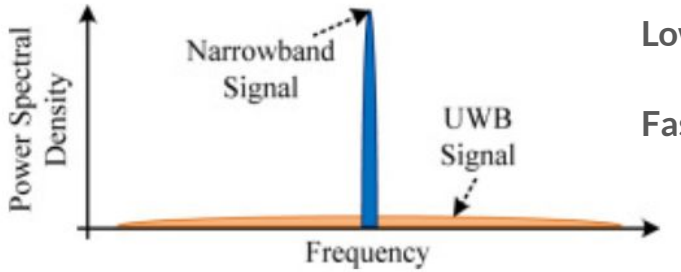
Ultra-Wide Band (UWB):
a radio technology that can use a very **low energy level** for short-range, **high-bandwidth** communications over a large portion of the radio spectrum



Since FCC opens up Ultra-wide band(UWB) from 2002, the applications were focusing mostly on medical and industrial applications.

Over the years, due to the special functions of UWB, it has attracted more and more attention. Especially in the field of Internet of Things.

UWB: Low energy and Good communication



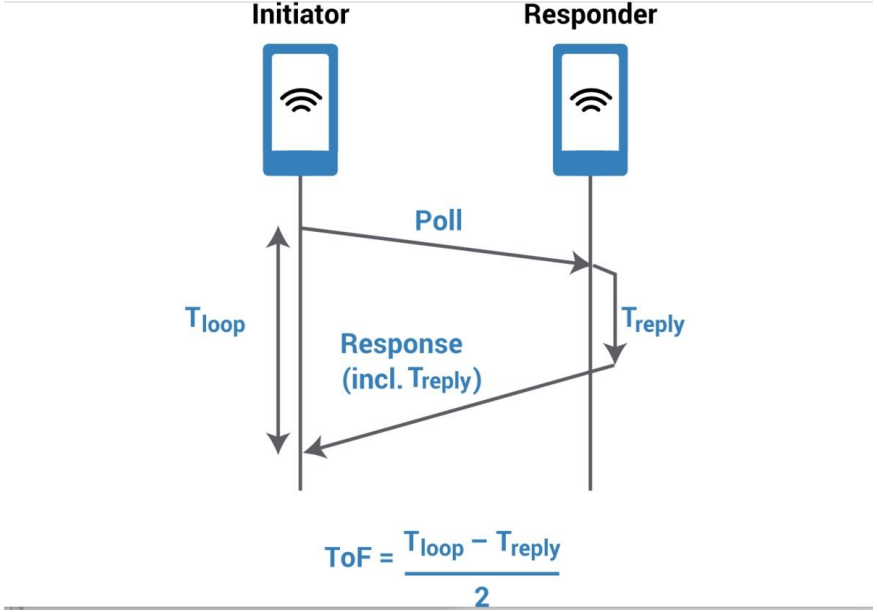
Low energy: prefered in embedded system, especially in IOT systems.

Fast Communication: up to 6, 9 GHz frequency

- Wireless communication security: low power spectrum →
  - easy to dissipate in environment noise → hard to pick up by other
  - can also be directional

UWB: Good Positioning

- Centimeter accuracy
- Up to hundreds of meters range (base on the system's design)
- Is able to support:
  - **Time of Fight (ToF)**
  - Phase Difference of Arrival (PDoA)
  - Received Signal Strength Indicator(RSSI)



Pointing Issue

Make devices smarter:

- Can device recognize that I’m referring to it by pointing at it?
- Can I jump over the setup part and skip remembering all the device names and locations (light1, light2, light 3, etc.) Let device to figure it out.

Project Goal & Aims

Goal:

- Designing a system based on UWB technology to achieve pointing selection of the device and the capability of controlling over gesture

Aims:

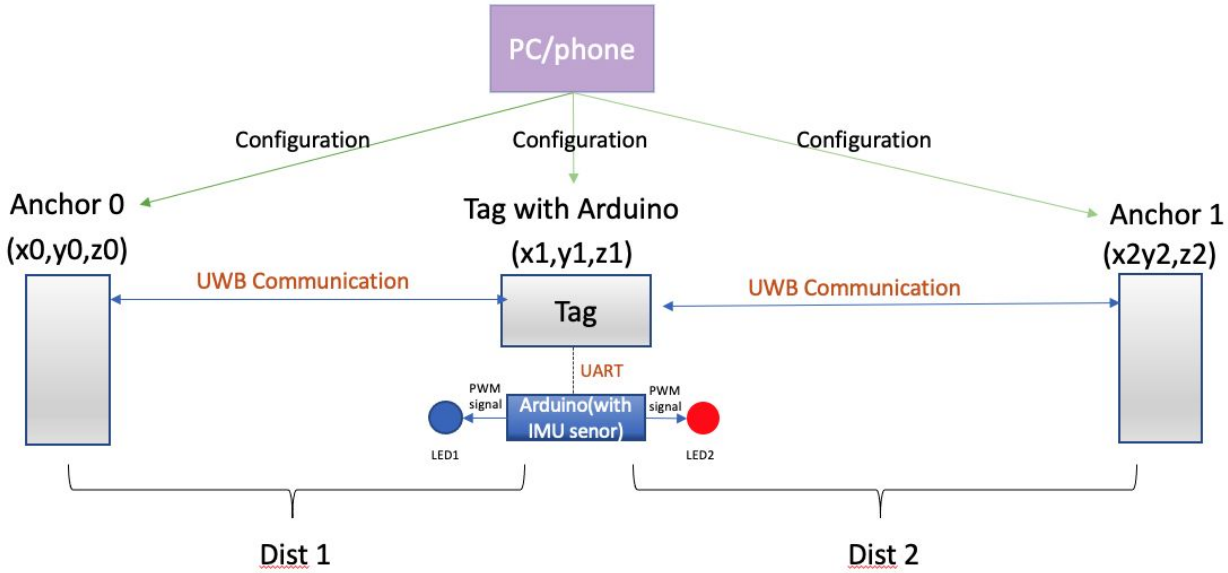
- Implementing UWB indoor positioning system
- Calculating UWB pointing action to select devices
- Introducing gesture control base on IMU sensors
- Improving robustness of the system based on IMU sensor data fusion and filter
- Integration of UWB system and IMU to achieve overall pointing selection and control

Prior Work

- DirectMe: Indoor Navigation System for Visually Impaired People
- Minuet: Multimodal Interaction with an Internet of Things
- Hand Pointing Gestures Based Digital Menu Board Implementation Using IR-UWB Transceivers
- Mathematical Model of an IMU

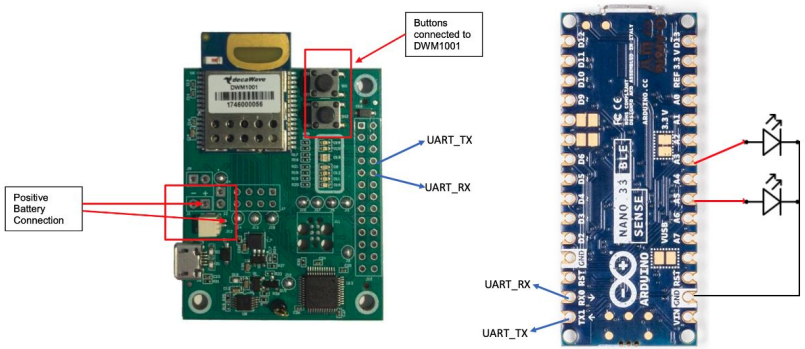
System Components & Overview

1. Decawave DWM 1001 units
2. J-Link driver & Terminal in Mac OS/Android App
3. Arduino Nano 33 BLE sense
4. LEDs



Part I: UART Communication Between Tag and Arduino

Communication principle

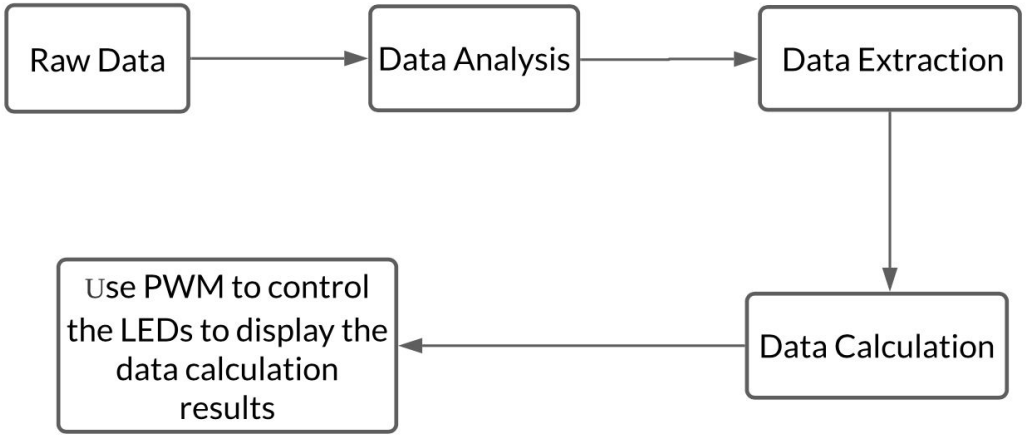


Positioning data got from UWB module

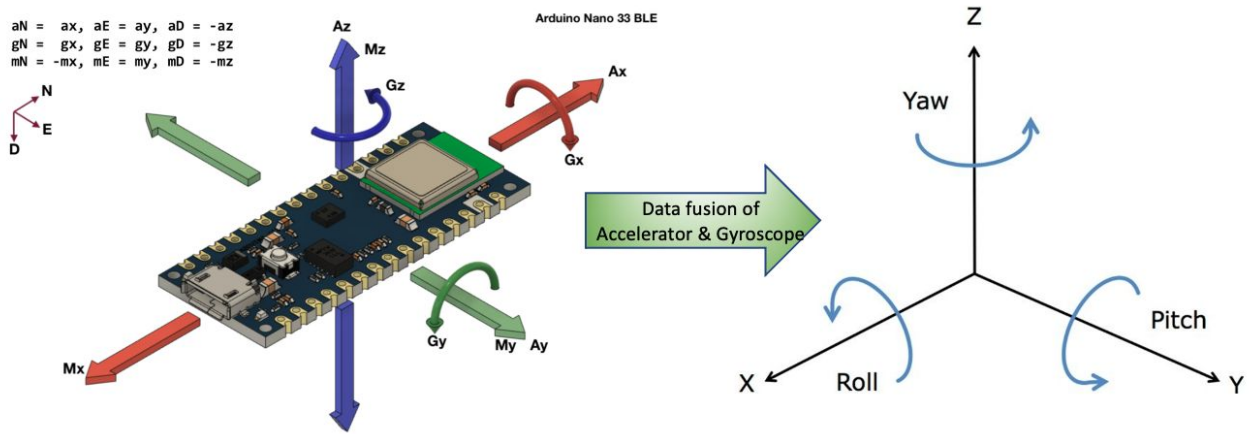
```
22:14:12.289 -> DIST,2,AN0,9C1F,0.00,0.00,0.00,0.32,AN1,4C17,0.50,0.00,0.00,0.28
22:14:13.288 ->
22:14:13.288 ->
22:14:14.277 -> DIST,2,AN0,9C1F,0.00,0.00,0.00,0.32,AN1,4C17,0.50,0.00,0.00,0.30
22:14:15.265 ->
22:14:15.265 ->
22:14:16.281 -> DIST,2,AN0,9C1F,0.00,0.00,0.00,0.30,AN1,4C17,0.50,0.00,0.00,0.70
22:14:17.290 ->
22:14:17.290 ->
22:14:18.263 -> DIST,2,AN0,9C1F,0.00,0.00,0.00,0.37,AN1,4C17,0.50,0.00,0.00,0.70
```

Part I: UART Communication Between Tag and Arduino

Data Processing:



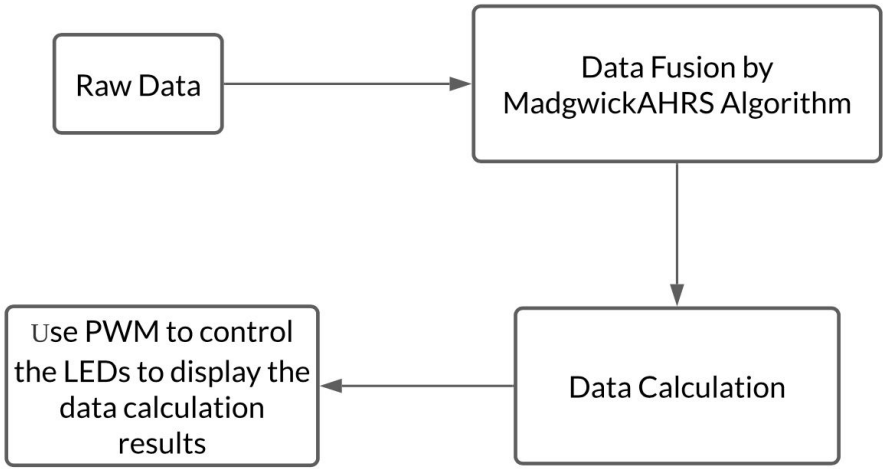
Part II: Using a Built-in IMU Sensor of Arduino to Do the Gesture Control



Data fusion to get the Roll, Pitch and Yaw from Accelerometer and Gyroscope

Part II: Using a Built-in IMU Sensor of Arduino to Do the Gesture Control

Data Processing:



Demo

1. UWB pointing selection https://youtu.be/nipZlUt71tk
2. IMU data acquiring and fusion
    a. Data fusion results https://youtu.be/96_kEfkgSSQ
    b. IMU controls the brightness of LEDs https://youtu.be/eY7SCoWoKno
3. Integration: Selection + Control https://youtu.be/pOg3HAAUCMk

Strength

1. **Accuracy:** The accuracy of UWB can reach the centimeter level, which is required for indoor positioning.
2. **Low Power:** UWB is not only a positioning system, it also has the characteristics of low power and low latency. This is an excellent feature for embedded systems.
3. **Multifunctional:** While realizing indoor positioning, we also added the function of gesture control based on the IMU sensor. This will make this device more robust and useful when we are indoors.

Weakness

1. We can only use two anchors at present due to potential serial communication problems between Tag and Arduino. This will make us temporarily not using the z-axis for calculations.

2. The firmware of the UWB module itself has not been modified. After the modification, there will be more possibilities.

3. Limited gesture control options: due to time constraints

Limitation & Future works

1. Instead of using evaluation kit, use the UWB IC on a PCB design that targeting this system can:
    a. solve the communication issue
    b. more optimization option available
    c. more stable performance
2. Scaling up the system and implement in more real-life environment to make sure the high robustness
3. Embedded IMU data and UWB data increase position and gesture detection accuracy
4. Introduce voice control

Contribution

- Jiacheng Liu:
  - Figure out how to set up and configure the UWB system.
  - UWB-Arduino Communication
  - System and Algorithm Elaboration
- Yibo Wang:
  - Exploring the uwb data acquiring method
  - Code the Arduino to integrate the overall system
  - Acquire the built-in IMU sensor data for gesture control
  - Implement the IMU sensor fusion function

References:

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