

# Fine-Grained Activity Detection in the Kitchen with UWB

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# Chapter 1

## Introduction

This thesis project will investigate how to detect fine-grained action within the meal preparation activity of daily living (ADL) in the home without the use of privacy-intruding cameras. ADLs are common activities that an individual performs inside their homes. These include walking around, eating, dressing, personal hygiene, toileting, transportation, meal preparation, house cleaning, and managing medication. The meal preparation ADL was chosen as the main focus because cooking is a uniquely enjoyable activity while being procedurally dense. Meal preparation can include the following actions: opening the fridge, retrieving ingredients, cutting vegetables, and assembling the ingredients. Monitoring these actions may be used as part of a health monitoring program by enabling the assessment of the presence and length of each individual step in a goal-orientated activity. This information may help guide interventions and track the effectiveness of interventions in clinical populations such as people with dementia or frailty.

Several studies have used features from inertial data to classify these fine-grained action. . .

It is hypothesized that inclusion of context to this inertial data, such as hyper accurate indoor localization (down to 30 cm) to the inertial data can result in higher and more reliable classification of fine-grained ADLs. The system used for indoor localization is the Pozyx Creator Kit which provides a wrist mounted wearable that can obtain data at a maximum of 60 Hz [2]. This data includes position relative to a floorplan, and inertial data from a BNO055 which outputs 3D Acceleration, 3D angular velocity, 3D Linear Acceleration, and the Heading, Pitch and Roll.

Prior to any experiments related to classification of these cooking actions,

the optimal configuration of the system that provides reliable position data had to be investigated. The next section details the different attempts at changing the configuration of the Pozyx Creator Kit to obtain the most reliable positioning data in X, Y, and Z at a satisfactory sampling rate.

# Chapter 2

## System Tuning at the Independent Living Suite

The Pozyx Creator Kit comes with anchors and several tags. Anchors are mounted on the walls and are used to position the tags. Multiple tags may be positioned at the same time. The Pozyx Creator kit uses ultrawideband (UWB) signals with the two-way ranging protocol to localize the tag. The tag is mounted on custom 3D printed wearables which the participant can wear as a wrist-watch or a necklace. Through trial-and-error and consultation with the Pozyx Creator Documentation [3, 1] it was determined that the accuracy of the system depends on factors listed below:

- Number of anchors
- Position of anchors

These variables were modified to achieve satisfactory actual position error and standard deviation below the expected error of 30 cm for UWB systems. The protocol for obtaining data and evaluating the actual position error and standard deviation will be described.

### 2.1 Methodology

This protocol tests the X, Y, and Z positional accuracy of the Pozyx Creator system in the Independent Living Suite (ILS) at the Glenrose Rehabilitation Hospital by having a participant stand at a specific location in each room.

Permanent appliances or furniture such as the stove or dining table were used as much as possible to ensure that the experiment is repeatable.

### 2.1.1 Setup

Masking tape was used to mark the locations where the participant should place their feet. The following procedure was followed to place the tape:

1. Using a measuring tape, measure 1 meter out from the middle of the appliance or furniture and place a 20 cm piece of tape centered on, perpendicular to and underneath the measuring tape (the tips of the participant's toes should be 1 meter away from the appliance).
2. Place parallel tape on the sides of the tape placed in Step 1 to constrain the feet to a box. (The participant should have their toes on the tape perpendicular to the measuring tape and usually facing the appliance or furniture). Figure 2.1.1 outlines some examples of tape placements.

Following the tape placement guidelines outlined at the beginning of this section, tape was placed at or near the following locations. Refer to the AUTOCAD floor plan for the location of the rooms (Figure 2.1.1):

- The Hallway between Living Room and Kitchen facing the Dining Table.
- The Living Room facing the Desk.
- The Bedroom facing the bed.
- The Hallway between the bedroom and the bathroom, facing away from the wall.
- Bathroom facing the toilet.
- Kitchen facing the stove.
- The Hallway between Living Room and Kitchen facing the Dining Table.

### 2.1.2 Protocol

A stopwatch python script was created with predetermined labels and used as the ground truth for positions. A single participant wore the tag on a 3D printed necklace mount (Figure 2.1.2). The measuring tape was used to measure the height from the ground and height when squatting. For this participant, the standing height was **144cm** and the squatting height was **68.5cm**.

The protocol had the following steps:

1. At the first location (Hallway Between Living Room and Kitchen) stand still for 10 seconds
2. Squatt still for 10 seconds.
3. Move to next position.
4. Repeat steps 1-3 until all of the positions have been reached.
5. Finally return to the first position (Hallway Between Living Room and Kitchen)

There were 5 trials for each configuration.

### 2.1.3 Analysis

Trials for each configuration were aggregated, transition periods were removed, data of interest was time normalized and the mean and standard deviation of each location while standing and squatting were recorded.





Figure 2.1: Box tape placement at the stove, fridge, and dining table. Participant's toes and sides of feet should touch the tape.

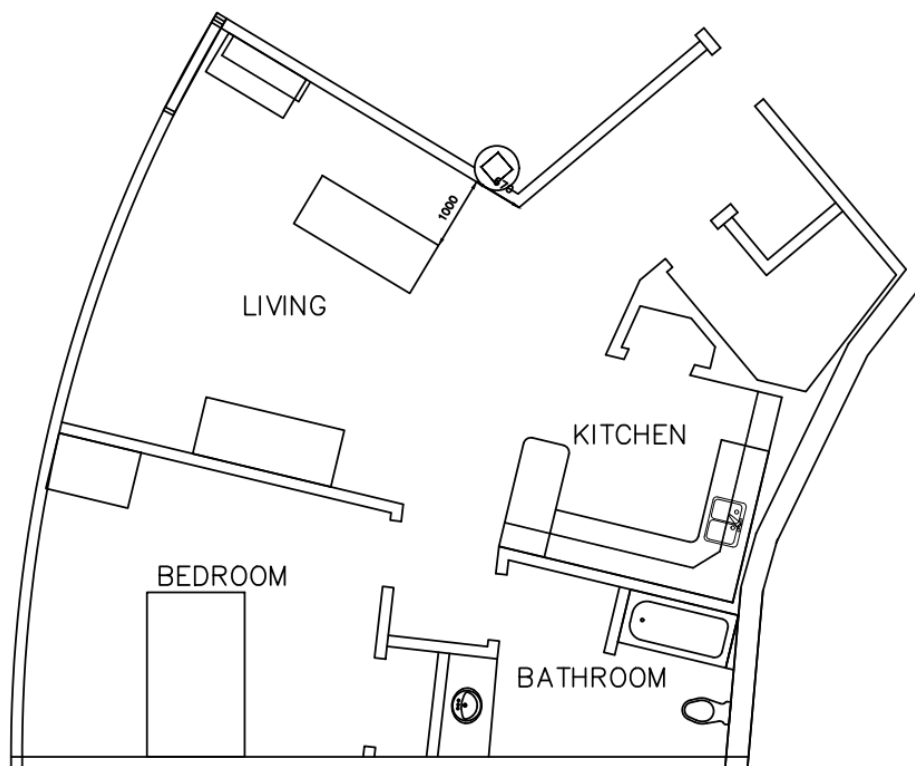


Figure 2.2: Floor plan of the ILS.



Figure 2.3: The Pozyx tag mounted in a custom 3D printed necklace mount.

**Appendix A**

**Appendix**

# Bibliography

- [1] Configuration of the UWB parameters (Arduino).
- [2] Creator One Kit for research and prototyping - Pozyx.
- [3] Hardware setup.