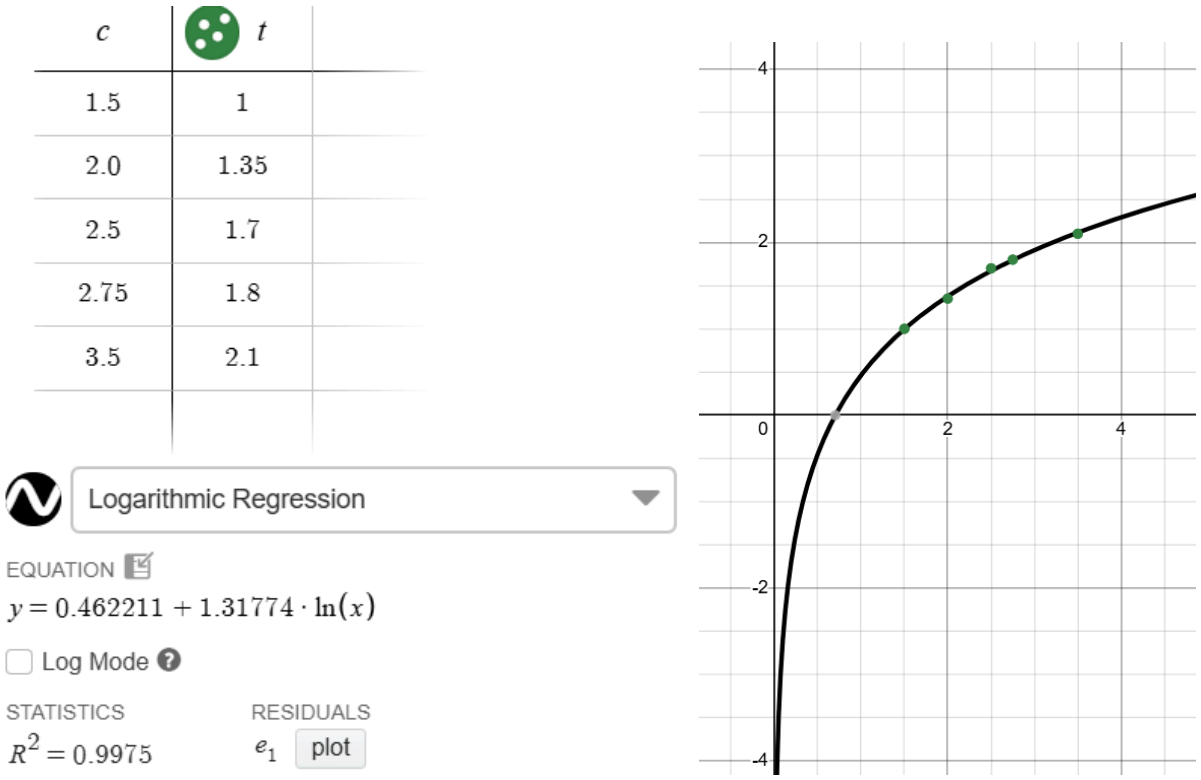
Threshold Distance: Code-to-Truth Conversion Table

Test no.	Code Threshold FOWARD_ENTER / m	True Threshold FOWARD_ENTER / m	True Threshold FOWARD_EXIT / m	Raw Increment / m (Code - True)
1)	3.0	2.1	1.9	-0.9
2)	2.75	1.8	1.6	-0.95
3)	2.5	1.7	1.5	-0.8
4)	2.0	1.35	1.2	-0.65
5)	1.5	1.0	0.85	-0.5



Relationship equation: code value =0.462211+1.31774(ln(true value))

As observed, the dog seems to walk about 20cm past the distance threshold into the hold area due to its high velocity and inertia, which is fine as long as the follow threshold > 20cm

Test Cases

This document outlines the test cases for evaluating the performance and reliability of the "Follow Me" function implemented using UWB triangulation. The robot uses three UWB tags to estimate the user's position and heading relative to itself and generates motion commands accordingly.

Vision60 x UWB - Follow Me Test Cases

Case no.	Environment	Description	Requirement	Expected Behaviour	Result	Notes
1)	Flat indoor ground	User walks directly forward past the threshold distance = TD	Distance threshold	Robot moves forward only when the user is beyond the distance threshold =TD	Pass	
2)	Flat indoor ground	The user stands before the threshold distance = TD and leans slightly forward/backwards	Distance deadzone threshold	The robot does not move, avoids x-oscillation	Pass	
3)	Flat indoor ground	User walks in an arc from right (0°→90°→180°)	Heading threshold	Robot starts turning right as heading > Right threshold angle = RTA	Pass	
4)	Flat indoor ground	The user stands before threshold distance = TD in front (0°)	Stability in hold	The robot holds position without motion	Pass	
5)	Flat indoor ground	The user slowly moves across the turn zone to the forward zone	Forward cone test	Robot moves forward only in the forward cone = FC And turns outside the cone	Pass	
6)	Rough, Asphalt Ground	User walks past threshold distance = TD in forward cone = FC	Robustness to terrain	Follow action still generated reliably	Pass	
7)	Narrow corridor (2m width)	User walks past threshold distance = TD	Straightness of path	Reliability in narrow pathway conditions, does not turn and make off-path movements drastically	Pass	

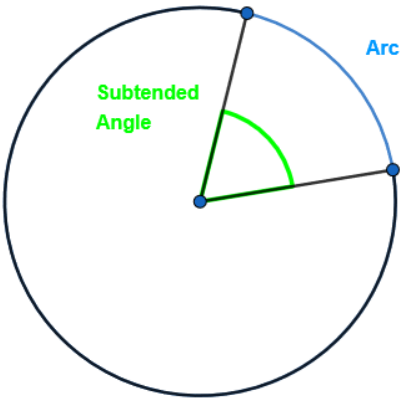
8)	Curbs at curb height = CH	The robot follows the user over the curb	Navigation continuity	Robot continues following without getting stuck/stopping	Pass	
1)	Curbs at curb height = CH	The robot follows the user while walking onto and off the curb on the sides of the robot	Navigation continuity	Robot continues following without getting stuck/stopping	Pass	We even tried making it walk in curvilinear fashion up and down a ramp next to a curb, the dog could manoeuvre just fine.
9)	Obstacle in front	User walks past threshold distance = TD in forward cone = FC	Obstacle test	The robot does not collide and goes to hold	Pass	
1)	Obstacle below	Feet, boxes, bricks and the like near the feet and below the chassis of robot	Obstacle test	The robot does not trip and navigates smoothly	Pass	
10)	UWB reports user before threshold distance = TD, behind	The user behind the dog, to hold	Rear response test	The robot turns in the direction of user's presence in the corresponding sector	Pass	
11)	UWB reports user past threshold distance = TD, behind	The user behind the dog, to follow	Rear response test	The robot turns in the direction of user's presence in the corresponding sector, and then proceeds to walk forward	Pass	
12)	Robot on hold, to move forward	User runs past threshold distance = TD fast	Follow the re-acquire test	The robot moves forward continuously	Pass	
13)	Robot on hold, to turn, then move forward	User runs past threshold distance = TD fast, on the side of the robot for angle > RTA and for angle > LTA	Follow re-acquire test	The robot turns to face, then moves forward continuously	Pass	
14)	Robot bootup	No UWB data	Safety on start	The robot does not move until all distances are valid, and the UWB mode is initialised	Pass (simulated with stm32	

					reset)	
15)	Large area	UWB Anchor Out of Range / Disconnected	Safety on connection loss	Robot holds	Pass	Max range was about 20m, I advise selling the product as 15m max range for safety.
16)	Flat Ground	Sudden loss of one UWB signal (simulate unplugging / reset of tag)	Signal loss handling	Robot holds; avoids erratic behaviour	Pass	
17)	Indoor, tight space	The user quickly rotates around the robot in a full circle	Heading continuity	Robot updates heading reliably without erratic motion	Pass	
18)	Flat ground	The user walks in a zigzag pattern (changes heading constantly)	Path tracking accuracy	The robot follows the updated heading without confusion	Pass	
19)	Flat Ground	2 UWB systems operating at once	Addressing and system independence	Both dogs follow their respective users without interference	Not tested yet	
20)	The robot is near a wall	UWB gives a noisy bounce	Noise rejection	The robot avoids sudden turns/movements, and the proper required action is given	Fail	Near wall is risky movement because of the lack of obstacle avoidance on the sides. However, the dog does turn in the correct direction.
21)	Flat Ground	The user sprints towards the dog while the dog is moving forward towards the user	Reaction Speed of obstacle avoidance	The robot should stop without colliding with the user	Fail	If the user comes towards the dog fast enough (full sprint), it will collide. However, this scenario is decently

						far-fetched and is quite the limit test.

Test Notes:

1. There is an optimal distance between the dog and the user, because of the calibration and interaction between the forward cone angle, and the compounding of circle arc length over an increase in distance / radius - essentially the closer the user is to the dog the better, but it can't be too close or it will stop following



(green arc length < blue arc length, therefore user can walk in a wider arc before the dog turns to face him when the user is very far away)

2. There is a certain amount of interference from being behind a computer screen, behind a person, and even being inside the pouch - what i would recommend is the following:
   a) the pouch is minimal and skeletal as possible
   b) the pouch is worn at waist height (because this is what we have calibrated it to) ~ 95cm - 100cm above the ground
   c) the pouch is worn behind the user (lower back area)
   This combination gives the best follow-me results.

3. There are blind spots to the obstacle avoidance function (mainly the sides, and especially the shoulder to rear area). As such, turning when the shoulder/side of the dog is close to a wall is NOT ADVISED. The user should switch back to RC mode and navigate the dog away from the wall before resuming follow-me.

4. Under hot sun, all mechanical and electrical systems seem to be functioning optimally.

5. Maximum range ~ 20m, best is to stay within a safe operating range of 15m from the dog.

To summarise, the sweet spot calibration we have come to accept is as follows:

1. Forward velocity x = 1.0 (good for outdoor walking)
2. if (heading > 20 && heading <= 180) return "turn_right"
   if (heading > 180 && heading < 340) return "turn_left"
   Essentially, the front deadzone / cone is from 340^{o} to 20^{0} (this angle, the dog will not turn because it deems the user in front of it)
3. if (distance > 2.5) return "forward"

This corresponds to a real life distance of approximately 1.7m, so that the human doesn’t need to be too far in front for the dog at all times.

Subsequent test goals:

1. Implement backward function safely (x=-0.2)
2. Implement variable velocity based on distance from user (so it catches up to user from far, and near it when navigating tight spaces and corners it moves slower)