SECURO DOG

For your Home & Business safety

OUR TEAM

Darragh Flynn(psydf8)

Matteo Romano(psymr8)

Milosz Wojciechowicz (psymw12)

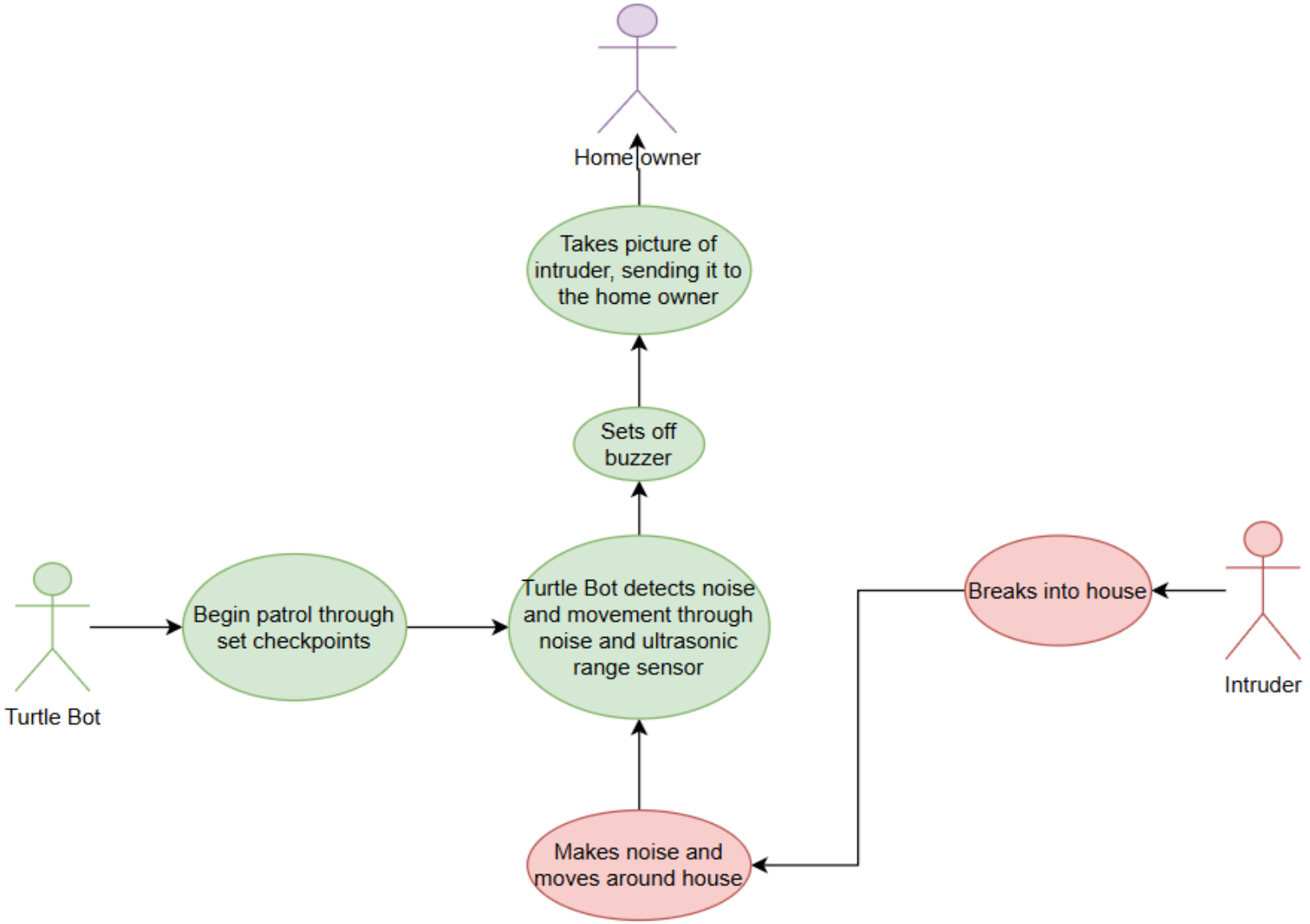
INTRODUCTION

- The goal of our project was to develop a **smart security system** using a TurtleBot that autonomously patrols a predefined route while actively monitoring for potential intrusions.
- The TurtleBot follows a series of waypoints, stopping at strategic entry points such as doors or windows, where it uses an onboard camera to capture images. In parallel, sensors are placed at these locations to continuously monitor for abnormal sound levels or sudden changes in distance—both possible indicators of an intruder.
- When a sensor detects unusual activity, the TurtleBot immediately interrupts its patrol and navigates to the location of the alert. Upon arrival, it captures images and activates a buzzer to notify nearby individuals of the disturbance.
- Captured images are then processed using a machine learning model to determine if an actual intruder is present. If confirmed, an alert message is sent to the designated user for further action.
- Once the situation is assessed, the TurtleBot resumes its patrol route, maintaining continuous security surveillance throughout the area.

HARDWARE

- Securo Dog (Trurtle Bot) equipped with sensors
- Rasberry Pi (user) that receives messages of intruder or safety
- Linux, receives images and mainly runs the code

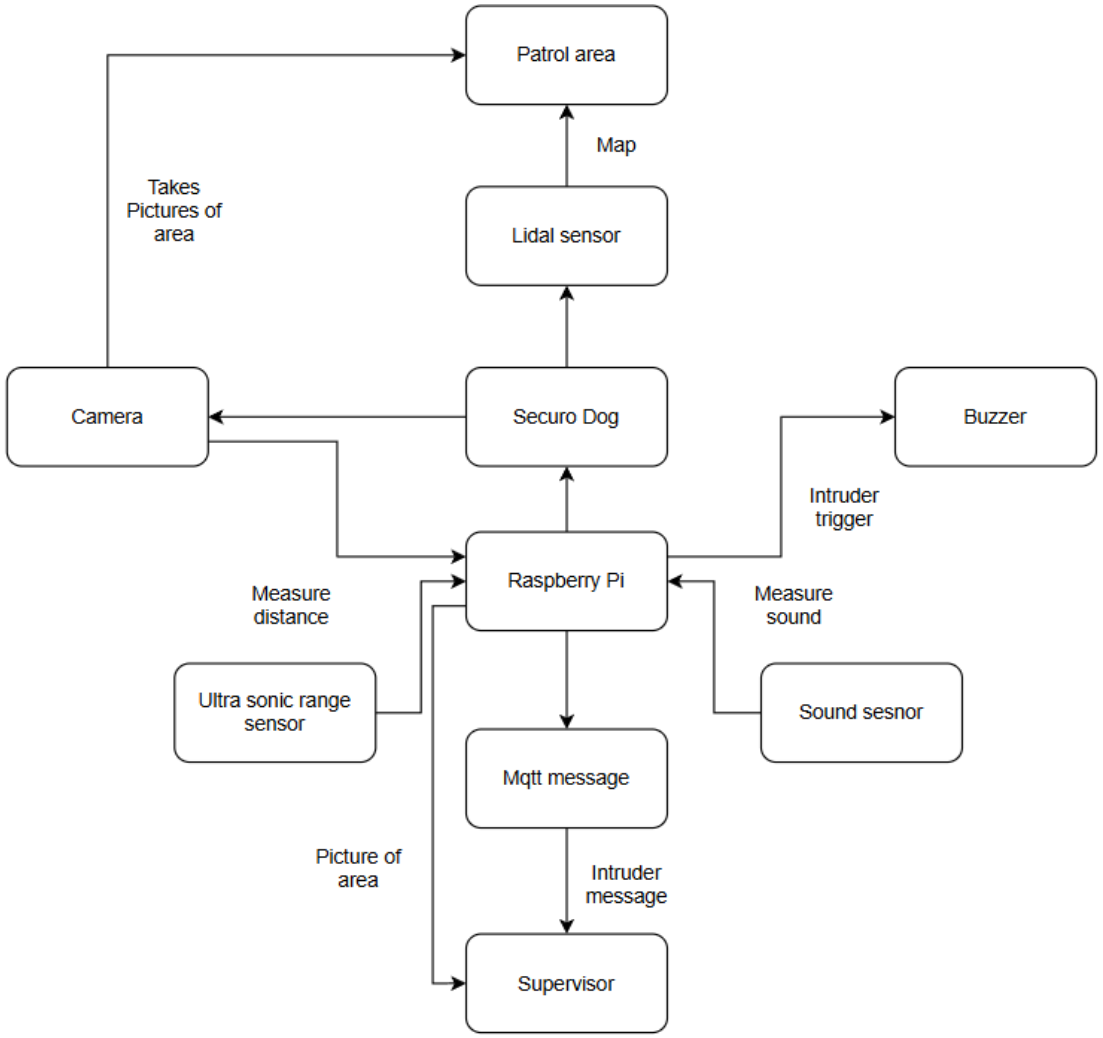
USE CASE


Home owner
Takes picture of intruder, sending it to the home owner
Sets off buzzer
Turtle Bot detects noise and movement through noise and ultrasonic range sensor
Begin patrol through set checkpoints
Turtle Bot
Breaks into house
Intruder
Makes noise and moves around house

SCENARIO JUSTIFICATION

- Home security is important for your loved ones, property, and providing peace of mind
- 215,933 burglaries went unsolved across England and Wales in 2023
- We believe our system can help protect homes and business effectively, preventing loss of capital and keeping people safe.
- Using taking photos of intruders sending messages to people as well as a buzzer all can help scare of unwanted access and help apprehend the perpetrator
- This system could be Implemented in business to stop robberies over night as well as in homes being used either at night or when no one is currently in the home (e.g. at work or on holiday)

HOW EACH COMPONENT INTERACT WITH EACH OTHER



OUR CHOSEN SENSORS

Ultrasonic sensor

We chose to use this sensor as its good for the detection of people if they were to enter the home it would show a change in distance based of the waves.

Sound sensor

This sensor was used was because if someone was entering the house by force it would cause a notable change in sound allowing the system to be aware of the intrusion.

Both are effective at being placed at possible entry locations allowing us to detect changes.

OUR CHOSEN SENSORS

Lidar sensor of the turtle bot allows for turtle bot to get an understanding of its environment allowing, to navigate to multiple areas representing possible entries of home.

Camera, the use of this is to be able to capture an image at the possible entrances to get a picture of an intruder that will then be sent and saved.

HOW SENSORS WERE INTEGRATED

- 1. Camera
- Function: Captures images at entry points and during anomaly responses.
- Implementation:
  - Subscribed to `/camera/color/image_raw` using ROS.
  - Images are processed via OpenCV with `cv_bridge` to convert ROS image messages into OpenCV format.
  - Images are saved periodically during rotation at entry points or when a disturbance is detected.

HOW SENSORS WERE INTEGRATED

- 2.Ultrasonic Distance Sensor (via MQTT)
- Function: Detects proximity changes near critical areas (e.g., windows, doors).
- Communication:
  - Uses MQTT to receive continuous distance readings.
  - Topic: rangeTopic; Payload contains {"distance": <value>, "sound": <value>}.
- Spike Detection:
  - A rolling window (deque) stores recent distance values.
  - Custom logic detects sudden drops in distance (indicating a person approaching).

HOW SENSORS WERE INTEGRATED

- 3. Sound Sensor (via MQTT)
- Function: Monitors for sudden loud noises that could indicate a break-in.
- Integration:
  - Also published over MQTT on the same topic as the distance data.
  - Sound values are similarly tracked with a rolling window to detect spikes.

PSYCHICAL ACTION

- We have used the actuator a of the Grove – Buzzer when the sensors have a spike in the past reading triggering it, and when the machine learning identifies the intruder, this action is caused
- Another psychical action is the turtle bot where it patrols around using the wheels and lidar to move between the goal of the possible entries and redirects to the goal to the location when the sensors have a spike again.
- The final psychical action is the capturing of photos using the camera attached to turtle bot once it reaches the goal location the turtle bot spins and takes a photo every seconds.

REAL-TIME MONITORING

- Having multiple sensors for the same role of detecting intrusions' is it improves accuracy and reliability by utilising both sensors, reducing false detections and giving the system a better understanding of its environment.
- Also detecting the spike of the recent readings of the sensor stops false alarms when in a loud room

EXAMPLE SCENARIOS AND RESPONSES

No threat :

- Follows the patrol route.
- Reaches each checkpoint, captures images.
- No high sound detected.
- No objects within critical distance.
- Continues to next checkpoint without alert.

EXAMPLE SCENARIOS AND RESPONSES

Loud Sound Detected:

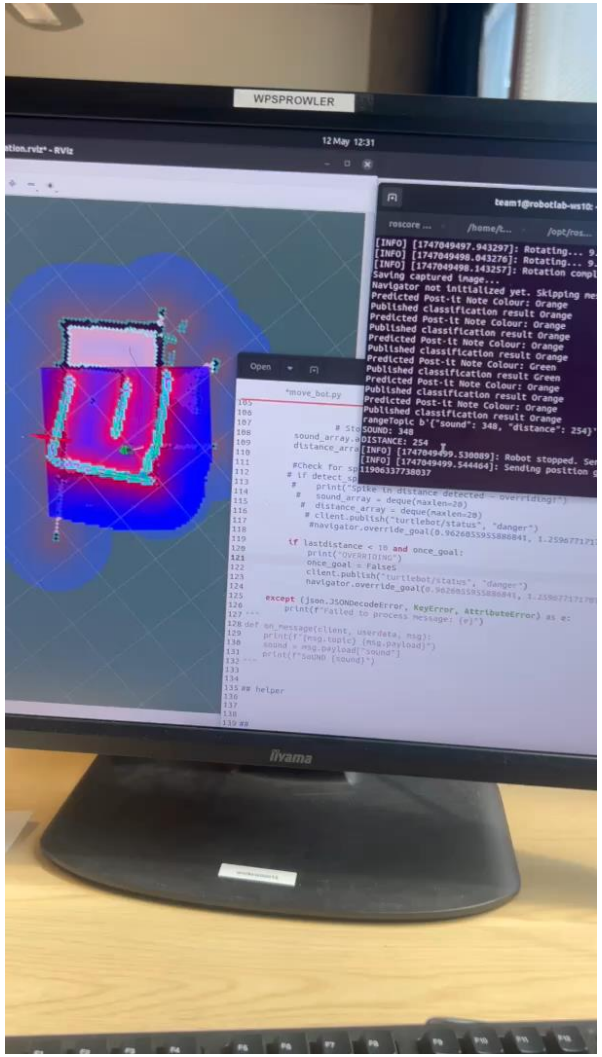
- Measures sound level above the threshold.
- Checks distance sensor – no nearby object.
- Logs event, captures image.
- No buzzer activation since proximity is safe.

EXAMPLE SCENARIOS AND RESPONSES

Close Object and Loud Sound:

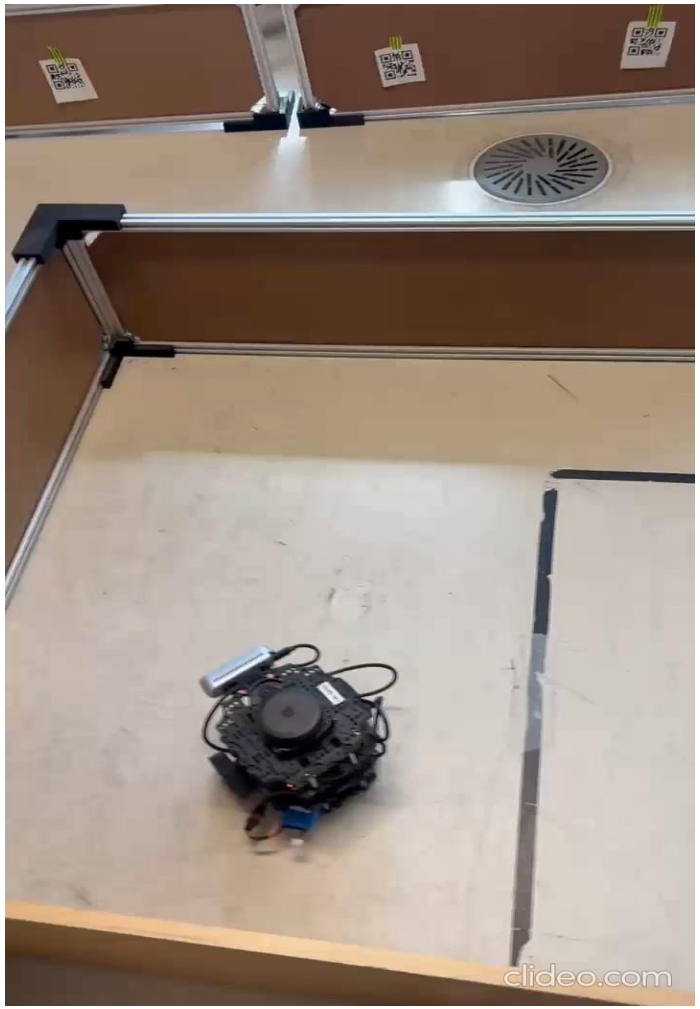
- Distance sensor detects object.
- Microphone picks up sound above threshold.
- Activates buzzer.
- Captures image and sends alert to supervisor.

THE TURTLE BOT MAP

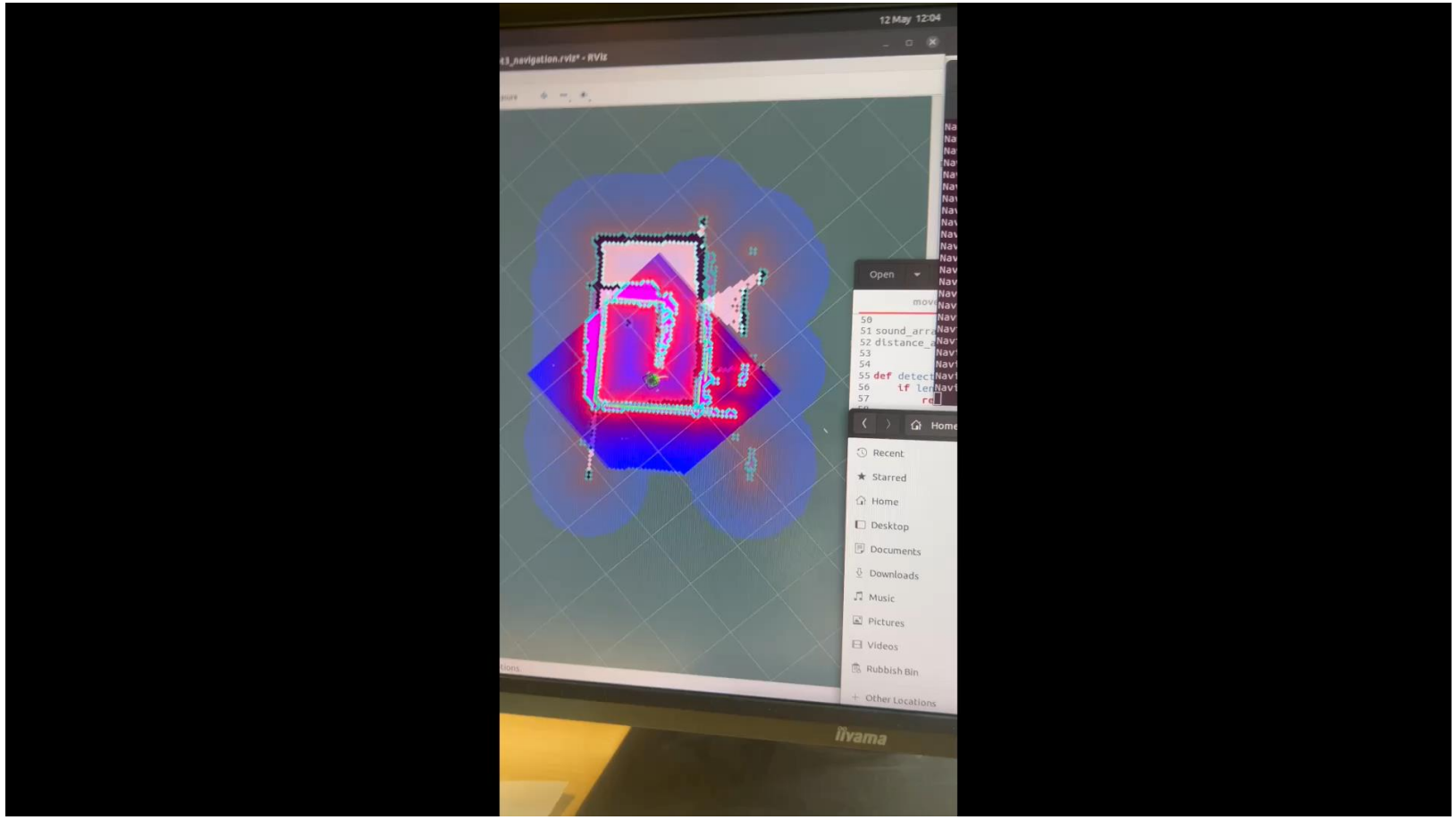


VIDEO SHOWING THE TURTLE BOT IN ACTION

- Moving and sensor demonstration



OUTPUT IMAGES



CHALLENGES AND ISSUES WE HAD TO OVERCOME

CHALLENGES WE FACED AS A TEAM

WHAT WE COULD IMPROVE IN FUTURE OR IF GIVEN MORE TIME...

WHAT THE TEAM LEARNT

CHALLENGES

- We originally struggled with getting the turtle bot to game to the same location and face the correct direction due to the odometry changing overtime, to fix this we made the robot spin based of time to make sure it does capture a photo the entry point
- Had planned to trigger the physical action based of using an if the sensor detects higher than a certain number(>) however due to a loud room the sound sensors would trigger the physical action when not wanted creating false alarms so to get around that we used the spike of recent values allowing it to adjust for the environment and still detects changes.

FUTURE POTENTIAL

- We could add **more sensors**, to better improve accuracy detecting and stopping possible fake alarms such as light sensor to detect flashlights or lights from blinds opening etc.
- Possible could add having the turtle bot **track and monitor** an intruder after it was detected from a safe distance
- Improve ML model with **deep learning** for better accuracy.
- Add **face/person detection** for real-world scenarios.
- Extend the system to **multi-robot collaboration** for large-area surveillance.

WHAT THE TEAM LEARNED

- Sensors and Actuators use for real time data and responses in a smart system
- MQTT and Python, for robotics
- Designing and research of a smart system
- Use of GrovePi+, Raspberry Pi, and TurtleBot, gaining practical skills

TEAM CONTRIBUTIONS

- Darragh Flynn - Machine Learning & Debugging – demonstration video
- Matteo Romano - System Design & Planning – abstract & presentation
- Milosz Wojciechowicz - Sensor Setup & Integration – diagrams & presentation

Worked collabartory on most of the project working inside the labs to create the smart system

CONCLUSION

- Overall, we believe what we have allows for safety and protection of a location using a Varity of techniques and skills we have learned across this module
- Afterall, we designed and implemented a **smart security system** using TurtleBot, integrating autonomous patrolling with real-time sensor monitoring and machine learning.
- Our system can:
- **Patrol predefined routes** autonomously using ROS Navigation Stack.
- **Detect potential intrusions** via ultrasonic and sound sensors.
- **Capture and classify images** at entry points and during disturbances using an SVM-based intruder classifier.
- **React intelligently** by interrupting patrols and responding to anomalies in real time.

THANK YOU

We welcome your questions and feedback.