GNG1103

Design Project User and Product Manual

A.N.A. - The Artificial Navigation Assistant

Submitted by:

The A.N.A. Project – Group 5

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Table 1. Acronyms

Acronym	Definition
A.N.A.	Artificial Navigation Assistant
PID	Proportional-Integral-Derivative
RM	RoboMaster S1

Table 2. Glossary

Term	Acronym	Definition
LED Feedback		Visual signal through light indicating the status of A.N.A.
Line Following		The process of using sensors and control algorithms to follow a marked path on the ground
Symbol Detection		The feature allowing the robot to recognize and respond to unique visual symbols

1 Introduction

This User and Product Manual (UPM) provides essential guidance for effectively utilizing the Artificial Navigation Assistant (A.N.A.), ensuring a comprehensive understanding of its capabilities and functionalities. The document is structured to cover the purpose, scope, intended audience, and key security considerations associated with using the A.N.A.This User and Product Manual (UPM) provides the information necessary for the general use to effectively use the Artificial Navigation Assistant (A.N.A.) and for prototype documentation.

Whether it's a hospital, an office complex, or a university, getting lost is frustrating and stressful. Directions can be unclear, and asking for help isn't always an option. But what if there was a system that could guide you seamlessly, reducing confusion and making navigation effortless?

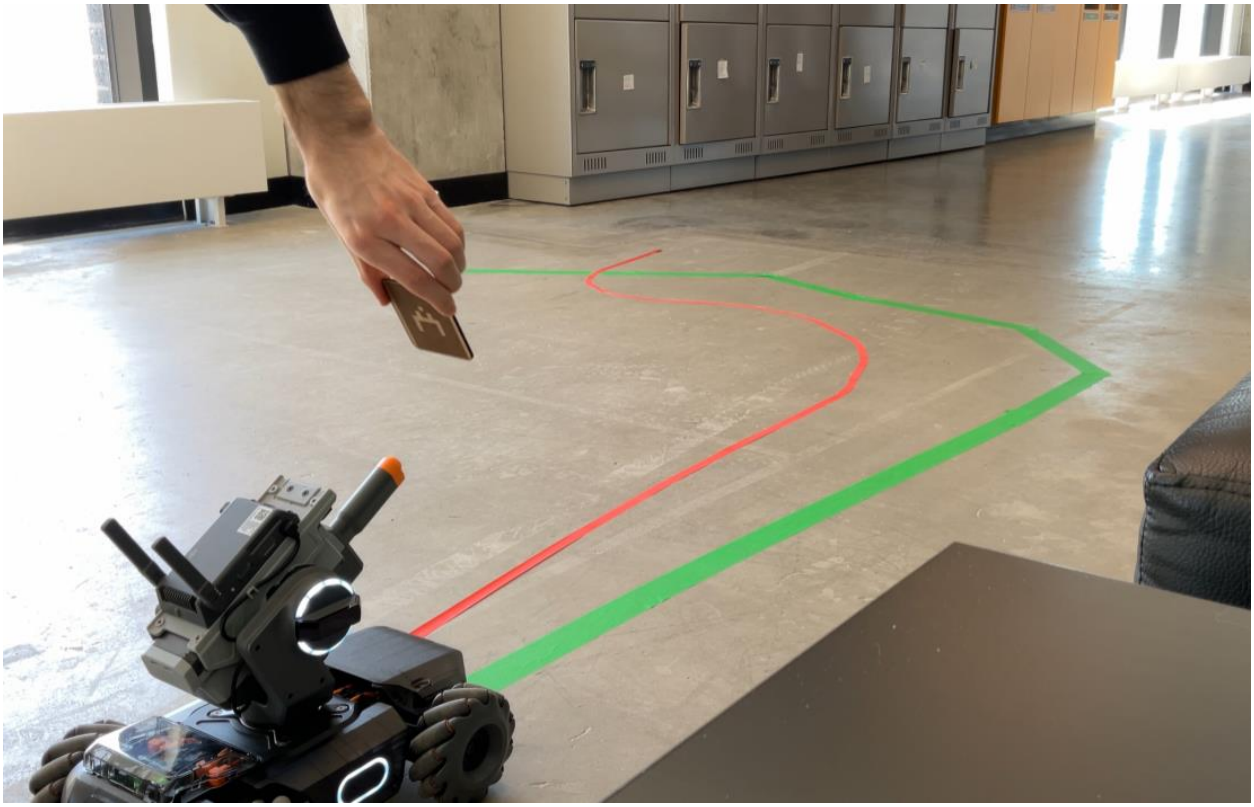
That's where A.N.A. comes in! Users simply show the symbol cards we created to the robot's camera, which are assigned to destinations. The robot then follows color-coded tape pathways to guide users efficiently. Using its camera and the PID controller function, A.N.A. can correct its path if disrupted, and assures smooth navigation. Upon arrival, it signals success with a change in color on the chassis and gimbal LEDs, then returns to its starting point, ready for the next user.

2 Overview

A.N.A. is a simple implementation of repurposing the Robomaster S1 to demonstrate that robotics can be used for AI in ethical and peaceful ways. It is designed to combat and pivot away from autonomous weapon systems. Our group developed A.N.A. by utilizing the PID controller function to integrate real-time line following, along with symbol detection to determine where the user wants to go. Key functionalities include:

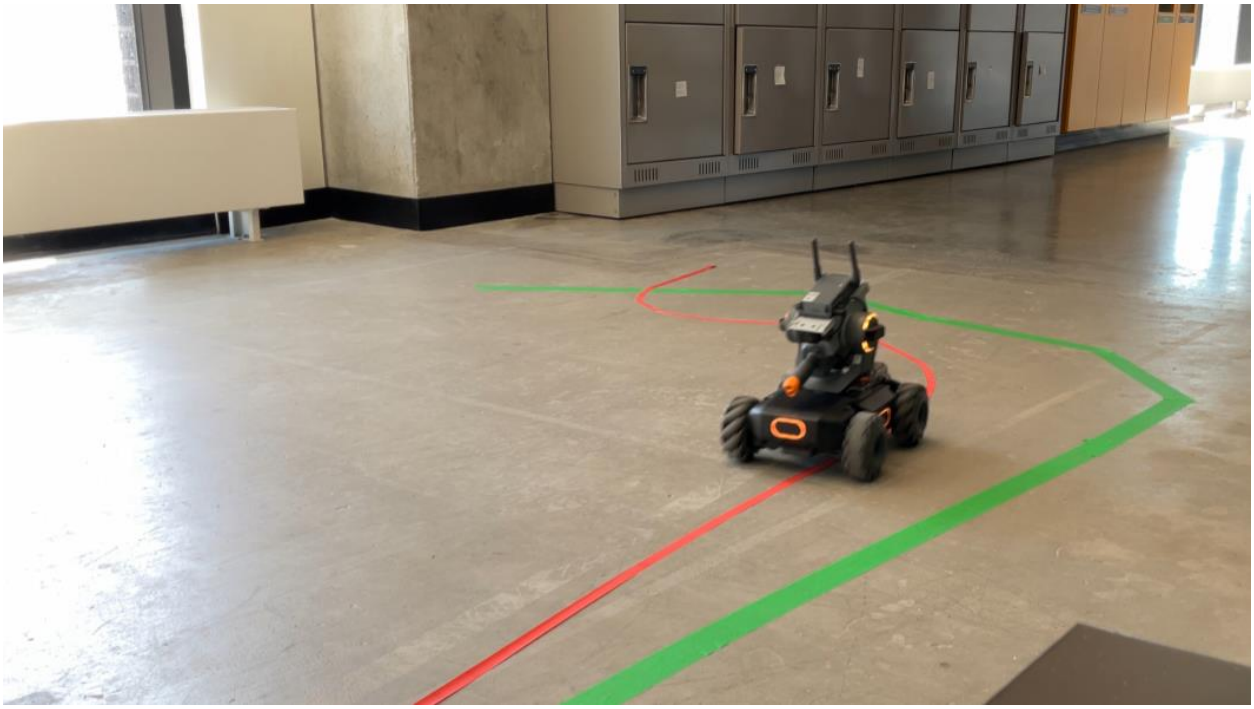
- Real-time Line Following: A.N.A. uses a PID controller to follow predefined paths efficiently and accurately.
- Symbol Detection: The system recognizes symbols placed in its environment to determine navigation routes dynamically.
- Feedback System: A.N.A. provides status updates through chassis and gimbal lighting:
    - One color indicates waiting for a symbol.
    - Another color signifies route in progress.
    - A third color confirms route completion.

Figure 1. Waiting for Symbol Detection



To use A.N.A., the user must begin by selecting a symbol from the provided set of cards, which are individually assigned to destinations in the building. The chosen card must then be presented to the Robomaster S1's camera, allowing the system to recognize the symbol and determine the appropriate navigation path.

Figure 2. A.N.A. Line Following



2.1 Conventions

User actions in this manual begin with "Action:". Warnings are prefaced by "Caution:". Steps are sequentially numbered.

2.2 Cautions & Warnings

Caution: Ensure the system is fully charged before each operation

Caution: Avoid wet environments to prevent short-circuiting

Caution: Always place the symbol cards within direct view of the camera

3 Getting started

Step 1: Charge the Robot Action: Use the official RoboMaster S1 charger and ensure full charge is achieved.

Step 2: Lay Down the Navigation Path
Action: Use color-coded tape to design paths on flat indoor surfaces.

Step 3: Place Symbol Cards at Checkpoints

Action: Affix printed symbol cards at destination points and keep extras near the RM starting area.

3.1 Configuration Considerations

The system must be placed in a flat, well-lit indoor area.

Tools: Tape, scissors (for cutting tape), printed symbols.

3.2 User Access Considerations

Target users include individuals navigating public indoor spaces (students, hospital visitors). No prior technical knowledge is required.

3.3 Accessing/setting up the System

Action: Power on the RoboMaster S1.

Action: Connect to the RM via DJI App on your smartphone or laptop.

Action: Ensure camera alignment and sufficient lighting for detection.

3.4 System Organization & Navigation

Subsystem 1: Camera and PID controller

Subsystem 2: Symbol cards for input

Subsystem 3: LED feedback lights on chassis and gimbal. All components are pre-configured in software for seamless operation.

3.5 Exiting the System

For physical prototypes: Turn off the RoboMaster S1 using the button on the battery, typically found on the rear end.

For software prototypes: Stop the program and disconnect from the RoboMaster S1.

4 Using the System

The following sub-sections provide detailed, step-by-step instructions on how to use the various functions or features of the navigation assistance, built around the line following concept.

4.1 Navigation Assistance

Action: Place the robot on the starting line of the tape.

Action: Present a symbol card in front of the RM camera.

Action: Observe LED feedback, where:

Color 1 (White) = waiting

Color 2 (Orange) = navigating

Color 3 (Sky Blue) = Either:

Thinking if gimbal has scrolling animation

Arrived if all LEDs are solid with no change in display

4.1.1 Symbol Recognition and LED Feedback

Action: Ensure symbol card is aligned within the center of the RM's camera field.

Feedback: The robot flashes blue (ready), then green (navigating), then white (arrived).

Note: If path deviation occurs, robot will slow down and adjust.

5 Troubleshooting & Support

This section outlines common issues that users may encounter while using A.N.A. and provides guidance on how to resolve them. The goal is to ensure that even users without technical knowledge can troubleshoot and maintain the system effectively.

5.1 Error Messages or Behaviors

Below are common issues observed during use, along with likely causes and recommended solutions:

Table 3. Solutions to Potential Error Messages

Issue	Likely Cause	Solution
Robot does not recognize the symbol card	Poor lighting or misalignment	Ensure room is well-lit and card is centered in camera view
Robot flashes red or remains still after scanning	Symbol unrecognized or blurry	Reprint the symbol card or ensure it matches the expected format
Robot deviates from the tape line	Tape is peeling, dirty, or insufficient contrast	Replace or clean the tape; ensure it contrasts with floor
Robot fails to return to start	Path obstructed or software error	Clear obstacles and restart the program via RoboMaster app
LED color does not change after scanning	Program did not initiate	Restart robot and verify DJI app is properly connected

5.2 Special Considerations

Lighting: Natural lighting may vary throughout the day. Ensure consistent overhead lighting for best symbol detection.

Surface Quality: Smooth, flat indoor floors work best. Avoid textured, reflective, or dark surfaces that could interfere with tape contrast.

Battery Life: A.N.A. may perform erratically when the battery is low. Always begin with a fully charged robot.

Environmental Noise: Avoid environments with excessive visual clutter or competing colored lines that may confuse the system.

Symbol Integrity: Laminating or reinforcing symbol cards may help avoid creases or wear that could interfere with detection.

5.3 Maintenance

To ensure smooth long-term performance, the following maintenance tasks should be performed regularly:

Battery Check: Fully charge the robot before each use. Avoid leaving it plugged in overnight.

Camera Lens: Wipe gently with a microfiber cloth to keep the lens clear of dust or smudges.

Symbol Cards: Inspect for scratches, fading, or bending. Replace or reprint when needed.

Tape Path Inspection: Replace any peeling or dirty tape. Ensure strong adhesion and clear visibility.

Software Updates: Periodically check the DJI RoboMaster app for firmware or software updates.

5.4 Support

If issues persist beyond basic troubleshooting, please reach out to the designated support contact:

Contact Information

Jordan Maggiano – jmagg095@uottawa.ca

Reporting Problems

When reporting an issue, please include:

A description of the issue

Environment details (lighting, surface type)

Any photos or video of the behavior

Steps already taken to troubleshoot

For immediate support, you can also refer to DJI's RoboMaster S1 support resources:

https://www.dji.com/ca/support/product/robomaster-s1

MakerRepo Page

GNG1103 Group 5 — A.N.A - https://makerepo.com/jmagg095/2478.gng1103-group-5-ana

6 Product Documentation

Our prototype was primarily developed with a focus on coding, vision testing, and tape guide path setup, rather than specific mechanical modifications. We used DJI RoboMaster S1 as our platform because it already came with key components installed, such as a high solution camera, motors, and coding system, which allowed us to concentrate on the coding and testing rather than the hardware components.

Since our system highly relies on scanning symbol cards to determine the destination, we dedicated a significant of time to test the visual recognition system to ensure the accuracy. The symbol cards were fabricated using the Makerspace laser cutter and made of free MDF boards, which provided a consistent size. We designed the card graphics in Inkscape by importing the images provided by DJI and resizing them, exporting them in PDF format for laser cutting and engraving. One of the challenges we addressed was to ensure the robot could accurately detect and follow the corresponding-colored paths. We tested various times and eventually selected the electrical tape from Dollarama for its strong adhesion and cheap cost. The robot was able to follow the paths and reach the corresponding destination. Overall, by using the existing hardware provided by DJI RoboMaster S1 and its accessible software tools, and cost-effective materials, we created a reliable artificial navigation assistant.

6.1 BOM (Bill of Materials)

Table 4. Bill of Materials

Item name	Description	Quantity	Unit Cost	Cumulative Cost
Electrical Tape	For testing line tracking	2	$1.75	$3.50
Painter's Tape	Testing line tracking, thicker width	1	$2.25	$2.25
Thicker Painter's Tape	Testing line tracking, increased width	1	$2.50	$2.50
Construction Paper	Poster Board	1	$4.25	$4.25
Poster Board	Design day	2	$3.00	$6.00
Glue	Poster board	1	$2.50	$2.50
		8 items	**Total after Tax**	$23.74

6.2 Equipment List

Table 5. Equipment List

Item Name	Description	Cost (Purchased FOR this Project)	Source(s)?
Personal Laptop	To work on deliverables and program the prototypes	$0	N/A
DJI RoboMaster Software	For programming the RoboMaster S1	$0	https://www.dji.com/ca/support/product/robomaster-s1

RoboMaster Mobile App	For programming the RoboMaster S1 and to connect to the RM S1	$0	https://apps.apple.com/us/app/robomaster/id1449678340
Office 365	For documenting and collaborating on deliverables	$0	N/A
Total Cost:		$0	

6.3 Instructions

Step 1: charge the robot, use the RoboMaster S1 battery and ensure the robot is fully charged before use.

Step 2: Install the require software (RoboMaster), using device such as iPad or PC, integrate the robot.

Step 3: design symbol cards, use Inkscape to design 10x10 cm cards, import DJI provided A, B, C icons, resize them, and export as PDF files.

Step 4: Laser cut the cards using 3mm MDF boards to engrave and cut.

Step 5: Lay down the navigation path, use red, blue, and green vinyl tape to create three distinct paths on indoor floor.

Step 6: Run the program and begin testing, connect the device to the RoboMaster via Wifi, run the code and old the symbol card in front of the camera for scanning

Step 7: Observe robots' behavior, see of the robot is identifying the correct path color and navigate to the destination.

6.4 Testing & Validation

To validate the final design of A.N.A., we conducted a series of tests focusing on symbol card recognition, color path tracking, and full system integration. We found that symbol recognition was highly accurate under bright and moderate lighting but dropped to 60% success in dim conditions, highlighting the importance of adequate lighting. In path-following tests, red and blue tape produced consistent results, while yellow occasionally caused minor drift, likely due to contrast issues with the floor. Full system runs showed that A.N.A. could successfully scan a card, follow the correct path, and return to its starting point, with an average round trip time of around 27 seconds. Issues that emerged included the need for regular tape maintenance, smooth indoor flooring, and fully charged batteries to ensure stable performance. Overall, the prototype performed reliably under test conditions, but improvements in lighting adaptability and path flexibility would enhance sustained use.

7 Conclusions and Recommendations for Future Work

Throughout our work on the Artificial Navigation Assistant (A.N.A), we learned the importance of organizing our time, testing early, adapting quickly, and always thinking from the user's point of view. Most of our time was spent integrating the software, testing how well the robot could

recognize cards, and making sure it could follow the tape paths smoothly. We kept things simple by using the DJI RoboMaster S1 and free resources from the university such as the laser cutter from Makerspace, which let us focus more on making the system work perfectly than building the hardware from scratch. If we had a few more months, we could have made A.N.A more interactive by adding more features. We were limited by the DJI coding system, which only allowed us to three different tape colors, red, green, and blue. If we had more time, we could explore other coding methods to support more color options and create additional routes. This would allow us to include a greater number of destinations.

8 Bibliography

RoboMaster S1 - programming guide - DJI. DJI Official. (n.d.).

https://www.dji.com/ca/robomaster-s1/programming-guide

APPENDICES

9 APPENDIX I: Design Files

This section is dedicated to all important files for the A.N.A. The files included here provide information on and illustration of the project's evolution throughout its conceptualization and fruition, allowing for viewing of different prototypes.

Other files also include helpful resources for troubleshooting for the A.N.A.'s functionality.

All files created over the course of the project evolution and fruition can be found and viewed at the relevant MakerRepo page, as shown below.

MakerRepo Page:

GNG1103 Group 5 — A.N.A - https://makerepo.com/jmagg095/2478.gng1103-group-5-ana

Table 6. Design Files

Document Name	Document Location and/or URL	Issuance Date
A.N.A Project Manifesto.pdf	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ0JzIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--03b6bca75d1eb56f93ffdc8f1652444a7c213078/A.N.A%20Project%20Manifesto.pdf	March 28th 2025
Code.jpg	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdVJyIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--48c96f296e96fff98e6ec69d16bcb5e86d551df2/Code.jpg	March 27th, 2025

PD-F-Prototype I.pdf	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdU5yIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--021c4aa37e522de7f56ce3e50a7d12123e213d90/PD-F-Prototype%20I.pdf	March 27th, 2025
PD-G-Prototype II.pdf	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdUpyIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--685989f4c9fb5e0964e391fb1bceba8cff45af36/PD-G-Prototype%20II.pdf	March 27th, 2025
PD-H-Prototype III.pdf	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ3RzIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--462227ae72c51db6c0b2551273630b7c62229f26/PD-H-Prototype%20III.pdf	March 28th, 2025
Symbols - Laser Cutting.pdf	https://makerepo.com/rails/active_storage/blobs/redirect/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ3hzIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--68d342fda4f55be9564aff4df91bf555afab926e/Symbols%20-%20Laser%20Cutting.pdf	March 28th, 2025