MILITECH

Autonomous Tank

R&D Project

Luca Boninsegna

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Contents

1 Gears' system and turret

1.1 Introduction

This report details the design, implementation, and ongoing development of an automated robot tank equipped with a rotating turret and laser-based targeting system. The project represents an integration of mechanical engineering principles, custom 3D-printed components, and electronic systems to create a functional mobile platform with target acquisition capabilities.

The robot features a wheeled chassis for mobility, a rotating turret system driven by a step motor through a custom gear mechanism, and a laser-based targeting system that serves as a safer alternative to an actual electronic cannon. This document will cover the mechanical challenges encountered during development, the solutions implemented, and the remaining issues to be addressed in future iterations.

1.2 System Overview

1.2.1 Base Platform

The foundation of the project is a tank-style chassis equipped with wheels for mobility. This platform serves as the mounting point for all other components, including the drive system, electronics, and turret assembly. The base is designed to provide stability during movement and targeting operations while accommodating the necessary electronic components.

1.2.2 Turret Assembly

The turret represents the most complex mechanical component of the system. It features:

- A custom 3D-printed housing
- Rotation capabilities via a gear system
- An integrated laser sensor for target detection
- Mounting provisions for potential future weaponry

The turret connects to the base through a gear mechanism that allows for precise rotational control, enabling the system to track and engage targets within its operational range.

1.2.3 Electronic Components

The electronic subsystem consists of:

- Arduino microcontroller board for system control
- Step motor for driving the turret rotation
- Laser sensor for target acquisition
- Associated wiring and power management components

The Arduino serves as the central control unit, processing sensor inputs and controlling the step motor to position the turret as required.

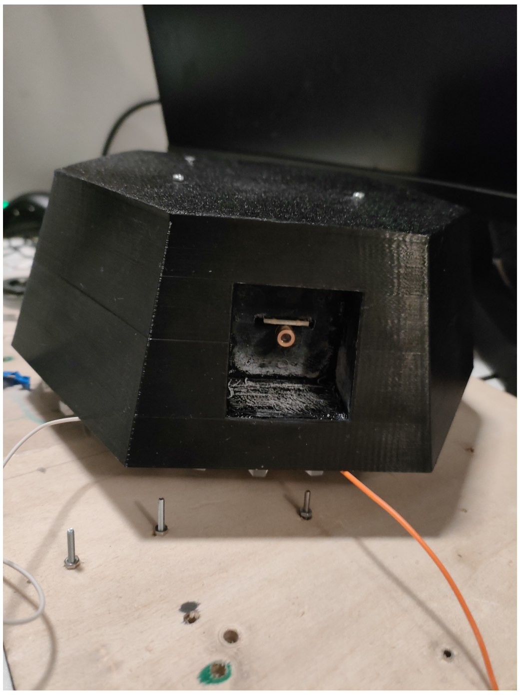

Figure 1.1: Robot tank prototype with rotating turret and laser targeting system

1.3 Mechanical Design Challenges and Solutions

1.3.1 Gear System Design

The rotational mechanism for the turret presented significant mechanical challenges. The system employs two primary gears:

1. **Small Gear (Driver):**
    - Directly connected to the step motor
    - Responsible for transferring rotational force to the large gear
    - Initially experienced issues with axial rotation relative to the motor shaft
2. **Large Gear (Driven):**
    - Connected to the turret assembly
    - Requires smooth rotation with minimal friction
    - Bears the weight and operational forces of the turret components

1.3.2 Small Gear Adapter Solution

The initial configuration of the small gear presented a significant challenge, as it rotated freely with the motor axis rather than transmitting torque effectively. This rotation compromised the precision required for accurate turret positioning.

To address this issue, a custom bearing adapter was designed and 3D-printed with the following features:

- Gear-shaped perimeter with notched edges that securely interface with the small gear
- Central mounting mechanism to attach firmly to the motor shaft
- Appropriate tolerance design to ensure proper mechanical coupling

This adapter effectively eliminated the undesired independent movement, ensuring that the gear rotates coaxially with the motor shaft. This modification significantly improved the system's ability to precisely control turret position.

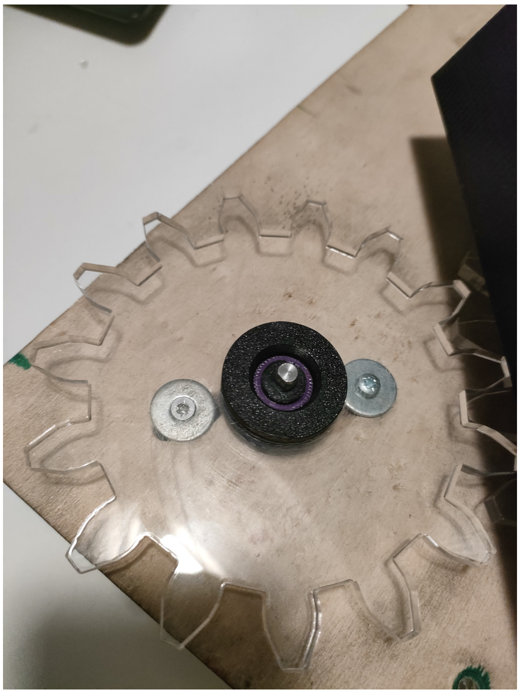

Figure 1.2: Custom 3D-printed adapter for the small gear

1.3.3 Large Gear and Rotational Axis Implementation

For the large gear component, the design objective differed significantly. Rather than restricting rotation, the goal was to facilitate smooth movement while maintaining proper alignment with the drive system.

The implemented solution included:

- A custom-designed rotational axis for mounting the large gear
- A specifically engineered bearing adapter to accommodate a standard bearing assembly
- Proper alignment features to ensure concentricity with the rotation axis

The integration of a standard bearing into this custom housing significantly reduced rotational friction, allowing the turret to move smoothly even under varying load conditions. The wear patterns observed on the bearing surfaces indicate proper function and load distribution, validating the design approach.

1.4 Turret Integration and Target Acquisition System

1.4.1 Turret Design Considerations

The turret assembly was designed with several critical requirements in mind:

- Stable platform for the laser targeting system
- Sufficient internal space for potential future electronic components
- Balanced weight distribution to minimize strain on the rotation mechanism

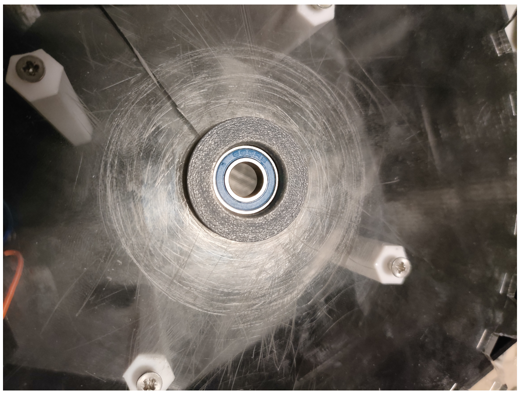

Figure 1.3: Bearing assembly for the large gear

Figure 1.4: Rotation axis for the big gear

Custom 3D-printed components for the big gear

- Appropriate apertures for the laser sensor

Through iterative design and testing, the final turret configuration successfully balances these requirements while maintaining functional compatibility with the gear system.

1.4.2 Laser System Implementation

Instead of implementing an actual electronic cannon, which would present safety concerns, the project utilizes a laser-based targeting system. This approach offers several advantages:

- Enhanced safety during development and demonstration
- Reduced power requirements
- Simplified mechanical integration
- Comparable targeting accuracy for demonstration purposes

The laser sensor is precisely positioned within a custom-designed housing in the turret, allowing for accurate target detection within the system's operational range.

1.4.3 System Integration

The integration of the mechanical components with the electronic systems presented its own set of challenges. Particular attention was paid to:

- Mechanical tolerances to ensure proper fit between components
- Stability of mounting connections to prevent unwanted movement
- Appropriate clearances for operational movement
- Access provisions for maintenance and modifications

The current implementation successfully addresses these integration considerations, resulting in a functional prototype capable of demonstrating the core capabilities of the system.

1.5 Current Limitations and Future Work

1.5.1 Cable Management Challenges

A significant ongoing challenge relates to cable management for the turret's electronic components. Currently, the laser system in the turret requires a cable connection to the Arduino board, which is mounted on the fixed part of the robot. This arrangement presents several issues:

- Potential for cable tangling during rotation
- Limitations on continuous rotation capabilities
- Risk of connection failures due to repeated movement stress
- Aesthetic and functional compromises

1.5.2 Proposed Solutions for Cable Management

Several approaches are being considered to address the cable management issue:

1. **Slip Ring Implementation:** Installing a slip ring would allow for continuous rotation while maintaining electrical connections.
2. **Onboard Electronics:** Relocating certain electronic components to the turret itself could reduce the number of required connections.
3. **Wireless Communication:** Implementing wireless data transmission between the turret and base could eliminate some cable requirements.
4. **Cable Routing Optimization:** Designing a more effective cable path with appropriate strain relief could mitigate some current limitations.

1.5.3 Additional Future Improvements

Beyond addressing the cable management issues, several other enhancements are being considered for future iterations:

- Improved power management system
- Enhanced targeting algorithm implementation
- Addition of distance sensing capabilities
- Implementation of autonomous navigation features
- Further refinement of the 3D-printed components for increased durability

1.6 Conclusion

The robot tank project has successfully integrated mechanical design, 3D printing technology, and electronic systems to create a functional prototype with target acquisition capabilities. The custom-designed bearing adapters and rotational components have effectively solved the initial challenges related to gear rotation and system integration.

The current implementation provides a solid foundation for future enhancements, particularly in addressing the cable management challenges. The modular approach to design allows for iterative improvements without requiring complete system redesign.

This project demonstrates the effectiveness of targeted mechanical solutions in addressing specific operational challenges. The combination of standard components with custom-designed interfaces illustrates a practical approach to prototype development that balances functionality, cost, and implementation complexity.