Competition Report: WRO 2025 National Qualifiers & RiSE 2025

Introduction

This report details our participation in the **World Robot Olympiad (WRO) 2025 National Qualifiers & RiSE 2025** held on **Saturday, July 19th, 2025,** at **Central Cafeteria, University of Ghana**. It covers the comprehensive preparation leading up to the event, our experiences during the competition, and key takeaways for future engagements across the distinct categories we competed in.

Overall Competition Overview

- **Date:** Saturday, July 19th, 2025
- **Location:** Central Cafeteria, University of Ghana, Accra, Ghana
- **Organizers:** Ghana Robotics Academy Foundation (GRAF)
- **Participating Teams:**
    - **WRO Future Innovators (Cleanover Project):** Team Cleansweep
    - **WRO RoboMission:** Team Lumen
    - **RiSE MGCS:** Team Sortify

WRO Future Innovators: Cleanover Project

3.1. Competition Details

- **Competition Name:** World Robot Olympiad (WRO) 2025 National Qualifiers - Future Innovators Category
- **Theme:** The Future of Robots
- **Objective:** To develop an innovative and functioning robotic solution that helps solve real-world problems. Our project, "Cleanover," aimed to build a semi-autonomous rover to clean solid waste from street-side gutters in urban Ghana, reducing flooding and improving sanitation.
- **Team:** Team Cleansweep (Senior Age Group, 14-19 years old)
    - Aforo Emmanuel Amoh (Software Lead, 18 years old)
    - Anum Ryan Nii-Akwei (Hardware Design Lead, 17 years old)
    - Asare Kofi Brako Junior (Design & Modeling Lead, 18 years old)
    - Oblitey Josiah Nii Oblitey (Support tasks, Development & Testing, 16 years old)

    - Okuntade Emmanuel George (Robot Testing & Performance Support, 16 years old)
    - Quarcoo Stesha Tettey Buadjorm (Lead Graphic Designer, 16 years old)
    - Honorary mention: Obeng Abel (Assisted in the development and testing as well)

3.2. Preparation Phase (Cleanover Project)

Our preparation for the WRO Future Innovators category was thorough and multi-faceted, focusing on skill development, strategic planning, and logistical readiness, adhering to WRO and GRAF guidelines for team's own work and ethical conduct.

3.2.1. Training & Skill Development

- **Technical Consultations:** Engaged in multiple technical consultations with Mr. Benedict Amoako to evaluate operational potential, discuss progress, and refine project proposals and 3D models (June 2, June 5, June 6, 2025). Mr. Benjamin Adjei-Peprah also shared insights on real waste and drainage issues.
- **Software Development:**
    - Built a Flask-based web dashboard for controlling, receiving, and sending data to the robot's various components (Beta version completed by June 5, 2025, with virtual joystick control and live webcam feed streaming). The dashboard also features Autonomous Navigation and Manual Override modes, calibration utilities, and an emergency stop.
    - Began programming of motors (May 29, 2025).
    - Initiated IMU programming and GPS Navigation programming (June 1, 2025).
    - Reprogrammed the robot for smoother control and dashboard integration (July 1, 2025).
    - Implemented Offline Maps for local geolocation using a Neo-7M GPS module and WebSockets for real-time tracking (July 2, 2025).
    - Utilized OpenCV (computer vision library) and Pyserial for the Python-based edge-following program. This involved a multi-stage vision pipeline including grayscale conversion, Gaussian blur, Region of Interest (ROI) masking, Canny Edge Detection, and Hough Line Transform for accurate edge detection.
    - Developed autonomous movement logic with three states: `EDGE_DETECTION`, `FOLLOWING_EDGE`, and `ADJUSTING`, ensuring the robot maintains a safe distance from the gutter edge.
- **Hardware Development:**
    - Began soldering motors and their drivers (JGA25-370 motors controlled by L298N motor driver boards) for movement (May 31, 2025).
    - Conducted 3D printing of DC Motor Mounts (May 30, 2025).
    - Began acrylic sheet cutting (May 31, 2025), though initially paused due to lack of proper tools.
    - Began battery pack making for robot's operation (June 6, 2025).
    - Received 3D model of chassis and began printing (June 17, 2025).

    - Replaced initial battery pack with dual 18650 holders (4 cells, ~15V) for consistent power supply (June 20, 2025).
    - Assembled 3D-printed parts including the main chassis, half of the chassis cover, wheels, and support braces (June 28, 2025).
    - Installed Raspberry Pi 4B (main brain), Arduino Nano (lower-level hardware control), motor driver, and motors into the assembled chassis (June 30, 2025).
    - Equipped Cleanover with a webcam (mounted at 60 degrees for edge detection) and LED status indicators (red for GPS/system errors, green for movement status).
- **Design & Modeling:**
    - Revised project scope to focus solely on cleaning dry, open gutters based on initial consultation (June 2, 2025).
    - Presented and refined 3D models of the robot and gutter environment (June 5, 6, 2025).
    - Researched various garbage collection methods (robot grabber arms, hydro-jetting, drone-assisted systems), ultimately settling on a cost-effective and efficient surgical intake system.
    - Designed and 3D printed numerous custom parts, including wheels optimized for various surfaces, the L-shaped surgical intake system, webcam holder, motor mounts, and a protective Raspberry Pi case.

3.2.2. Strategy Development

- **Analysis of Competition Format/Rules:** Thoroughly reviewed the "WRO Future Innovators-General Rules" to understand the judging criteria for the Senior age group, including Project & Innovation, Robotic Solution, and Presentation & Team Spirit.
- **Game Plan/Approach:** Focused on a semi-autonomous system for solid waste removal, utilizing vision-based navigation (OpenCV) and an L-shaped surgical intake system. The strategy emphasized efficiency, minimal human intervention, and adaptability to urban gutter environments. The project also addressed social impact and innovation, including entrepreneurship aspects using a Business Model Canvas framework, which is a key component for the Senior age group.
- **Contingency Planning:** Addressed technical challenges proactively during development, such as motor driver issues (rerouting motors to working channels), serial communication overflows (implementing rate limiting), and concurrency problems (thread isolation for Flask server and OpenCV processing).
- **Finetuning:** After sending the project video and report, We had 5 days left to the competition. We used this valuable time to reprint and make a few design changes to the project in preparation for the competition. We also fixed a few issues we were facing.

3.2.3. Logistics & Resources

- **Component Acquisition:**
    - Received the first batch of components on May 26, 2025.

    - Ordered a second batch of critical project components on May 27, 2025 (delivery delayed, expected May 30).
    - Procured additional components locally, including timing belt, bores, female header pins, 2-pin terminal blocks, and an acrylic sheet (May 29, 2025).
    - Purchased silicone glue and caulking gun (May 30, 2025).
    - Received a solar panel for the charging station (June 4, 2025).
    - Acquired extra components: Arduino Nano, upgraded GPS antenna, and an IR sensor (June 23, 2025).
- **Equipment & Supplies:** Managed the procurement, maintenance, and preparation of all necessary robotic components, 3D printed parts, and tools.
- **Project Report & Booth Preparation:** Began designing the banner for the competition's booth (June 6, 2025). Prepared a comprehensive project report (PDF, max 20 pages) detailing team introduction, project idea, robotic solution, social impact, innovation, and entrepreneurship aspects, as per WRO Future Innovators Senior age group requirements. This report was designed to help judges understand the project and prepare questions.

3.2.4. Team Building & Cohesion

- **Team Formation:** Selected first-year students to be part of the team (May 31, 2025), expanding the team's capabilities and fostering a collaborative learning environment.
- **Role Definition:** Clearly defined roles for each team member, covering software development, hardware design, mechanical assembly, graphic design, and testing, which fostered efficient collaboration.
- **Regular Meetings & Consultations:** Frequent technical consultations and internal discussions ensured alignment and progress on the Cleanover project, adhering to the WRO principle that only team members can build and code the robot, with coaches providing guidance. We met virtually everyday except Sundays.

3.3. Competition Experience (Cleanover Project)

The competition itself was a valuable learning experience.

- **Key Moments/Highlights:** During the presentation, some teammates had to intervene and answer certain questions which the judges posed. Ths showed the unity we posessed as a team.
- **Challenges Faced:** During our presentation, we atttempted testing our robot, but surprisingly it failed to move. This minor nerve-wrecker made us restart the bot which delayed a bit before it successfully moved.
- **Our Performance:** The presentation to the judges was smooth (aside the minor obstacle faced earlier). We were able to fully answer their questions as well. and had an optimistic feeling from the judges.
- **Results/Achievements:** Results are to be expected by Thursday, 24th July, 2025.
- **Interactions with Other Competitors/Officials:** We were able to meet and network with many active people in the robotics and tech workspace. For example, we met Mr.

Kojo Anyinam Boateng, an alumnus of PRESEC who is currently pursuing his masters in robotics in France, Mr. Yaw Nti- Addae, an alumnus who helped to fund the project and even had the chance to chat with others who have had first-hand experience in international robotics competitions.

3.4. Lessons Learned (Cleanover Project)

Our participation in the WRO Future Innovators category provided significant insights and learning opportunities.

3.4.1. What Went Well

- Our comprehensive technical consultations with external advisors proved invaluable in refining our project scope and design for Cleanover, aligning with the WRO Future Innovators' emphasis on research and development.
- The development of the web dashboard with its virtual joystick and live webcam feed significantly enhanced our control and monitoring capabilities, showcasing strong software engineering skills.
- The team's ability to diagnose and fix critical issues during development, such as faulty motor driver channels and camera live feed bandwidth problems, demonstrated strong problem-solving and technical engineering skills.
- The successful procurement of diverse components and the efficient utilization of 3D printing for custom parts accelerated our prototyping process, reflecting effective resource management.
- Clear role definition and collaborative efforts within the team were crucial to overcoming development hurdles and fostering a strong team spirit, as emphasized in WRO judging criteria.
- The Cleanover project's focus on a real-world problem (gutter cleaning in Ghana) and its exploration of innovation and entrepreneurship aspects aligned well with the WRO Future Innovators category's objectives.

3.4.2. Areas for Improvement

- **Hardware Reliability:** While fixed during preparation, initial issues with motor driver channels highlighted the need for even more rigorous component testing prior to final integration.
- **Software Robustness:** Addressing serial buffer overflows and concurrency issues required significant reprogramming, indicating the importance of anticipating such challenges in complex embedded systems and ensuring code efficiency for competition.
- **Tooling & Resources:** The acrylic sheet cracking due to a lack of proper cutting tools underscored the necessity of having all required equipment readily available from the outset to avoid delays in fabrication.
- **Supply Chain Management:** Delivery delays for key components impacted our timeline, emphasizing the need for contingency planning in procurement.

- **Intake Mechanism Design:** The iterative process of designing an effective intake mechanism showed that complex mechanical solutions often require extensive prototyping and improvisation, which could be streamlined with more initial design foresight.
- **Competition Day Readiness:** Ensuring the robot is fully functional and the booth is set up perfectly before the judging sessions is crucial for maximizing presentation time.

3.4.3. Unexpected Insights

- The practical application of our robotics project to a real-world community problem (gutter cleaning) reinforced the social impact potential of our work, demonstrating how robotics can directly benefit society.
- The experience highlighted the value of iterative design and continuous problem-solving in robotics, where unforeseen challenges are common and adaptability is key.
- Observing other teams and their approaches during the competition provided new perspectives on robot design, programming strategies, and overall competition execution, fostering a spirit of learning and inspiration.
- The importance of clear and concise presentation skills, especially during the 5-minute judging session, was reinforced as a critical factor in conveying the project's value and technical understanding.

3.5. Recommendations for Future Competitions (Cleanover Project)

Based on our experience, we recommend the following for future participation in similar Future Innovators competitions:

- **Preparation:**
    - Implement a longer and more structured preparation timeline, allowing for more extensive testing and refinement of both hardware and software. This includes dedicated time for thorough debugging and optimization of code for efficiency and automation.
    - Incorporate more rigorous component testing and quality control checks before final assembly to ensure robust and reliable robot performance on competition day.
    - Allocate dedicated time for advanced troubleshooting and bug fixing, especially for communication and concurrency issues in complex robotic systems.
    - Ensure all specialized tools and materials are acquired well in advance to avoid delays in fabrication and assembly.
    - Conduct more full-scale simulation exercises in environments that closely mimic real-world conditions relevant to the project.
- **Logistics:**
    - Develop a more robust supply chain strategy, including identifying alternative suppliers or maintaining a buffer stock of critical components to mitigate delivery delays.

    - Streamline equipment checks and booth setup procedures for competition day to maximize presentation time.
- **Performance:**
    - Practice the 5-minute presentation rigorously, focusing on clear and concise communication of the project idea, robotic solution, social impact, and innovation, tailored to the judging criteria.
    - Emphasize real-time problem-solving and adaptability during the Q&A sessions with judges.
- **Team Dynamics:**
    - Continue fostering strong team cohesion and communication through regular meetings and collaborative problem-solving sessions.
    - Encourage cross-training among team members to ensure redundancy in key technical areas and to promote a holistic understanding of the robot's design and function.