Index
Approach
Requirements
Alternatives
Selection
System Definition
Validation
Planification
Critical Design

Conceptualization

Milestone 1. Problem and Design Requirements

Concept	The problem has been explained and the criteria that will be used to evaluate the design as a solution to the problem.
Milestone Contents	-Design problem analysis
	- Identification of restrictions and requirements for the robot.
	- Assessment of prior knowledge
	- Initial proposal for evaluation criteria
Verification Review	MCR - Mission Concept Review

Problem description and context

The World Robot Olympiad is a nonprofit organization. Its mission is to promote robotics and STEM in education worldwide. We will be participating in the Future Engineers Category which intends to teach students an engineering workflow by solving real-world-problems. Each year the competition gets a different theme. This year's theme is "Robots Meet Culture".

The main goal of the competition is for us to use computer vision and sensor fusion to estimate the state of the parkours and the vehicle itself. The competition consists of a "Time Attack" races, that means that we're are going to compete one at a time; trying to achieve the best time. The robot operates as an autonomous navigation agent in a semi-structured environment with dynamic rule-based obstacles and no prior map.

There's 2 challenges that will be presented (and it is mandatory to participate in both):
- Open Challenge: The vehicle must complete 3 laps on the track with random placements of the inside walls.
- Obstacle Challenge: The vehicle must complete 3 laps on a track with "traffic signs", then, after completing the 3 laps, parallel park into a parking lot.

In addition to designing and programming the vehicle, the team must provide documentation that presents their engineering process.

Needs

Subsystem	Description	Used for
Rules and Strategy	Real-time detection of traffic pillars and track boundaries	Obstacle Challenge
Rules and Strategy	Autonomous decision-making without external input	Both Challenges
Rules and Strategy	Adaptive navigation in unknown track configurations	Open Challenge
Rules and Strategy	Stable lane following and obstacle avoidance	Obstacle Challenge
Rules and Strategy	Reliable operation across multiple laps	Both Challenges
Rules and Strategy	Accurate localization of the parking zone	Obstacle Challenge
Rules and Strategy	Precise low-speed maneuvering for parallel parking	Obstacle Challenge
Rules and Strategy	Operation within competition procedure and time limits	Both Challenges
Mobility and Mechanics	The vehicle shall not exceed overall dimensions of 300 mm in length, 200 mm in width, and 300 mm in height .	Both Challenges
Mobility and Mechanics	The maximum weigth is 1.5 kg.	Both Challenges
Mobility and Mechanics	The vehicle can't use differential drive.	Both Challenges
Mobility and Mechanics	The vehicle can use a maximum of 2 driving motors. Mechanically coupled.	Both Challenges
Mobility and Mechanics	The vehicle shall not use any type of omnidirectional wheel, ball caster, or spherical wheel.	Both Challenges
Documentation	The documentation must be uploaded to a public repository on GitHub.	Both Challenges
Documentation	The repository must contain discussion, information and motivation for the engineering decisions made; photos of the vehicle, a team photo, URL to a video showing the vehicle driving autonomously and any CAD models.	Both Challenges
Documentation	We should make at least 3 commits to the repository, at least 2 months before the competition.	Both Challenges
Documentation	We must include a README.md file with a description of the designed solution. This description should clarify the function of each code module.	Both Challenges
Software and Controls	The vehicle must be able to identify the traffic signs on the field and turn lanes based on their color. (red for right side and green for left side).	Obstacle Challenge
Software and Controls	The vehicle must be able to detect the walls and avoid them.	Open Challenge
Software and Controls	The vehicle must do 3 laps.	Both Challenges
Software and Controls	The vehicle CAN'T move a traffic sign out of its place.	Obstacle Challenge
Software and Controls	The vehicle should parallel park in a designated spot after completing the 3 laps.	Obstacle Challenge
Electronics Architecture	Main control unit (SBC and/or SBM) capable of processing sensor data and executing real-time control algorithms (RTOS-capable).	Both Challenges
Electronics Architecture	Stable electrical power supply system ensuring continuous operation throughout the entire round.	Both Challenges
Electronics Architecture	Exclusive use of wired connections between electronic components.	Both Challenges
Electronics Architecture	Single power-on button and a single program start button.	Both Challenges

Goals

Subsystem	Description	Used for
Rules and Strategy	Achieve the fastest possible completion time while maintaining correct behavior.	Both Challenges
Rules and Strategy	Perform reliably (can complete the course and the requirements multiple times) and precisely (maintain accurate and collision-free navigation throughout the run).	Both Challenges
Documentation	Commit our progress every time we make a change in code, the vehicle or CAD files.	Both Challenges
Documentation	Our commit description should be descriptive enough that every member of the team can understand what was changed.	Both Challenges
Mobility and Mechanics	Develop a mechanical chassis and mobility system capable of providing controlled forward, backward, and steering motion within competition-defined limits on size, mass, drivetrain configuration, and wheel architecture.	Both Challenges
Software and Controls	Complete the 3 laps without touching or ignoring any traffic signs.	Both Challenges
Software and Controls	The code must be fully commented, explaining the function of each module.	Both Challenges

Success Criteria

Subsystem	Description	Used for
Rules and Strategy	The robot completes the full mission autonomously, correctly navigating obstacles and staying within the track without collisions.	Both Challenges
Rules and Strategy	The robot successfully locates and performs parallel parking within the allowed time limit.	Both Challenges
Documentation	Our repository should be understood by people that didn't work on the project.	Both Challenges
Mobility and Mechanics	The fully assembled vehicle remains within the specified dimensional and mass limits	Both Challenges
Mobility and Mechanics	The vehicle uses an approved drivetrain and wheel configuration, and completes all required driving and steering maneuvers during testing with no structural damage or loss of mobility.	Both Challenges
Software and Controls	All the traffic signs are detected, and the vehicle makes the right choice a 100% of the times.	Both Challenges

System requirements

ID	Requirement Type	Requirement description	Verification criteria	Test method	How does it affect the design?
FR-01	Functional	The robot must start autonomously after the start button is activated	After the button is activated, the robot starts moving in accord of its mission	Run observation	
FR-02	Functional	The robot must navigate the track without human intervention	Completes 3 laps after start without external interaction	Full mission run observation	
FR-03	Functional	The robot must detect traffic pillars during operation	Robot alters trajectory before reaching each pillar	Video review frame-by-frame	We must use a way to detect colors and position of pillars on real-time, and act based on that.
FR-04	Functional	The robot must determine the correct passing side according to pillar color	Passes every pillar on the rule-correct side	Judge observation checklist	
FR-05	Functional	The robot **may** start from within the parking lot.	The robot exits the parking area and completes the route	Full mission run observation	
FR-06	Functional	The robot must avoid moving or touching traffic signs	No traffic signs are touched, moved or dropped	Field inspection	The vehicle should move based on its dimensions and the position and distance to the traffic sign.
FR-07	Functional	The robot must remain within the track boundaries while driving	No wheel exits track boundary lines	Video review	The vehicle should drive considering its distance to the walls.
FR-08	Functional	The robot must adapt to either clockwise or counterclockwise driving direction	Completes a valid lap in both directions across trials	Two test runs in opposite direction	The driving direction shouldn't matter on the robot's algorithm.
FR-09	Functional	The robot must complete three laps continuously in a single run	3 laps completed sequentially without reset	Judge observation	
FR-10	Functional	Detect parking zone after lap 3	Robot changes behavior only after third lap	Run observation	We must use a way to detect colors and position of the parking zone on real-time, and act based on that.
FR-11	Functional	Robot must perform parallel parking	The entire robot is inside parking area boundaries and no walls are displaced	Field measurment	
FR-12	Functional	The robot must complete the mission within the allowed attempt time	Mission completed before 180 seconds	Timer measurement	It must be fast enough to do 3 laps in less than 3 minutes. Considering the field and vehicle size.
FR-13	Functional	The robor must follow the defined driving direction	No reverse lap counted	Judge observation	It can't drive in reverse (exceptions apply)
FR-14	Functional	The robot must stop after succesful parking	Motors stop within 2 seconds after parking	Stopwatch	Once the vehicle is inside the parking spot, IT MUST REMAIN STILL.
OR-01	Operational	The robot must operate fully autonomously after the start button is pressed	No human contact after its start	Judge observation	The robot must use sensors and probably a camera to complete the challenge autonomously
OR-02	Operational	The robot must begin the attempt from a stationary powered-off state	Robot motion begins only after start signal	Start procedure observation	The robot must have two buttons or activators.
OR-03	Operational	The robot must not receive external communication or control during therun	No external packets detected	Wireless scanner / inspection	Team should avoid using/buying sensors or components with added wireless communication.
OR-04	Operational	The robot must operate without recalibration or parameter input after the start	No parameter changes during run	Judge observation	
OR-05	Operational	The robot must adapt to a randomly assigned starting position and driving direction	Succesful run from ≥2 different start tiles and run directions	Multiple runs	sensors and camera must have a wide vision range
OR-06	Operational	The robot must operate with randomly placed traffic pillars	Succesful runs with changed obstacle configurations	Multiple and different layouts	
OR-07	Operational	The robot must operate using only onboard sensors and processing	All sensing devices mounted on the robot body	Inspection	Every robot component must be inside the specified dimensions
OR-08	Operational	Robot must stop when round ends or mission completes	Motor stop within 3 seconds	Stopwatch	Robot must be aware of mission time.
OR-09	Operational	Robot must operate without map preloading of obstacle positions	Works with randomized field	Random setup trial	

Restrictions

Restriction Type	Restriction Description	Member affected	Is it self imposed?
Logistical	We want to spend as little as possible. Reusing components that we already have from other projects.	All of them	☑
Technical	It's our first time participating in the World Robot Olympiad.	All of them	☐
Logistical	We have only 17 weeks to design and manufacture a robot for the national competition.	All of them	☐
Technical	Limited knowledge of machine learning.	All of them	☐
Logistical	A constrained schedule due to academic and work commitments.	All of them	☐
Logistical	Limited mobility due to the lack of a valid U.S. visa.	All of them	☐

System Constraints

ID	Type of Constraint	Constraint Description
CONST-01	Mobility and Mechanics	The vehicle dimensions must not exceed 300 × 200 × 300 mm (L × W × H)
CONST-02	Mobility and Mechanics	The vehicle weight must not exceed 1.5 kg
CONST-03	Mobility and Mechanics	The robot must be a four-wheeled vehicle
CONST-04	Mobility and Mechanics	The vehicle must have one steering actuator
CONST-05	Mobility and Mechanics	The vehicle must have one driven axle (front-wheel drive or four-wheeldrive allowed); differential wheeled robots are not allowed.
CONST-06	Mobility and Mechanics	Electronic differential drive (one motor per side) is not allowed
CONST-07	Mobility and Mechanics	Omnidirectional wheels, spherical wheels, and ball casters are not allowed
CONST-08	Software and Controls	All sensing and processing must be onboard the robot
CONST-09	Software and Controls	External computation devices are not allowed
CONST-10	Software and Controls	External control or communication during the run is not allowed (allwireless communication interfaces must remain disabled)
CONST-11	Electronics Architecture	Only one start button and one power switch may be used to begin the run
CONST-12	Software and Controls	No manual parameter input is allowed after the start signal
CONST-13	Electronics Architecture	The robot must use onboard computing hardware (SBC and/ormicrocontroller)
CONST-14	Rules and Strategy	The robot must not intentionally move or manipulate traffic pillars
CONST-15	Rules and Strategy	The robot must not damage the track or competition elements
CONST-16	Rules and Strategy	The robot must fit completely inside the parking area during parking evaluation