TÉCNICO LISBOA

Robotics

P2, Winter, 2022

Departamento de Engenharia Electrotécnica e de Computadores

2nd lab assignment – v 1.0

Autonomous Cars

(Due by January 28, 2023)

1 Introduction

This lab assignment aims at developing components for an autonomous car operating inside a well defined environment, i.e., the IST Alameda campus.

The work considers multiple work possibilities, including

- Simulation of individual components, e.g., sensors such as accelerometers, gyroscopes, or GPS.
- Simulation of a complete system, i.e., the whole collection of systems to have the car running.
- Developing sensor components using real devices.
- Integrating multiple sensors (combinations of real and simulated sensors are possible).
- Developing a whole collection of systems for a real car.

Each group can select working on a single component or work on the full system. **Groups working in different complementary, components can collaborate to present a joint, integrated, system.** The workload must be carefully weighted by the groups.

From an evaluation perspective, working in simulation on a single component assumes that the level of realism must be high, matching that of a real device. Working in multiple components (or in the full system) assumes that the realism of each component may not be close to the real systems.

2 Syllabus

A car-like kinematics, as shown in figure 1, can be used to simulate the car.

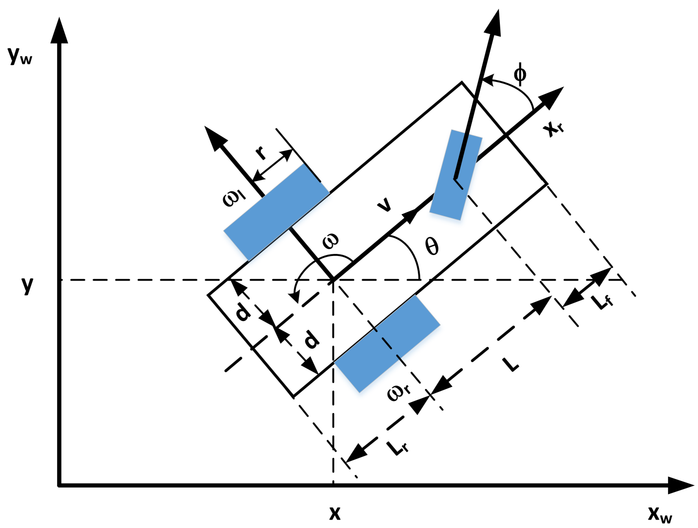

Figure 1: Kinematics of a car-like robot

However, if the goal is to achieve truly realistic behavior then a dynamics model of the type studied in the theory classes has to be used,

$$\tau = M(\theta)\ddot{\theta} + V(\theta, \dot{\theta}) + G(\theta)$$

Which model to use is at discretion of the students and must be duly justified in the report.

Table 1 shows the specs of a real car to be considered for this lab.

L	2.46 m
L_r	0.6 m
L_f	0.74 m
d	0.83 m
r	0.292 m
Length	3.8 m
Width	1.66 m
Mass	1190 Kg
Aerodynamic drag	0.34

Table 1: Vehicle specs

The goal is to have a car able to move between any two arbitrary configurations along trajectories entirely contained inside the road areas normally reserved for vehicles. The area to be considered corresponds to IST Alameda Campus (Figure **??**).

Figure 3 below shows a diagram with a (very) simple architecture of the system to be developed. Each of the blocks may include multiple sub-systems that may be addressed by independent groups which will then collaborate to deliver an integrated component.

The car must move according to an energy budget, i.e., the vehicle will have a limited (and fixed) amount of available energy to go between any two arbitrary configurations; this budget will be set before the simulation starts.

For a car robot of mass M, moving with velocity $v(t)$, the amount of energy used during an interval Δt is given by

$$\Delta E = (|F(t)|\,|v(t)| + P_0)\ \Delta t = (M\,|\dot{v}(t)|\,|v(t)| + P_0)\ \Delta t$$

where P_0 is a constant value (to model the cost of having the vehicle in operation but not moving, e.g., as when stopped for pedestrians to cross the road).

The number of collisions and energy spent must be displayed/logged for assessment purposes.

3 Expected outcomes

Students must deliver a zip/rar file containing all the software developed, tests ran, and adequate pdf documentation explaining, clearly, the project and how to use the software.

Groups presenting integrated components only need to deliver a single package. However, the report must be clear on the work done by each group and on the individual contributions to the integration.

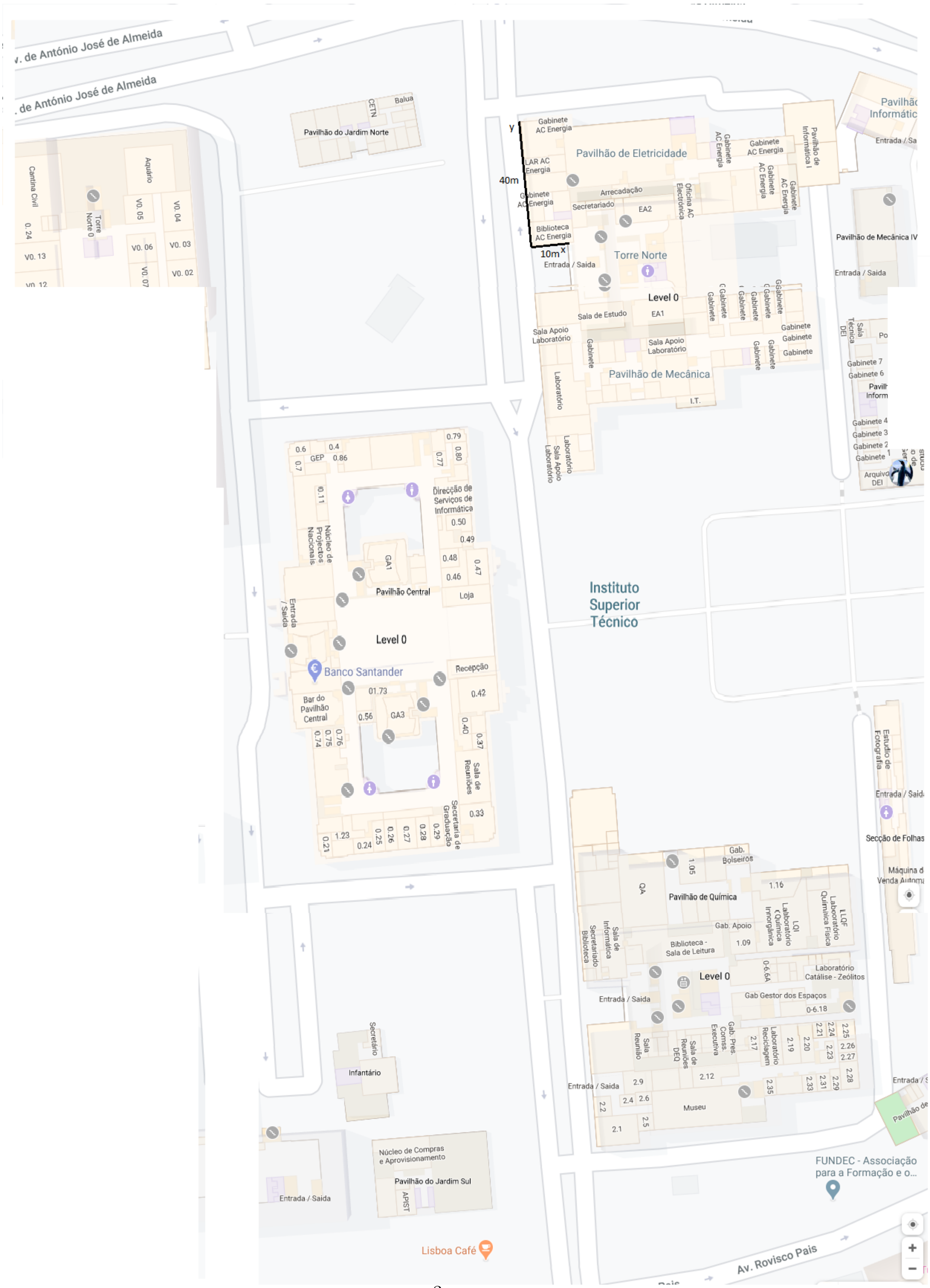

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Figure 2: Example of an admissible environment – IST Alameda campus. A world frame is marked with tick black lines (real dimensions are indicated for scaling purposes).

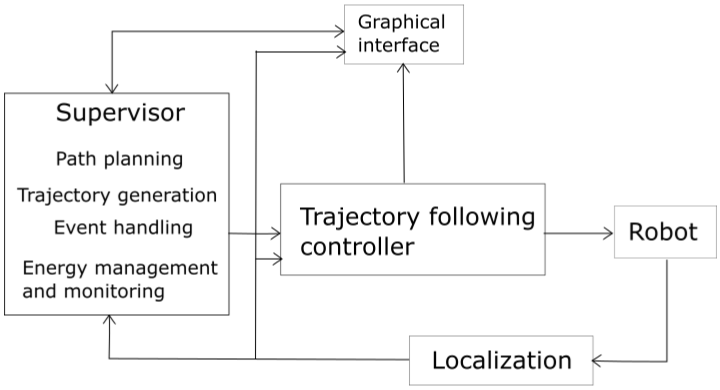

Figure 3: Simplified architecture for the Robotics-Lab autonomous car

4 Bonus points

Bonus points may be awarded if a dependability demonstration for the overall system is presented, i.e., a proof (or a sound argument) that the car is trustworthy.