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Safety controller - “Emergency Braking”

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Objective

Nowadays, a common feature of modern autonomous and mainstream cars is "Automatic Emergency Braking" (or AEB). The aim is simple: avoiding any collision of the car with its environment in order to preserve and ensure the integrity of the car.

Reminder

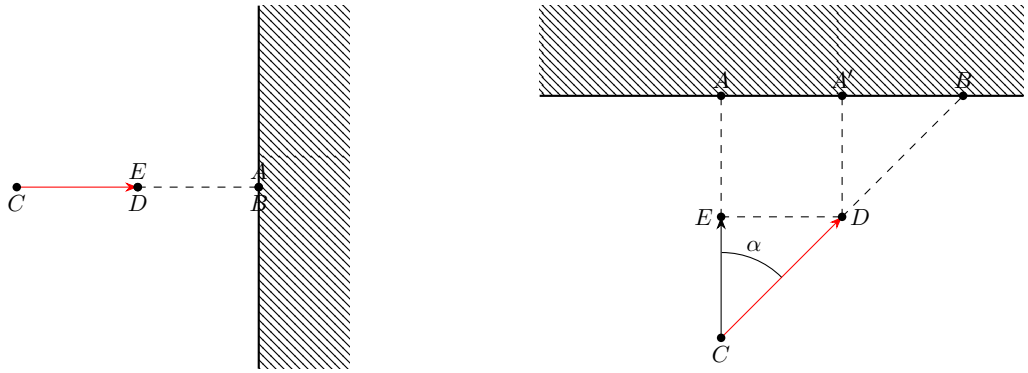
Such a controller uses the on-board Lidar in order to perceive how close the car is with respect to its environment and how likely a collision is. The likelihood is determined through the computation of a "time to collision" (or TTC).
Considering Fig. 1b situation, computing the TTC must be done for every beam returned by the Lidar using the following formula:

$$TTC = \frac{\Delta d}{v'}$$

Where:

- Δd is the distance between the car and its environment for an angle α (here: $|AC|$)
- v is the nominal speed of the car (here: $|CD|$)
- v' is the projected speed for a given observation angle noted α (here: $|CE|$)

If, one of the TTC computed is smaller than a given threshold, a collision is considered as likely and the car should be stopped as soon as possible.



(a) Straight to the wall ($\alpha = 0$)

(b) Collision with an angle (α =?)

Figure 1: Two cases where computing the TTC is interesting. The red arrow denotes the direction of the car.

10.1

We ask you to create a new node called `AEB` and add it to the ROS project. The new node should subscribe to the `\scan` topic and be able to publish messages toward the `mux` node.

Upon the detection of a incoming collision, the `AEB` module should override any other controller and stop the car. In addition, the reception of the emergency braking message must enforce the module to solely consider inputs from the `keyboard` node.

The TTC threshold used is arbitrary and this might lead to the `AEB` being activated in situations where either the driver or the follow-the-gap strategies are totally in control of the car. Consequently, fine tune this threshold such that you mitigate as much as possible this false positive cases.

10.2

Why should you always compute the TTC for all the values measured by the Lidar instead of just considering the smallest value? Describe and discuss a situation with a concrete example where it matters.

10.3

After an emergency braking being detected and enforced, the user gets the control back through the keyboard. However, the latter might will end up in a deadlock as any movement of the car will lead to the `AEB` kicking in and taking back the control. In this bonus, we ask you to extend the controller such that once the car is stopped, the `AEB` automatically drives the car backward long enough to make all TTCs bigger than the threshold.