Target interception final report

ALBiR 2022 [Dr Huai-Ti Lin]

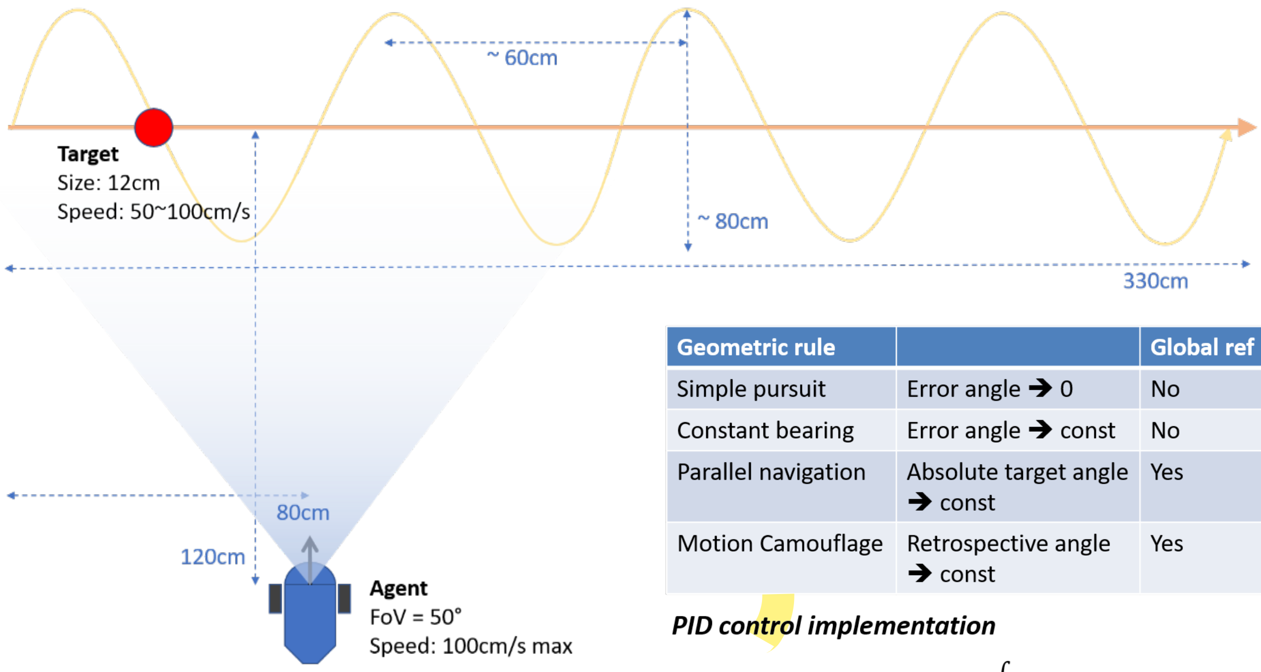
Introduction

As stated at the start of the term, this course is a training program to develop/reinforce your engineering practical skills applied to mobile robotics in the context of locomotion. We started from **well-defined** tasks and coursework and moved toward more **open-ended** robot implementations. We will summarize the visual guidance topic with this individual final report. Aside from the formulation of the interception problem, this report is relatively open-ended. You may explore some related questions that emerged during your implementation of robot track race through simulation here.

Sensorimotor integration is a complex process any autonomous mobile agent must master. The second part of this module aims to progressively guide you to implement complex behaviours. In the **motor-tuning exercise**, you experienced the characteristics of the differential drive. In the **target tracking task**, you learned the effects of PID parameters to the dynamics of a camera panning system. In the **obstacle avoidance task**, you explored how different visual parameters can be used to estimate the state of an external object. The **final Robot Race** challenged you to put everything you learned together. To move quickly on the track, you must explore various strategies. What's the best way to estimate target distance and speed when your robot is also moving? How do you distribute the power to driving and turning given the differential drive motor constraints? How do you reconcile conflicting agenda between the obstacle avoidance and goal-oriented behaviours? What's the best strategy to stay on course with egocentric information? These are all questions you would have discussed with your teammates or asked yourself during the **Robot Race** implementation. The following provides a guideline to completing the final report.

The individual final report (Four A4 single-side pages max; figures in the page limit, but not reference list)

- Use the **PID framework,** construct a controller that would achieve geometric relationship of simple pursuit and constant bearing in the scenario shown in the **schematics below** (linear and sinusoidal target trajectories). Evaluate if the geometric relationships are met and vary the target constant bearing angle. You may approximate the sine trajectory.
- **Proportional navigation** is a special case of the PID framework. Explore its dynamics compared to other controllers that implement constant bearing.
- In simulation, **explore** the impact of sensorimotor delay on different guidance strategies. **Plot** your results and discuss what you think can be done to compensate for the delay?
- Propose how you would implement parallel navigation in the current robot platform without any hardware changes. Produce a **control flowchart** how you would implement this.
- Finally, consider the relative advantages of your controllers. Why might you use one controller over another? And against which targets/ conditions might the optimum controller be different?



Geometric rule		Global ref
Simple pursuit	Error angle ➔ 0	No
Constant bearing	Error angle ➔ const	No
Parallel navigation	Absolute target angle ➔ const	Yes
Motion Camouflage	Retrospective angle ➔ const	Yes

PID control implementation

$$\dot{\theta}_h = K_P(\theta_r - \theta_h) + K_I \int (\theta_r - \theta_h) + K_D \dot{\theta}_r$$

Simple pursuit and constant bearing ➔ P or PI control
Proportional navigation ➔ D control only

Tips on building your simulation

- You may want to review lecture 5 and 6. The slides are on BlackBoard and the recordings are on Teams.
- When building your simulation, it's important to consider what information your robot can realistically measure (i.e. it likely doesn't have access to exact data on the speed and heading of the target).
- Set up the starting conditions, then choose what you consider to be a reasonable time-interval to update your simulation in a loop. At each time step update the positions of your target and your agent and measure relevant cues about the target.
- Use your designated controller to update the heading and/or speed of your agent and progress to the next step. You may assume constant speed for the agent and the target for simplicity.
- Remember that information about derivatives or integrals will need to be stored between loops (this also applies when time-delaying the agent's response).

Concluding remarks

Mobile agents, animals or robots, all share the **same fundamental challenges** in the physical world. Through **implementing** robot behaviours, we can better understand these challenges and thus propose the right questions in animal locomotion research. By studying **animal locomotion**, we obtain insights for solutions to intelligent mobility. It is this interplay between animal research and robotics that fuels **bioinspired robotics**.