Problem 1

Consider the following tracking system that's intended to turn the robot in place so as to keep a target centered in view of a camera. The target mostly moves at constant velocity. The direction in of the target relative to the robot is given as target-direction.

```
(define-signal tracker
  (* target-direction rotational-gain))
```

A. This system works adequately, but consistently lags behind the object. Suggest an improvement to the system that will eliminate the lag most of the time.

Answer: Introduce an integral term.

B. Describe the possible pitfalls of your modification.

Answers: (1) the integral term makes the controller more prone to oscillation, (2) the integral term only helps for targets with constant velocity.

Problem 2:

Consider the situation sketched below where robot drives through an open field and approaches a large irregularly-shaped object:

The rays emanating from robot indicate the distances read by different sonar pings. We assume that the robot has 16 sonars, each of which transmits a pulse with a lobe width of about 60 degrees. The ray is drawn in the center of the lobe.

A. Explain in one sentence of 20 words or less why some of the sonars seem to be detecting objects that aren’t there.
Write your name here:

**Answer:** some sonars not pointing at the object still receive echos from the object. (because of the wide lobe width)

B. Now consider the situation where the robot drives through a hallway, as sketched below. Fill in the rays for the sonars in this environment.

**Answer:** (note that sonars not drawn are assumed to have infinite readings due to specular reflections)

![Diagram of rays for sonars in a hallway](image)

C. Now consider the situation where there is a door in the hallway. Assume that the door is open and that the frame of the door protrudes slightly from the wall. Again, sketch the sonar rays as done above.

**Answer:** (note that dashed lines are generated by corner reflectors in the doorway).

![Diagram of rays for sonars in a hallway with a door](image)

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**Problem 3**

Consider the following code. Assume that all procedures and variables are defined as in your homework assignments:

```
(define-signal (orientation-controller set-point)
  (behavior #t
    (rt-vector (* (abs (- current-heading set-point))
                 rotate-gain)
     0)))
```

Suppose we run the behavior `(orientation-controller 0)` with an appropriate gain and run it from an initial orientation of 45 degrees. We find that the system turns clockwise toward zero degrees, slowing as it reaches its set-point, then suddenly jerks counter-clockwise to 90 degrees and starts turning slowly back.
A. Explain the bug in one sentence of 20 words or less.

   Answer: the system overshoots slightly, causing the angle to wrap around from 0 to 359 degrees.

B. Give the fix for the bug.

   Answer: change the comparison of the angles to handle wrap-around.

Problem 4

Suppose you have written behaviors for fight, flight, and feeding for an artificial animal and you want to integrate them with some conflict resolution mechanism. Evaluate each of the following conflict resolution mechanisms in 30 words or less. Do they even make any sense for this problem? If so, would they work? Would they have any advantages or disadvantages?

A. Motor schema combination

   Answer: No. The animal will try to average the different behaviors, leading to nonsensical local minima.

B. Subsumption

   Answer: Better. However, since priorities are fixed, there will be cases where the animal will starve while fighting or feed while being attacked.

C. Maximal activation

   Answer: Works well. The animal can choose based on how hungry, scared, etc. it is.

D. Weighted voting

   Answer: This would work too.