Artificial Intelligence 2019
Problem Sheet 1

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Notes

The homework serves as preparation for the exams. It is strongly recommended that you solve them before the given deadline - but you do not need to hand them in. Feel free to work on the problems as a group - this is even recommended.

1 Problem

Given the PDL code from figure 1 and the following values of cycle 42, respectively cycle 43. What are the motor values at the end of cycle 43?

cycle	LeftSensor	RightSensor	LeftMotor	RightMotor
42	70	80	30	20
43	90	100		

2 Problem

Given a controller that runs with a fixed frequency of $f = \frac{1}{\Delta t} Hz$.

- Turn the continuous version of the PID controller into a discrete one by replacing the integral and the derivative in a suited way. Note: do not forget to take the time basis Δt into account.
- Find a recursive formulation of the controller, i.e., compute $u(t)$ based on $u(t-1)$.

3 Problem

Given a PID controller running at 1 kHz with

- $P = 0.1$
- $I = 0.5$
- $D = -0.1$

At beginning of time step t, the different errors are

- current error $e_P(t) = 10$
- previous error $e_P(t-1) = 20$
- integrated error up to here $e_I(t-1) = 100$

Calculate the system input $u(t)$.

```
Initialization
    quantity  LeftSensor ∈ [0, 100]
    quantity  RightSensor ∈ [0, 100]
    quantity  LeftMotor ∈ [−100, +100]
    quantity  RightMotor ∈ [−100, +100]
    constant  DEFAULT_SPEED = +50
    constant  MAX_CHANGE = 10
    constant  SENSOR_MAX = 100

process(forward) {
    add_value(LeftMotor,
        −value(LeftMotor) + DEFAULT_SPEED)
    add_value(RightMotor,
        −value(RightMotor) + DEFAULT_SPEED)
}

process(taxis) {
    b_direction = (value(LeftSensor) − value(RightSensor)) / SENSOR_MAX
    add_value(LeftMotor,
        −1 · b_direction · MAX_CHANGE)
    add_value(RightMotor,
        +1 · b_direction · MAX_CHANGE)
}
```

Figure 1: A PDL program for homing in on a beacon with two sensors on a vehicle with differential drive.

4 Problem

Given an omnidirectional sensor that returns the angle α_b toward a beacon and the distance d to the beacon. The angle α_b is given in degrees following a counterclockwise rotation, i.e., $\alpha_b \in]-180^o, +180^o]$ going from right to left of the sensor. The distance output d_b is normalized between 0 and the sensor's maximum range of 2 m, i.e., based on the real distance d in meters, the output d_b is

$$d_b = \begin{cases} \frac{2-d}{2} & d \leq 2 \\ 0 & \text{otherwise} \end{cases}$$

Suppose the sensor is mounted on a differential drive robot. Its front is defined to be at 0^o orientation. The robot's drive has two commands to set its rotational and translational speeds, i.e., the speed with which its turns, respectively drives forward or backward:

- `set_rot(r)`, $r \in [-45, 45]^o/s$
- `set_trans(l)`, $l \in [-0.2, 0.2]m/s$

The robot runs PDL with 10 Hz. Write three PDL process to home in on the beacon, i.e., a process that

- drives forward with 0.1 m/s
- turns towards the beacon with a P-controller such that the maximum orientation error gets compensated within 4 seconds
- reduces the activation of the previous two processes in the spirit of Dual Dynamics when the robot gets closer to the beacon, i.e., that provides a P-controller such that the deactivation of the processes is normalized within the $[0, 2]m$ distance to the beacon.

5 Problem

Suppose we have k processes in a B-schedule. The highest exponential effect priority is *pvmax* for them.

1. What is the length of the major cycle, i.e., how many minor cycles exist?
2. How much memory is needed to store the complete schedule? Note: think about the actual algorithm and not of illustrations of the schedule.

6 Problem

Remember that the $REVERSE()$ of a number, or more precisely of the corresponding binary bit-string of length n, is derived by reading the bit-string in reverse order and interpreting this again as a number. More formal:

$$X = < x_{n-1}, ..., x_0 > = \sum_{i=0}^{n-1} x_i \cdot 2^i$$

$$Y = REVERSE(X, n) = < x_0, ..., x_{n-1} > = \sum_{i=0}^{n-1} x_i \cdot 2^{n-1-i}$$

What are the (decimal) values that results from the following $REVERSE()$ operations?

- $REVERSE(6, 3) =$
- $REVERSE(6, 4) =$
- $REVERSE(13, 5) =$