UNIVERSIDADE D
COIMBRA

Artificial Inteligence Fundamentals
Lab Assignment 1 - Stage 1

Perceptions, Actions and Production System Declarations

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Perceptions

Perception	Name	Description
observation[0]	x	Horizontal position relative to the landing platform. ($x < 0$ if the ship is to the left of the platform and $x > 0$ otherwise)
observation[1]	y	Vertical position, relative to the ground.
observation[2]	v_x	Horizontal velocity. Negative when the ship is going to the left and positive when its going to the right
observation[3]	v_y	Vertical velocity. Negative when the ship is going down and positive when its going up
observation[4]	θ	Ship's orientation ($\theta < 0$ if the ship is tilted to the left of the platform and $\theta > 0$ otherwise)
observation[5]	v_θ	Angular velocity ($v_\theta > 0$ if the ship is rotating counter-clockwise and $v_\theta < 0$ if cloclwise)
observation[6]	RLT	Boolean: $True$ if the right leg is in contact with the ground, $False$ otherwise
observation[7]	LLT	Boolean: $True$ if the left leg is in contact with the ground, $False$ otherwise

Table 1: Perceptions Declaration

Action Declaration

Name	Action	Description
Mm	Controls the main motor.	Activated for values larger than 0.5, linearly increases the acceleration until reaching the maximum value of 1.
Lm	Controls the left motor.	Activated for values larger than 0.5, the left motor is activated, rotating the ship to the right. It's acceleration linearly increases until reaching the maximum value of 1.
Rm	Controls the right motor.	Activated for values lower than -0.5, the right motor is activated, rotating the ship to the left. It's acceleration linearly increases until reaching the maximum value of -1.

Table 2: Actions declaration

Final Production System

Rules

(1) $RLT \wedge LLT \rightarrow$ NIL
(2) $RLT \wedge \neg LLT \rightarrow Md$
(3) $LLT \wedge \neg RLT \rightarrow Me$
(4) $y \geq 1.5 \rightarrow$ NIL
(5) $\theta \leq -0.15 \wedge v_y > -0.2 \rightarrow Md$
(6) $\theta > 0.15 \wedge v_y > -0.2 \rightarrow Me$
(7) $\theta > 0.15 \wedge v_y \leq -0.2 \rightarrow Mp, Me$
(8) $\theta \leq -0.15 \wedge v_y \leq -0.2 \rightarrow Mp, Md$
(9) $v_\theta \leq -0.3 \wedge v_y > -0.2 \rightarrow Md$
(10) $v_\theta > 0.3 \wedge v_y > -0.2 \rightarrow Me$
(11) $v_\theta > 0.3 \wedge v_y \leq -0.2 \rightarrow Mp, Me$
(12) $v_\theta \leq -0.3 \wedge v_y \leq -0.2 \rightarrow Mp, Md$
(13) $v_x \leq -0.2 \wedge v_y > -0.2 \rightarrow Me$
(14) $v_x > 0.2 \wedge v_y > -0.2 \rightarrow Md$
(15) $v_x > 0.2 \wedge v_y \leq -0.2 \rightarrow Mp, Md$
(16) $x = 0 \rightarrow$ NIL
(17) $x \leq 0.2 \rightarrow Me, Mp$
(18) $x > 0.2 \rightarrow Md, Mp$
(19) $v_y \leq -0.2 \rightarrow Mp$
(20) $v_y > 0.2 \rightarrow$ NIL

Table 3: Production System

(1)-(3): Stabilize the ship's orientation to keep it aligned with the vertical axis while landing
(4): Turn engines off if the ship goes too high
(5)-(8): Stabilize the ship's orientation to keep it aligned with the vertical axis
(9)-(12): Stabilize the ship's angular velocity to keep it aligned with a stabilized orientation
(13)-(15):Stabilize the horizontal velocity, keeping it as low as possible using the secondary engines
(16)-(18):Stabilize the horizontal position using the left and right engines
(19)-(20):Stabilize the vertical velocity, keeping it as low as possible using the main engine

Score Progression

Standard

- The first score obtained was **0.0%**, since the ship's angular velocity was not being properly stabilized causing the ship to turn and get away from the landing platform.

Rules

(1) $LLT \vee RLT \rightarrow$ NIL
(2) $\theta \leq -0.3 \wedge v_y > -1.5 \rightarrow Md$
(3) $\theta > 0.3 \wedge v_y > -1.5 \rightarrow Me$
(4) $\theta > 0.3 \wedge v_y \leq -1.5 \rightarrow Mp, Me$
(5) $\theta \leq -0.3 \wedge v_y \leq -1.5 \rightarrow Mp, Md$
(6) $v_\theta \leq -0.3 \wedge v_y > -1.5 \rightarrow Md$
(7) $v_\theta > 0.3 \wedge v_y > -1.5 \rightarrow Me$
(8) $v_\theta > 0.3 \wedge v_y \leq -1.5 \rightarrow Mp, Me$
(9) $v_\theta \leq -0.3 \wedge v_y \leq -1.5 \rightarrow Mp, Md$
(10) $v_x \leq -1.0 \wedge v_y > -1.5 \rightarrow Md$
(11) $v_x > 1.0 \wedge v_y > -1.5 \rightarrow Me$
(12) $v_x > 1.0 \wedge v_y \leq -1.5 \rightarrow Mp, Me$
(13) $v_x \leq -1.0 \wedge v_y \leq -1.5 \rightarrow Mp, Md$
(14) $x = 0 \rightarrow$ NIL
(15) $x \leq 0 \wedge v_y > -1.5 \rightarrow Me$
(16) $x > 0 \wedge v_y > -1.5 \rightarrow Md$
(17) $x > 0 \wedge v_x \leq -1.5 \rightarrow Mp, Me$
(18) $x \leq 0 \wedge v_x \leq -1.5 \rightarrow Mp, Md$
(19) $v_y \leq -1.5 \rightarrow Mp$ (20) $v_y > 1.5 \rightarrow$ NIL

- After establishing better thresholds for the angular velocity and Y velocity, we managed to achieve a score of **54.0% with 42752 steps**.

Rules

(1) $RLT \wedge LLT \rightarrow$ NIL
(2) $RLT \wedge \neg LLT \rightarrow Md$
(3) $LLT \wedge \neg RLT \rightarrow Me$
(4) $\theta \leq -0.3 \wedge v_y > -0.1 \rightarrow Md$
(5) $\theta > 0.3 \wedge v_y > -0.1 \rightarrow Me$
(6) $\theta > 0.3 \wedge v_y \leq -0.1 \rightarrow Mp, Me$
(7) $\theta \leq -0.3 \wedge v_y \leq -0.1 \rightarrow Mp, Md$
(8) $v_\theta \leq -0.2 \rightarrow Mp, Md$
(9) $v_\theta > 0.2 \rightarrow Mp, Me$
(10) $v_x \leq -0.2 \wedge v_y > -0.1 \rightarrow Me$
(11) $v_x > 0.2 \wedge v_y > -0.1 \rightarrow Md$
(12) $v_x > 0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Md$
(13) $v_x \leq -0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Me$
(14) $x = 0 \rightarrow$ NIL
(15) $x \leq 0.2 \rightarrow Me, Mp$
(16) $x > 0.2 \rightarrow Md, Mp$
(17) $v_y \leq -1 \rightarrow Mp$
(18) $v_y > 1 \rightarrow$ NIL

- This value was further increased to **66.9% with 48901 steps** as we paired the verification of the angular velocity with the Y velocity.

Rules

(1) $RLT \wedge LLT \rightarrow$ NIL
(2) $RLT \wedge \neg LLT \rightarrow Md$
(3) $LLT \wedge \neg RLT \rightarrow Me$
(4) $\theta \leq -0.3 \wedge v_y > -0.1 \rightarrow Md$
(5) $\theta > 0.3 \wedge v_y > -0.1 \rightarrow Me$
(6) $\theta > 0.3 \wedge v_y \leq -0.1 \rightarrow Mp, Me$
(7) $\theta \leq -0.3 \wedge v_y \leq -0.1 \rightarrow Mp, Md$
(8) $v_\theta \leq -0.2 \wedge v_y > -0.1 \rightarrow Md$
(9) $v_\theta > 0.2 \wedge v_y > -0.1 \rightarrow Me$
(10) $v_\theta > 0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Me$
(11) $v_\theta \leq -0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Md$
(12) $v_x \leq -0.2 \wedge v_y > -0.1 \rightarrow Me$
(13) $v_x > 0.2 \wedge v_y > -0.1 \rightarrow Md$
(14) $v_x > 0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Md$
(15) $v_x \leq -0.2 \wedge v_y \leq -0.1 \rightarrow Mp, Me$
(16) $x = 0 \rightarrow$ NIL
(17) $x \leq 0.2 \rightarrow Me, Mp$
(18) $x > 0.2 \rightarrow Md, Mp$
(19) $v_y \leq -1 \rightarrow Mp$
(20) $v_y > 1 \rightarrow$ NIL

- After further constrictions on the thresholds for angular velocity, angle and Y velocity, and by adding a maximum y value that stops the ship from flying out of vertical range (rule 4) we managed to achieve a score of **81.39% with 37050 steps**, using the production system stated here.

Wind enabled

- The first production system used for this new environment, was very similar to the original one, with the only difference being the addition of a new rule that makes the ship drop if its below a certain y value (rule 19), since before, with a slower aproach, it was being pushed by the wind, sometimes not stopping even when landed. With this we achieved an average **37.5% hit score with 7621 steps** .

Rules

(1) $RLT \land LLT \rightarrow$ NIL
(2) $RLT \land \neg LLT \rightarrow Md$
(3) $LLT \land \neg RLT \rightarrow Me$
(4) $y \geq 1.5 \rightarrow$ NIL
(5) $\theta \leq -0.15 \land v_y > -0.2 \rightarrow Md$
(6) $\theta > 0.15 \land v_y > -0.2 \rightarrow Me$
(7) $\theta > 0.15 \land v_y \leq -0.2 \rightarrow Mp, Me$
(8) $\theta \leq -0.15 \land v_y \leq -0.2 \rightarrow Mp, Md$
(9) $v_\theta \leq -0.3 \land v_y > -0.2 \rightarrow Md$
(10) $v_\theta > 0.3 \land v_y > -0.2 \rightarrow Me$
(11) $v_\theta > 0.3 \land v_y \leq -0.2 \rightarrow Mp, Me$
(12) $v_\theta \leq -0.3 \land v_y \leq -0.2 \rightarrow Mp, Md$
(13) $v_x \leq -0.2 \land v_y > -0.2 \rightarrow Me$
(14) $v_x > 0.2 \land v_y > -0.2 \rightarrow Md$
(15) $v_x > 0.2 \land v_y \leq -0.2 \rightarrow Mp, Md$
(16) $x = 0 \rightarrow$ NIL
(17) $x \leq 0.2 \rightarrow Me, Mp$
(18) $x > 0.2 \rightarrow Md, Mp$
(19) $y \geq 0.2 \rightarrow$ NIL
(20) $v_y \leq -0.2 \rightarrow Mp$
(21) $v_y > 0.2 \rightarrow$ NIL

- For the final production system, we achieved an average score of **41.5% with 8197 steps** after adding a dynamic theta threshold. The threshold is the *dynamic_theta* present in the production system (closer to the center = stricter requirement) and it corresponds to $x\_percentage = min(1.0, abs(x)/X\_BOUNDARY), dynamic\_theta = MIN\_THETA + (0.55 - MIN\_THETA) * x\_percentage$. Here, $X\_BOUNDARY = 1.0$ and it corresponds to the distance where we start caring about theta alignment with the vertical axis and $MIN\_THETA = 0.05$ and its the minimum threshold where x=0. These values and all the changes in the thresholds from the last production system were obtained by optimizing a cost function corresponding to the ship's hitrate with a bayesian optimization model. Ending with the following as the final production system:

Rules

(1) $RLT \wedge LLT \rightarrow$ NIL
(2) $RLT \wedge \neg LLT \rightarrow Md$
(3) $LLT \wedge \neg RLT \rightarrow Me$
(4) $y \geq 2.1 \rightarrow$ NIL
(5) $\theta \leq -dinamic\_theta \wedge v_y > -0.3 \rightarrow Md$
(6) $\theta > dinamic\_theta \wedge v_y > -0.3 \rightarrow Me$
(7) $\theta > dinamic\_theta \wedge v_y \leq -0.3 \rightarrow Mp, Me$
(8) $\theta \leq -dinamic\_theta \wedge v_y \leq -0.3 \rightarrow Mp, Md$
(9) $v_\theta \leq -1.3 \wedge v_y > -0.3 \rightarrow Md$
(10) $v_\theta > 1.3 \wedge v_y > -0.3 \rightarrow Me$
(11) $v_\theta > 1.3 \wedge v_y \leq -0.3 \rightarrow Mp, Me$
(12) $v_\theta \leq -1.3 \wedge v_y \leq -0.3 \rightarrow Mp, Md$
(13) $v_x \leq -0.3 \wedge v_y > -0.3 \rightarrow Me$
(14) $v_x > 0.3 \wedge v_y > -0.3 \rightarrow Md$
(15) $v_x > 0.3 \wedge v_y \leq -0.3 \rightarrow Mp, Md$
(16) $x = 0 \rightarrow$ NIL
(17) $x \leq 0.1 \rightarrow Me, Mp$
(18) $x > 0.1 \rightarrow Md, Mp$
(19) $y \geq 0.1 \rightarrow$ NIL
(20) $v_y \leq -0.3 \rightarrow Mp$
(21) $v_y > 0.3 \rightarrow$ NIL