Lunar Lander

Project 1 for Artificial Intelligence Fundamentals

Francisco Silva, Miguel Pereira and Guilherme Rodrigues
Nº 2022213583, 2022232552 and 2022232102

Department of Informatics Engineering
University of Coimbra, Coimbra, Portugal
{francisco.lapamsilva,miguelmpereira0409,grf04}@gmail.com

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1 Perceptions

We use built-in perceptions of the lander and a zoning system that determines safe and unsafe zones, so that the lander reacts according to its placement, as described in Figure 1.

1.1 Zoning System

The Zoning System helps us determine where to do what. We consider zones **G** and **H** to be difficult to move the Lunar Lander to the landing zone, so we move them up to zones **E** and **F**. Zones **E** and **F** are almost acceptable, we have to move the to, which we call the chimney. The chimney is in zones **B**, **C**, and **D**. They're the zones where we move the lander down while trying to center it in the middle of the landing. **C** and **D** make the small adjustments to get the lander to the **B** zone, where it slowly descends to zone **A**. Zone **A** is where we determine that the Lunar Lander is in a safe enough place that we can turn off the jets and safely land it without the need for minor adjustments.

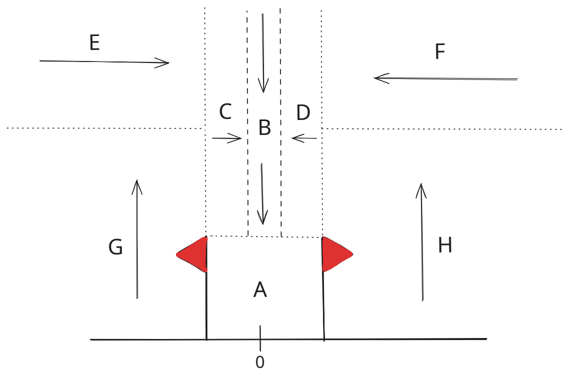

Figure 1: Zoning System of the lunar landing

1.2 Perceptions

We utilize the following perceptions to determine horizontal, vertical and angular speeds, as well as angular directions, if the left and right legs are touching the ground, and, again, the zoning systems.

- **Za**: Landing Zone
- **Zb**: Safest Descent Zone
- **Zc**: Left Safe Descent Zone
- **Zd**: Right Safe Descent Zone
- **Ze**: Left Upper Safe Zone
- **Zf**: Right Upper Safe Zone
- **Zg**: Left Unsafe Zone
- **Zh**: Right Unsafe Zone
- **Vx**: Horizontal velocity (positive rightward)
- **Vy**: Vertical velocity (positive upward)
- **A**: Angular direction (positive counter-clockwise)
- **Va**: Angular velocity (positive counter-clockwise)
- **L**: Left leg in ground contact
- **R**: Right leg in ground contact

2 Actions

To control the Moon Lander we utilized the actions that were given to us on different levels. They are ON, partially ON and OFF. The partially ON levels help us stabilize the Lunar Lander by making minor adjustments so we don't overshoot it and end up being in a unwanted state again.

2.1 Action Definition

- **Mp0**: Main Motor OFF (0.0)
- **Mp1**: Main Motor partially ON (0.1)
- **Mp2**: Main Motor ON (1.0)
- **Ms0**: Secondary Motors OFF (0.0)
- **Msl1**: Left Secondary Motor partially ON (0.55)
- **Msl2**: Left Secondary Motor ON (0.8)
- **Msr1**: Right Secondary Motor partially ON (0.55)
- **Msr2**: Right Secondary Motor ON (0.8)

3 Production System

3.1 Basic Production System

To maximize successful landings our priority is maintaining the stability of the lander for better maneuvering. Only when the stability is guaranteed the lander tries to land. The basic set of instructions the lander must follow, regardless of position and/or zone are:

1. V_a[1] $\geq$ MAS $\rightarrow$ Mp1, Msl1 — prevents spinning
2. $V_a \leq -$MAS $\rightarrow$ Mp1, Msr1 — prevents spinning
3. V_x[2] $\geq$ MXS $\rightarrow$ Mp1, Msl2 — prevents rightward drift
4. $V_x \leq -$MXS $\rightarrow$ Mp1, Msr2 — prevents leftward drift
5. V_y[3] $\geq$ MYS $\rightarrow$ Mp0 — prevents ascending
6. V_y[4] $\leq -$MYS $\rightarrow$ Mp2 — prevents excessive descent speed

3.2 Constants

With the basic Production System we can create the final Production System, changing the {...} values according to what the lander should do in its current zone. We also need to define constants, determining the values that we want to set for the perceptions.

Constants:

- **MAS**: Maximum Angular Speed (e.g., 0.1)
- **MXS**: Maximum Horizontal Speed (e.g., 0.01)
- **MYS**: Maximum Vertical Speed (e.g., 0.1)

[1] V_a: angular velocity
[2] V_x: horizontal velocity
[3] V_y: vertical velocity (upwards)
[4] V_y: vertical velocity (downwards)

3.3 Final Production System

The final production system adjusts control rules based on the current zone and observed velocities.

Zone A Rules:

1. Za, $V_a \geq 0 \rightarrow$ MP1, Msl1 — prevents lander spinning out
2. Za, $V_a \leq 0 \rightarrow$ MP1, Mrl1 — prevents lander spinning out
3. Za, $V_x \geq 0 \rightarrow$ MP1, Msl2 — prevents lander moving right
4. Za, $V_x \leq 0 \rightarrow$ MP1, Mrl2 — prevents lander moving left
5. Za, $V_y \geq 0 \rightarrow$ MP0 — prevents lander flying away
6. Za, $V_y \leq 0 \rightarrow$ MP2 — prevents lander descending too fast

Zone B Rules:

1. Zb, $V_a \geq 0 \rightarrow$ MP1, Msl1 — prevents lander spinning out
2. Zb, $V_a \leq 0 \rightarrow$ MP1, Mrl1 — prevents lander spinning out
3. Zb, $V_x \geq 0 \rightarrow$ MP1, Msl2 — prevents lander moving right
4. Zb, $V_x \leq 0 \rightarrow$ MP1, Mrl2 — prevents lander moving left
5. Zb, $V_y \geq 0 \rightarrow$ MP0 — prevents lander flying away
6. Zb, $V_y \leq -\text{MYS} \rightarrow$ MP2 — prevents lander descending too fast

Zone C Rules:

1. Zc, $V_a \geq 0 \rightarrow$ MP1, Msl1 — prevents lander spinning out
2. Zc, $V_a \leq -\text{MAS} \rightarrow$ MP1, Mrl1 — prevents spinning, allows rotation right
3. Zc, $V_x \geq \text{MXS} \rightarrow$ MP1, Msl2 — prevents moving too fast right
4. Zc, $V_x \leq 0 \rightarrow$ MP1, Mrl2 — prevents moving left
5. Zc, $V_y \geq 0 \rightarrow$ MP0 — prevents flying away
6. Zc, $V_y \leq -\text{MYX} \rightarrow$ MP2 — prevents descending too fast, allows descent

Zone D Rules:

1. Zd, $V_a \geq \text{MAS} \rightarrow$ MP1, Msl1 — prevents spinning, allows rotation left
2. Zd, $V_a \leq 0 \rightarrow$ MP1, Mrl1 — prevents spinning
3. Zd, $V_x \geq 0 \rightarrow$ MP1, Msl2 — prevents moving right
4. Zd, $V_x \leq -\text{MXS} \rightarrow$ MP1, Mrl2 — prevents moving too fast left
5. Zd, $V_y \geq 0 \rightarrow$ MP0 — prevents flying away
6. Zd, $V_y \leq \text{MYX} \rightarrow$ MP2 — prevents descending too fast, allows descent

Zone A Rules:

1. Ze, $V_a \geq 0 \rightarrow$ MP1, Msl1 — prevents spinning
2. Ze, $V_a \leq 0 \rightarrow$ MP1, Mrl1 — prevents spinning
3. Ze, $V_x \geq \text{MXS} \rightarrow$ MP1, Msl2 — prevents moving too fast right
4. Ze, $V_x \leq 0 \rightarrow$ MP1, Mrl2 — prevents moving left
5. Ze, $V_y \geq \text{MYS} \rightarrow$ MP0 — prevents flying up too fast
6. Ze, $V_y \leq 0 \rightarrow$ MP2 — prevents descending too fast

Zone F Rules:

1. Zf, $V_a \geq 0 \rightarrow$ MP1, Msl1 prevents spinning
2. Zf, $V_a \leq 0 \rightarrow$ MP1, Mrl1 prevents spinning
3. Zf, $V_x \geq 0 \rightarrow$ MP1, Msl2 prevents moving right
4. Zf, $V_x \leq$ MXS $\rightarrow$ MP1, Mrl2 prevents moving too fast left
5. Zf, $V_y \geq$ MYS $\rightarrow$ MP0 prevents flying up too fast
6. Zf, $V_y \leq 0 \rightarrow$ MP2 prevents descending too fast

Zone G Rules:

1. Zg, $V_a \geq 0 \rightarrow$ MP1, Msl1 prevents spinning
2. Zg, $V_a \leq -$MAS $\rightarrow$ MP1, Mrl1 prevents spinning, allows rotation right
3. Zg, $V_x \geq$ MXS $\rightarrow$ MP1, Msl2 prevents moving too fast right
4. Zg, $V_x \leq 0 \rightarrow$ MP1, Mrl2 prevents moving left
5. Zg, $V_y \geq 0 \rightarrow$ MP0 prevents flying away
6. Zg, $V_y \leq 0 \rightarrow$ MP2 prevents descending too fast

Zone H Rules:

1. Zh, $V_a \geq$ MAS $\rightarrow$ MP1, Msl1 prevents spinning, allows rotation left
2. Zh, $V_a \leq 0 \rightarrow$ MP1, Mrl1 prevents spinning
3. Zh, $V_x \geq 0 \rightarrow$ MP1, Msl2 prevents moving right
4. Zh, $V_x \leq -$MXS $\rightarrow$ MP1, Mrl2 prevents moving too fast left
5. Zh, $V_y \geq 0 \rightarrow$ MP0 prevents flying away
6. Zh, $V_y \leq 0 \rightarrow$ MP2 prevents descending too fast

4 Conclusion

The presented control system emphasizes stability prior to descent, relying on zone-specific velocity constraints and corrective actions. Further improvement is possible by optimizing threshold values, adjusting motor actions, modifying zone boundaries, and incorporating combined perceptions to handle complex scenarios beyond the current system's capabilities.