REACTIVE NAVIGATION

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DEPARTMENT OF ELECTRICAL AND COMPUTER
ENGINEERING

AUTONOMOUS MOBILE ROBOTICS
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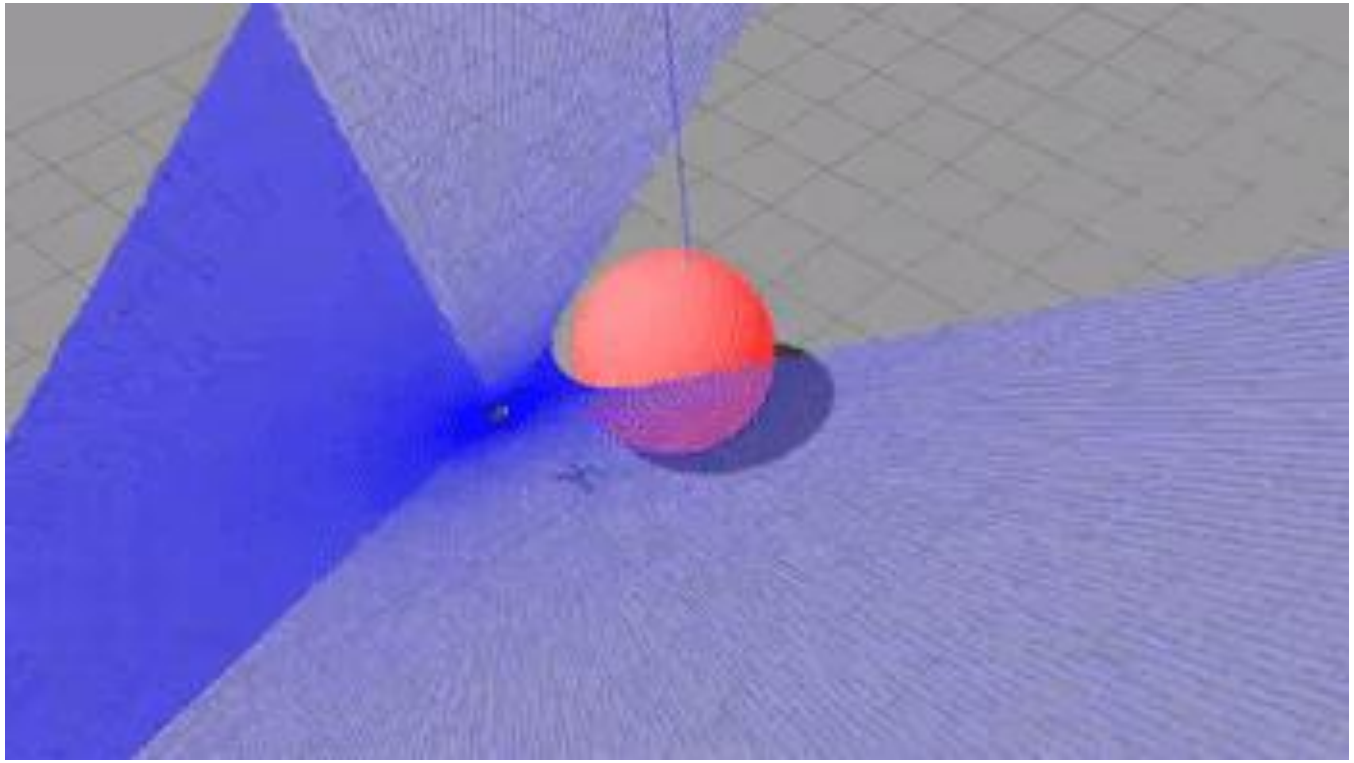
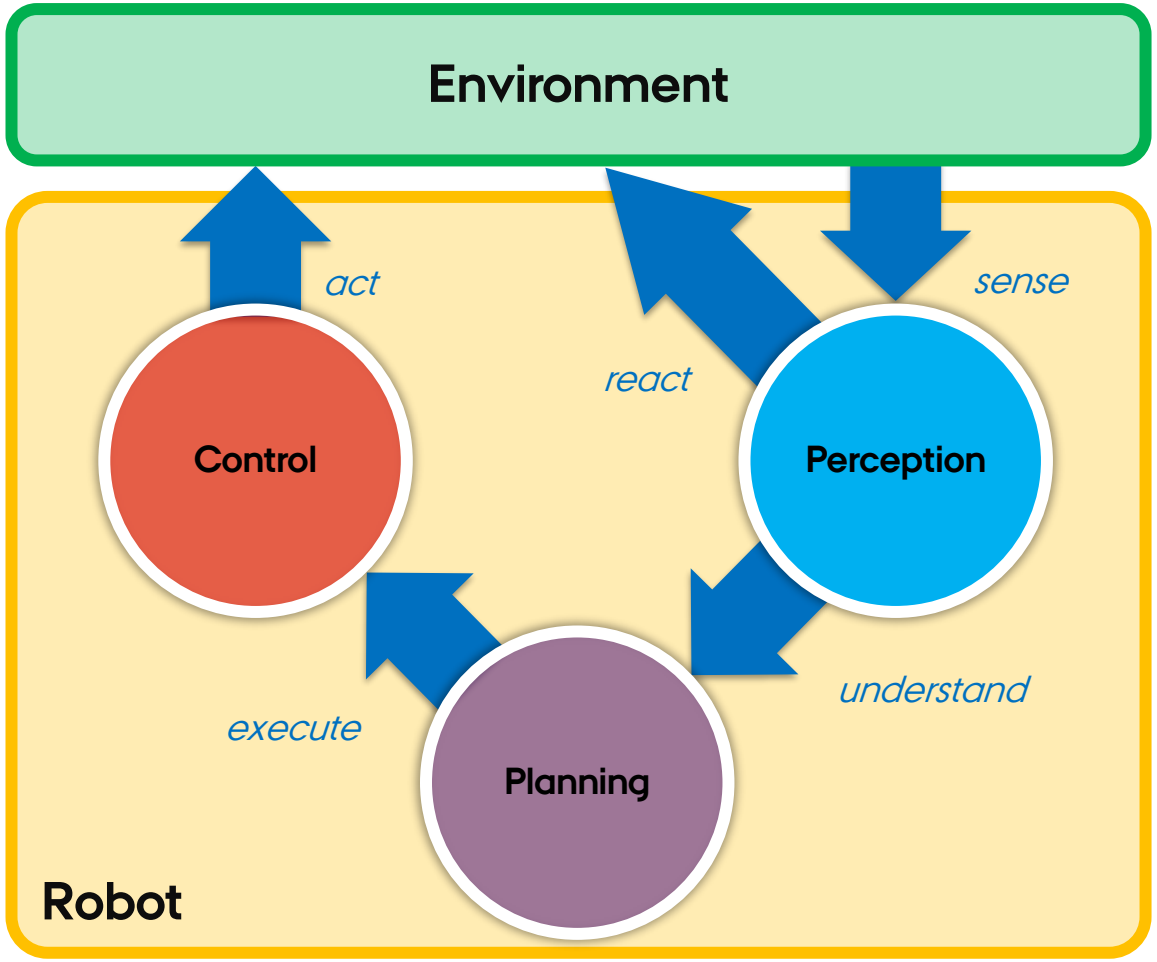
REACTIVE NAVIGATION

- **Reactive navigation** is a type of robotic navigation approach where the robot responds directly to its immediate sensory inputs.

- In reactive navigation, the robot typically employs a set of predefined rules or behaviors to respond to different sensory stimuli.



REACTIVE NAVIGATION PARADIGM

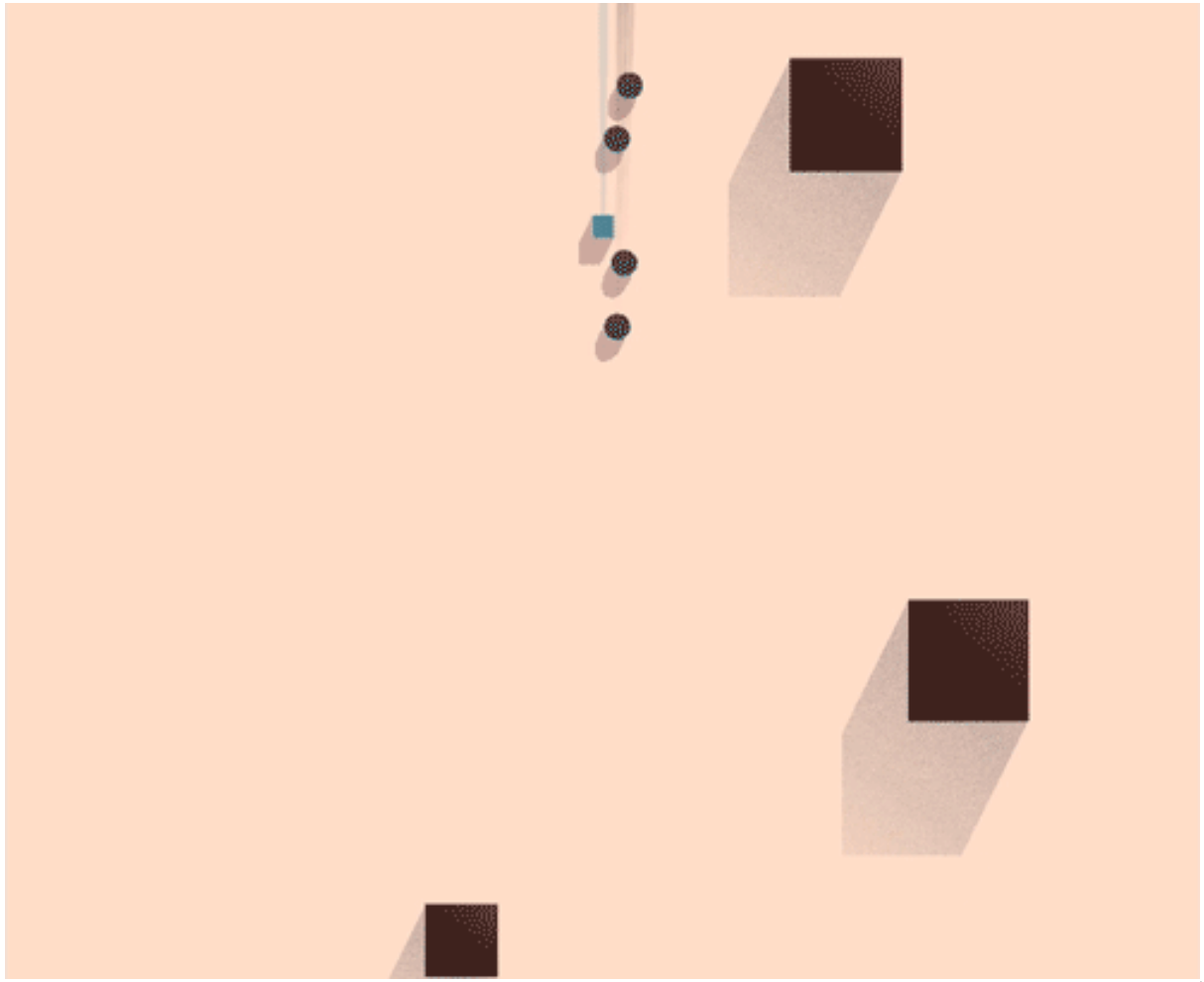


COLLISION AVOIDANCE

- **Collision avoidance** is a safety tool designed to avoid imminent collisions.
- Collision avoidance is a binary classification task which consists of two classes: *blocked* and *free*.
- Collision avoidance uses a variety of sensors, such as radar and lasers.

OBSTACLE AVOIDANCE

- **Obstacle avoidance** is the capability of a robot to detect and circumvent obstacles in its path.
- Obstacle avoidance enables robots to operate safely and efficiently in dynamic and complex environments, reducing the risk of collisions.
- Obstacles can be *static* or *dynamic*.

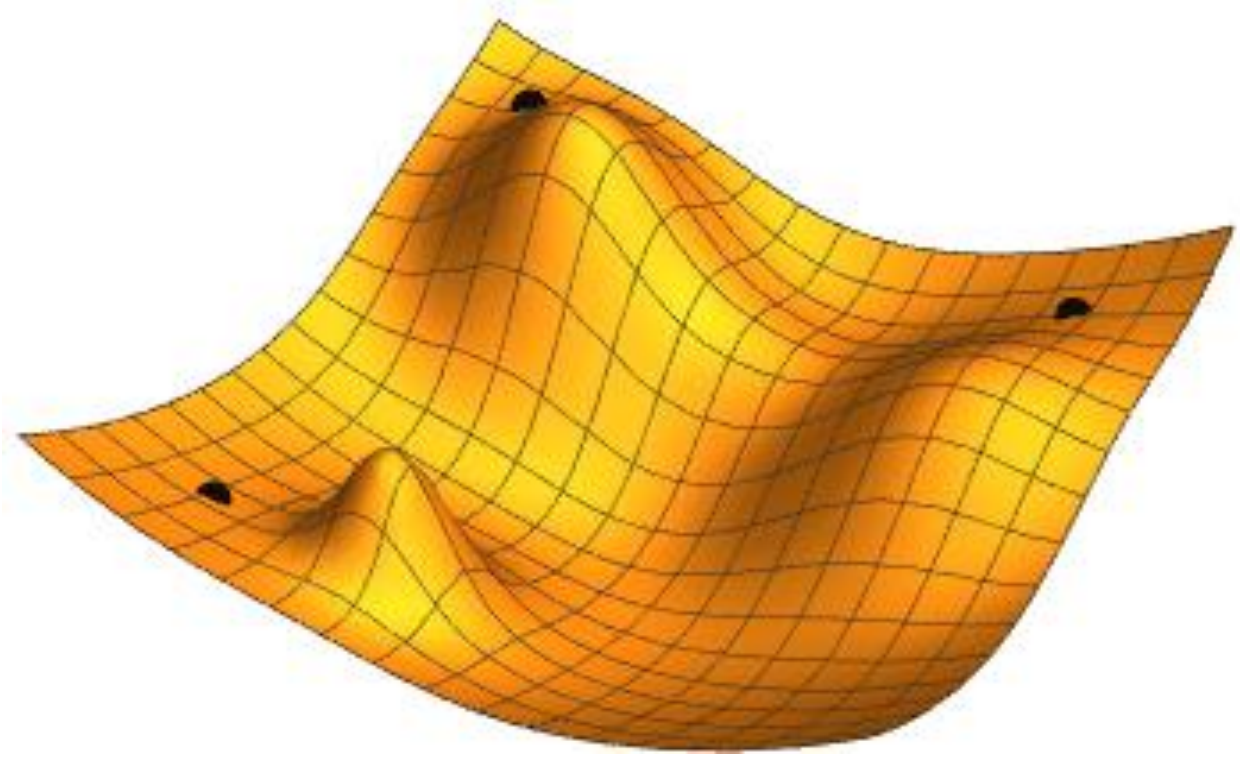


POTENTIAL FIELD

- **Potential field** is any physical field that obeys Laplace's equation, such as electrical, magnetic and gravitational fields.

- Potential fields is superposition of *attractive* and *repulsive* fields:
$$U(\mathbf{p}) = U_{\mathrm{A}}(\mathbf{p}) + U_{\mathrm{R}}(\mathbf{p}).$$

- The gradient descent moves the particle towards the minima:
$$\mathbf{f}(\mathbf{p}) = -\vec{\nabla} U(\mathbf{p}).$$



ATTRACTIVE POTENTIAL FIELD

- **Attractive force** is generated by the goal or direction of motion.

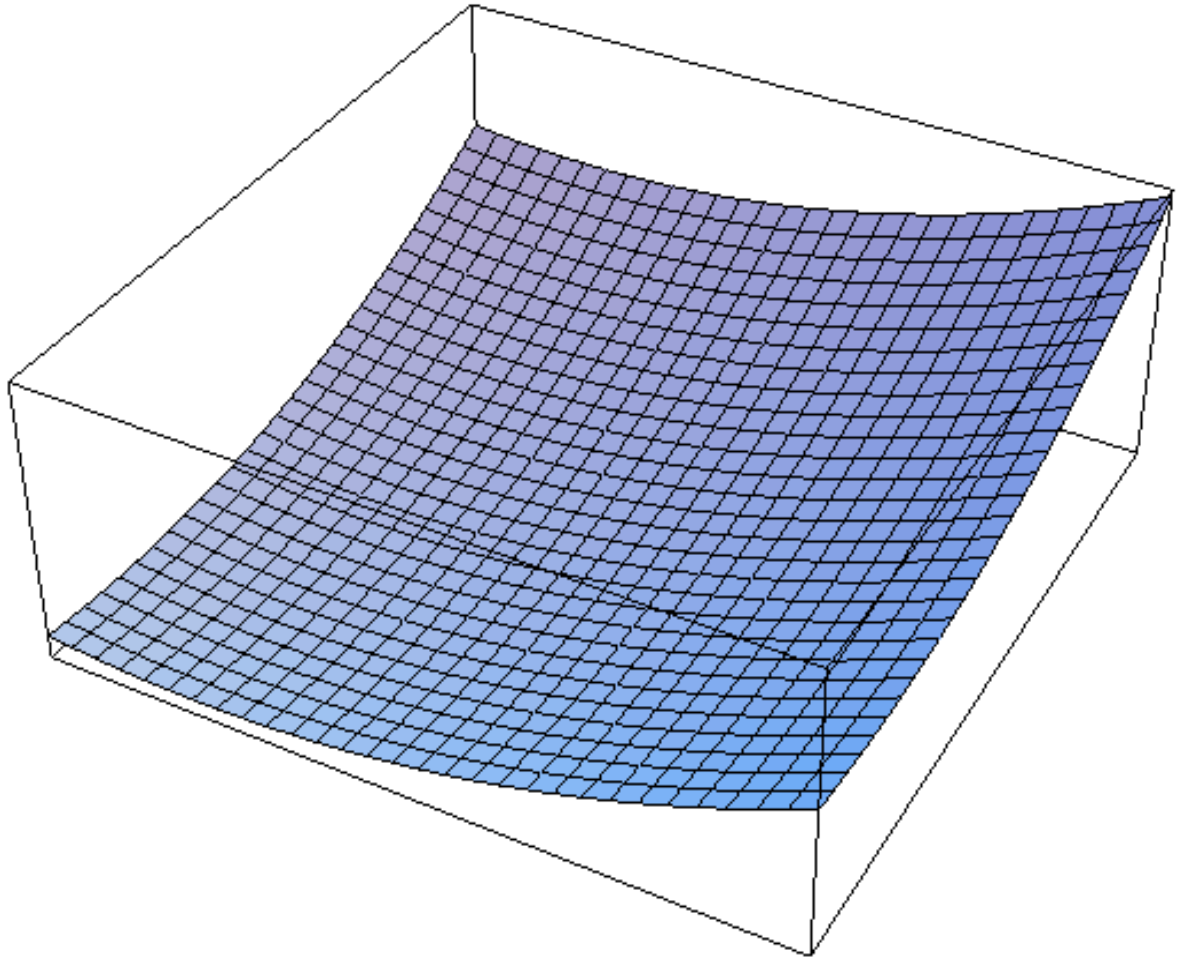
- Goal located at $\mathbf{p}_\mathrm{G}$ attracts the robot located at $\mathbf{p}_\mathrm{R}$:

$$U_\mathrm{A} = \frac{1}{2}(\mathbf{p}_\mathrm{G} - \mathbf{p}_\mathrm{R})^2$$

$$\mathbf{f}_\mathrm{A} = -\vec{\nabla} U_\mathrm{A}(\mathbf{p}) = \mathbf{p}_\mathrm{G} - \mathbf{p}_\mathrm{R}$$

- Velocity command $\mathbf{v}_\mathrm{C}$ attraction:

$$\mathbf{f}_\mathrm{A} = \mathbf{v}_\mathrm{C}$$



REPULSIVE POTENTIAL FIELD

- **Repulsive forces** are generated by obstacles.

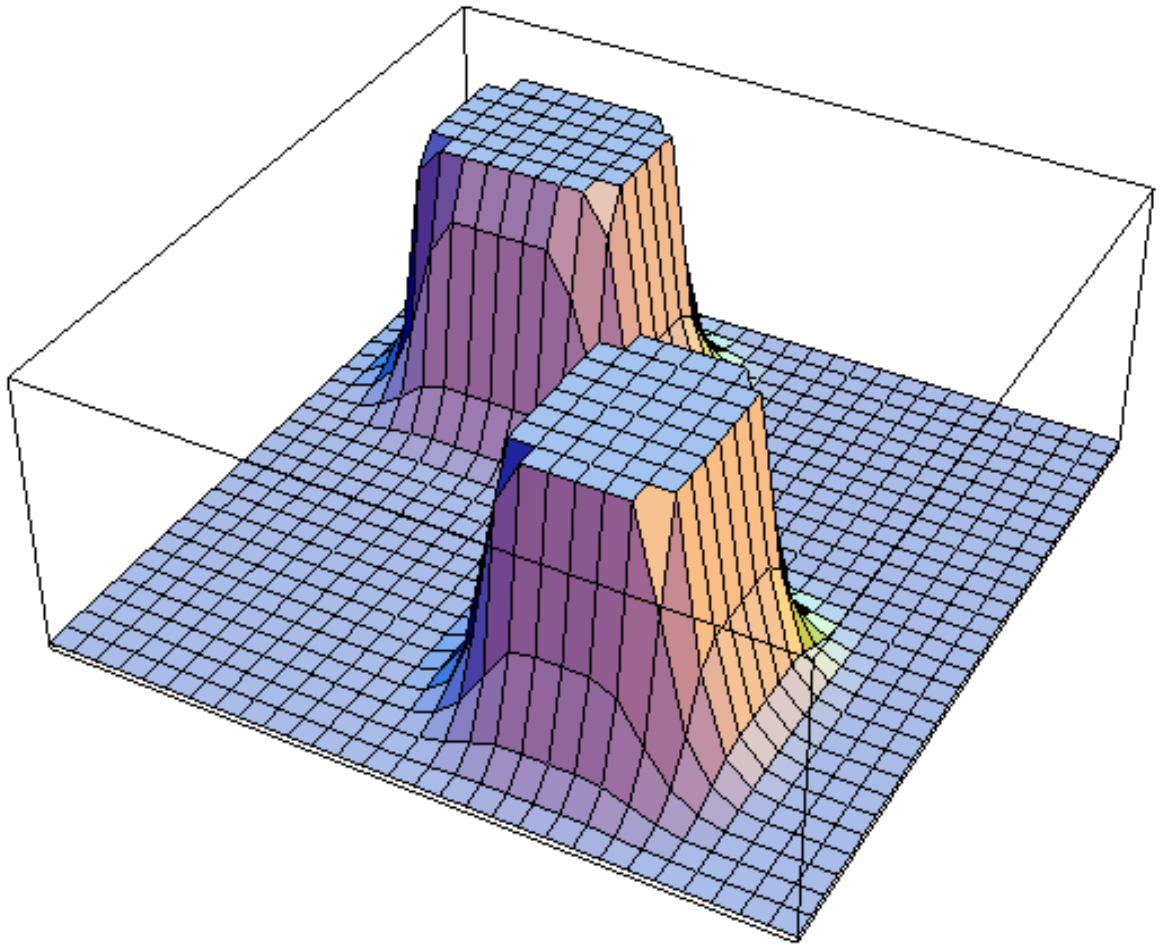
- For each obstacle i, the distance to the obstacle is d_i

$$U_{\mathrm{R},i} = \begin{cases} \left(\frac{1}{d_i} - \frac{1}{d_0}\right)^2 & \text{if } d_i \leq d_0 \\ 0 & \text{if } d_i > d_0 \end{cases}$$

$$\mathbf{f}_{\mathrm{R},i} = \begin{cases} \frac{1}{2d_i^2}\left(\frac{1}{d_i} - \frac{1}{d_0}\right) & \text{if } d_i \leq d_0 \\ 0 & \text{if } d_i > d_0 \end{cases}$$

- Aggregated repulsive force:

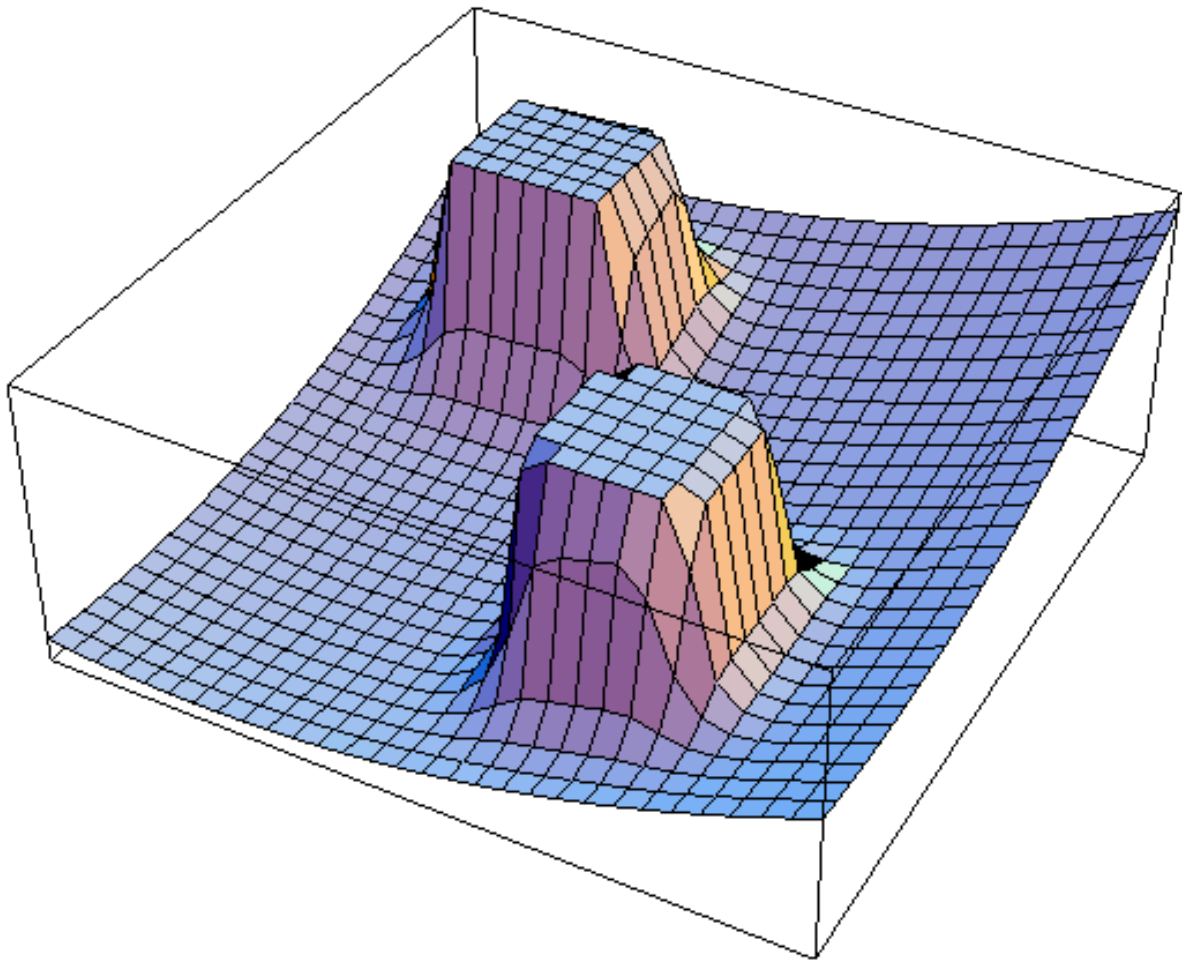
$$\mathbf{f}_{\mathrm{R}} = \sum_{i=1} \mathbf{f}_{\mathrm{R},i}$$



ARTIFICIAL POTENTIAL FIELD

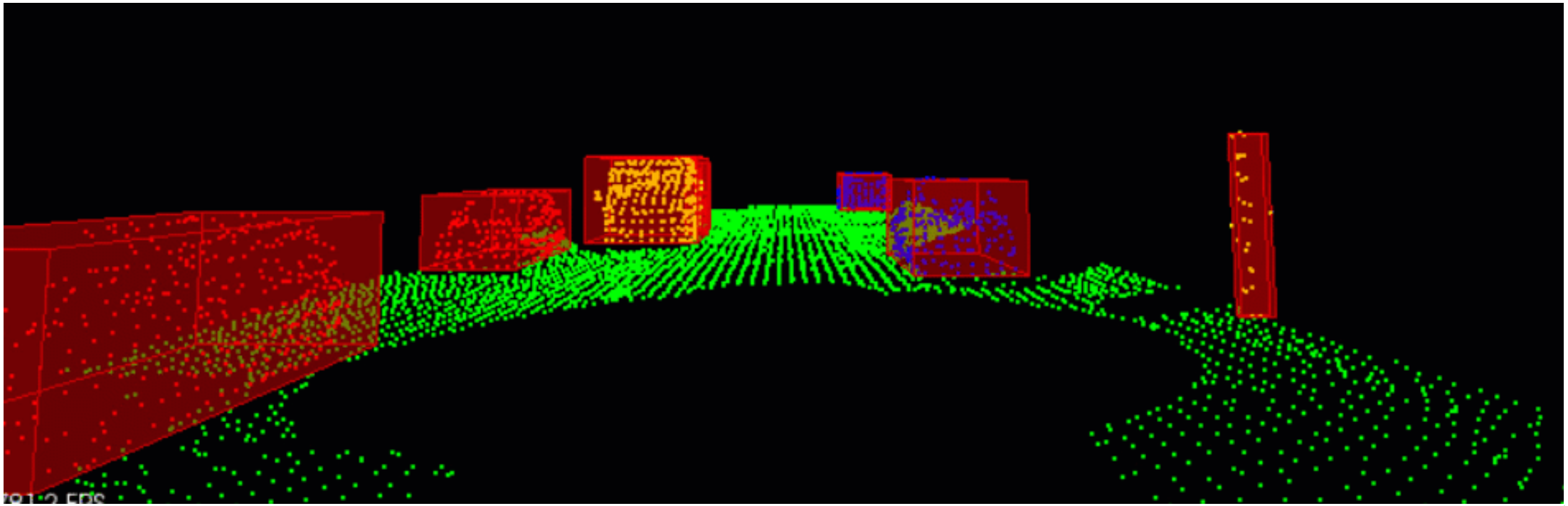
- **Artificial potential field** is a method to move a robot in a certain space by using potential fields.
- The robot is represented as a particle under the influence of an artificial potential field.
- Artificial potential field can be used for obstacle avoidance.
- For reactive obstacle avoidance, the total force field:

$$\mathbf{f} = \mathbf{v}_C + \sum_{i=1} \mathbf{f}_{R,i}$$



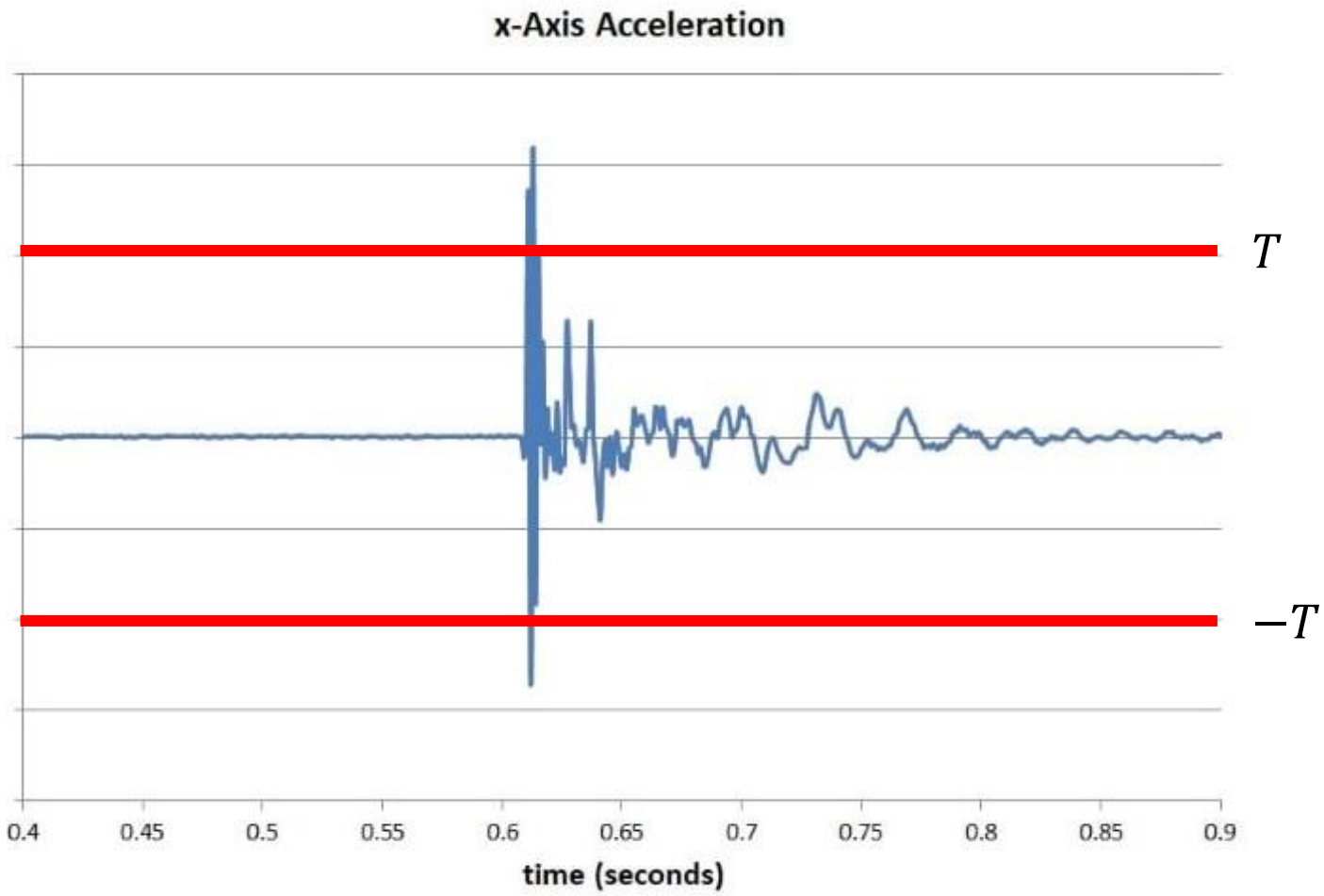
OBSTACLE DETECTION

- **Obstacle detection** is the process of using sensors to detect objects that impede motion.
- For a robot to successfully navigate through obstacles, it must be able to detect such obstacles.



COLLISION DETECTION

- **Collision detection** is a method which enable the robot to realize that collision happened and take appropriate actions.
- Collision involves significant deceleration.
- Simple approach: check if accelerations are below a threshold.



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