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## But wait again...

- Given
  - A current position
  - A goal position ?
  - Information on the environment
  - Constraints to satisfy / criteria to optimize
- Find
  - A trajectory that satisfies the constraints / optimizes the criteria



# Outline

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- Basic notions
  - Configuration space, kinematic constraints, search algorithms
- Practical field solutions
  - Potential field approaches
  - Short-term (“reactive”) planning
  - Long-term itineraries
- Other research problems



# Navigation strategies

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- Given
  - A current position
  - An objective (far away goal, area to map/explore)
  - Information on the environment
  - Constraints to satisfy / criteria to optimize
- Find
  - A itinerary that satisfies the constraints / optimizes the criteria
    - Where should the robot head?
    - How should it head there?
    - What for?

An itinerary is akin to a coarse trajectory: sequence of waypoints, enriched with tasks and modalities

# Navigation strategies

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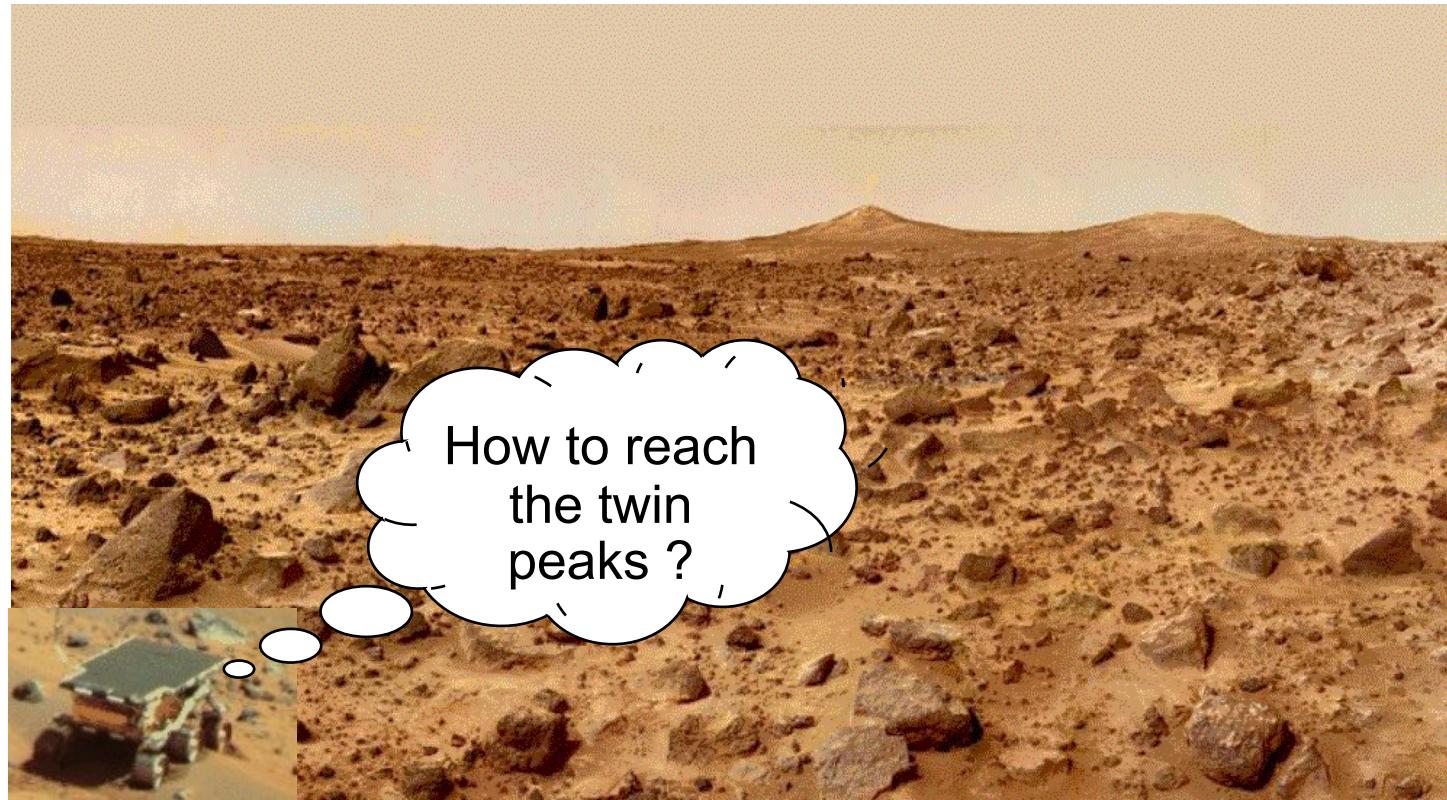
nav•i•ga•tion |,nəvē'gā shən|

noun

**1** the process or activity of accurately ascertaining one's position and planning and following a route.

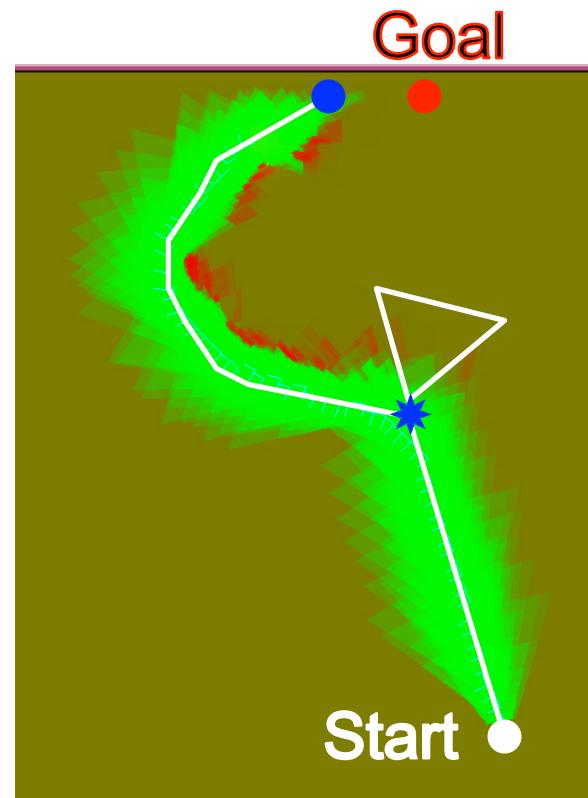
# Navigation strategies

- For instance:



# Navigation strategies

- *Where to go and what for ?*



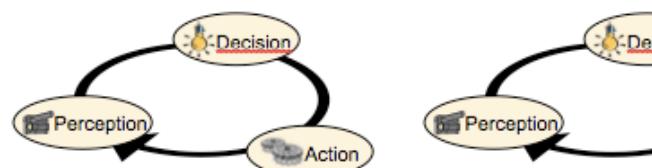
# Navigation strategies

- *How to go there ?*

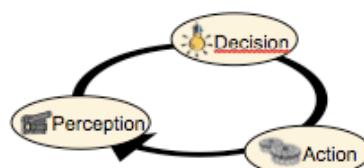
A *huge* variety of situations



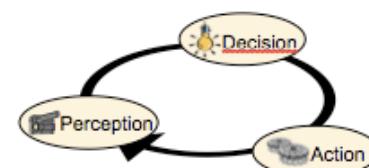
⇒ Several motion modes, *adapted* to the situation at hand



Potential



Local arcs



Route following

Who selects, configures and controls the navigation modes ?

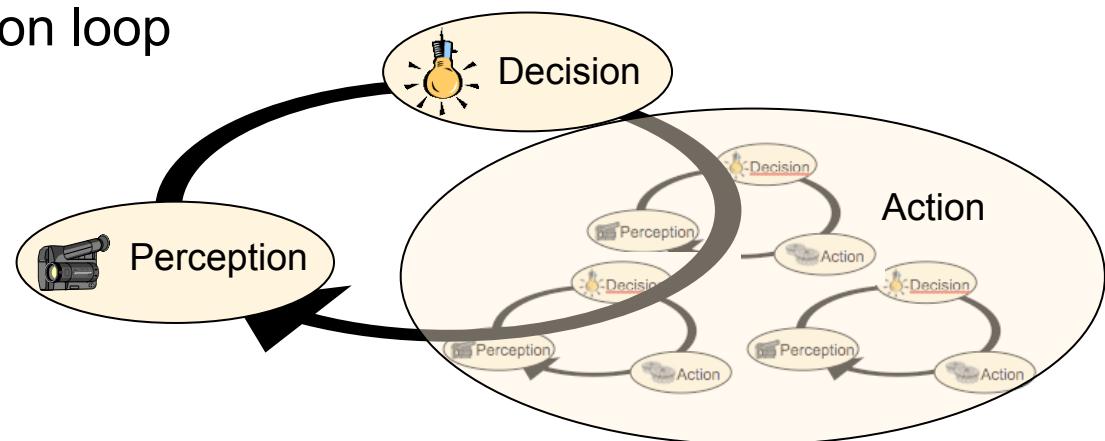
# Navigation strategies

- *How to go there ?*

A *huge* variety of situations

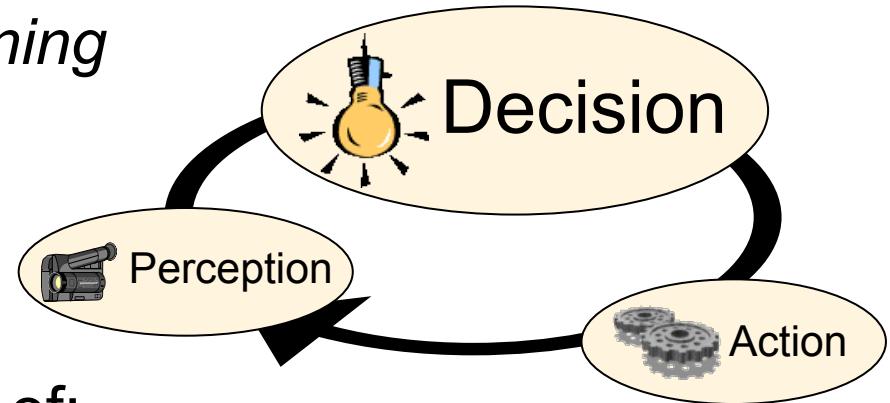


⇒ “Navigation strategies”, a higher level instance of the perception / decision / action loop



# Navigation strategies

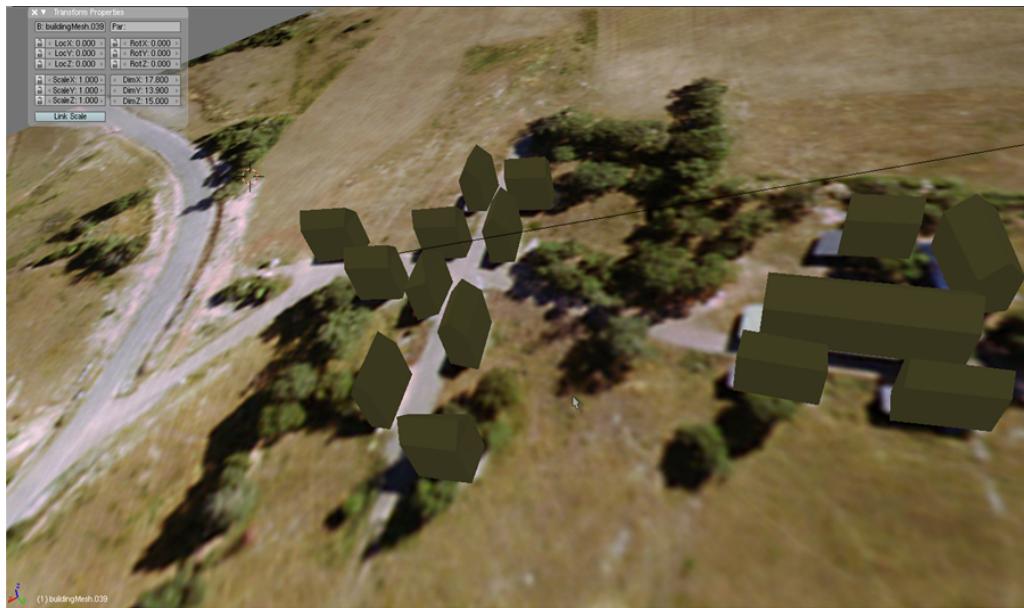
- Now we are really into *planning*



- We need dedicated *models* of:
  - Each available motion mode
  - The environment
    - Navigation mode applicability
    - “localisability”
    - Quantity/quality of information
  - The perception tasks
    - Localisation
    - Environment modeling

# Navigation strategies

- Models of the environment:
  - Navigation mode applicability
  - “localisability”
  - Quantity/quality of information



Example 1: exploit existing geographic data

# Navigation strategies

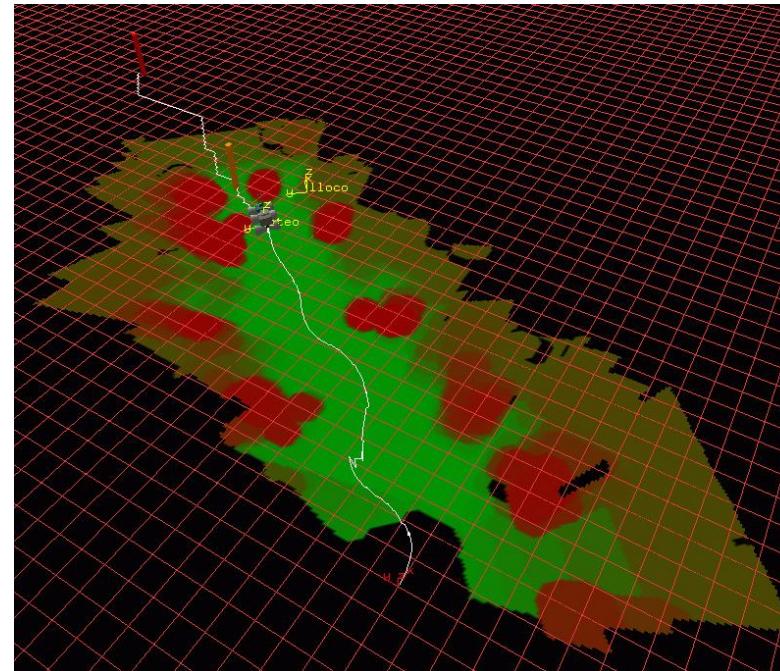
- Models of the environment:
  - Navigation mode applicability
  - “localisability”
  - Quantity/quality of information



Example 2: exploit low altitude aerial imagery

# Navigation strategies

- Models of the environment:
  - Navigation mode applicability
  - “localisability”
  - Quantity/quality of information



Example 3: build a dedicated model from rover data



# Navigation strategies

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- “Spirit” of the solutions
  - Exploit graph search ( $A^*$ ,  $D^*$ )
  - Turn the goal-finding problem into an information acquisition problem
  - Exploration case: analyse *frontiers* to assess relevant goals