Robotics

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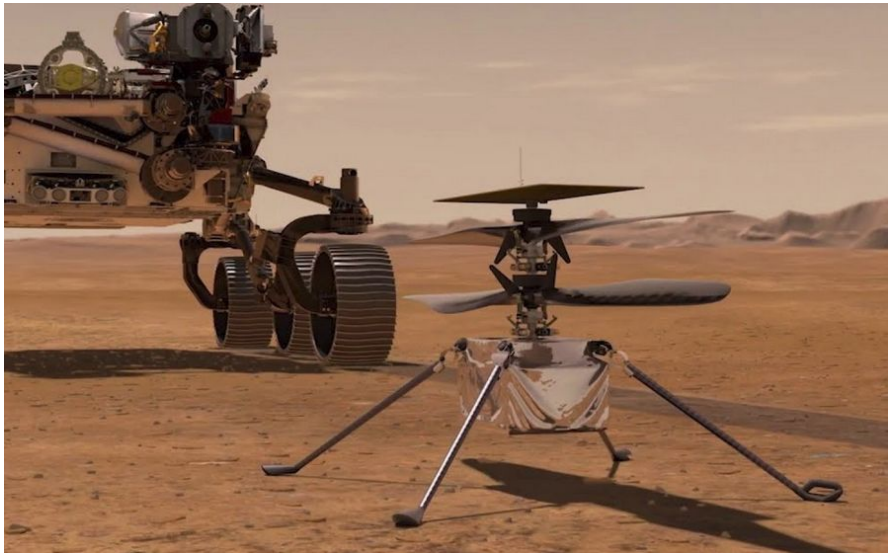
Why Robots ?

D2R3

Dirty, Dangerous, Rapid, Repetitive, Right



Robotics: Interdisciplinary Nature

Agent vs Robot

Robots are physical agents that perform tasks by manipulating the physical world.

Key Challenges:

Continuous Space-time, Dynamic Constraints, Cost, Real-time operation, Uncertainty in modeling of robot and environment, uncertainty in sensing, disturbances from environment ….

How Intelligent Robots are today ? When can robots takeover the world physically ?

Few Hardware and Design choices, and their implication on Software Development :

Sensor: Active and Passive Sensor, …. Rate of sensor input, uncertainty in measurement.

Actuator: Linear Actuators, Motors, Wire driven, Pulley driven …. Introduces delays, backlash, limits on performance

Locomotion: Differential Drive, Car-like, Underwater, Fixed Wing, Quadrotors, Bio-inspired, Legged Robots, Manipulators (Arms) ---- size of configuration space and search space, Stability

Joints: Revolute (Hinge), Prismatic, Spherical etc---- constraints

Problems in Robotics: where AI is being used

Mathematical Modeling (state, input , output)

Simultaneous Localization and Mapping (SLAM)

Motion Planning

Task Planning

Machine Vision

Control

Coordination Cooperation Collaboration--- Multiagent Robotics

Mathematics: Linear Algebra, Probability + Differential Equations

SENSE PLAN ACT (Hierarchical, Reactive, Hybrid)

Cognitive Science:

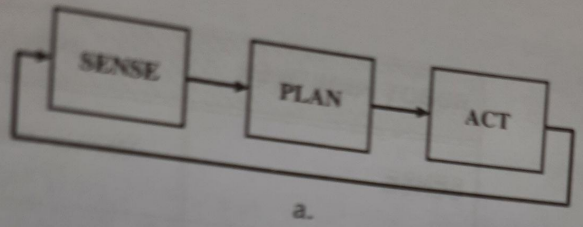
Hierarchical: P-S-A See door , approach it, move through chairs, Shakey

Slow, closed world model, planning heavy, doesnot confirm with cognitive studies

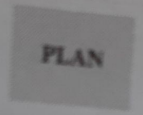
Reactive: S-A Realtime, no plan, insect behaviour (stimulus-response), cheap robots, not for complex tasks (Potential Fields for motion planning)

Hybrid Deliberative 1990s : P, S-A… P loop slow, S-A fast, multiple S-A behaviours.

Subsumption Architecture: Rodney Brook 90s

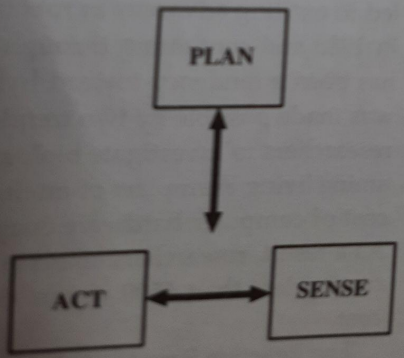

SENSE
PLAN
ACT

a.

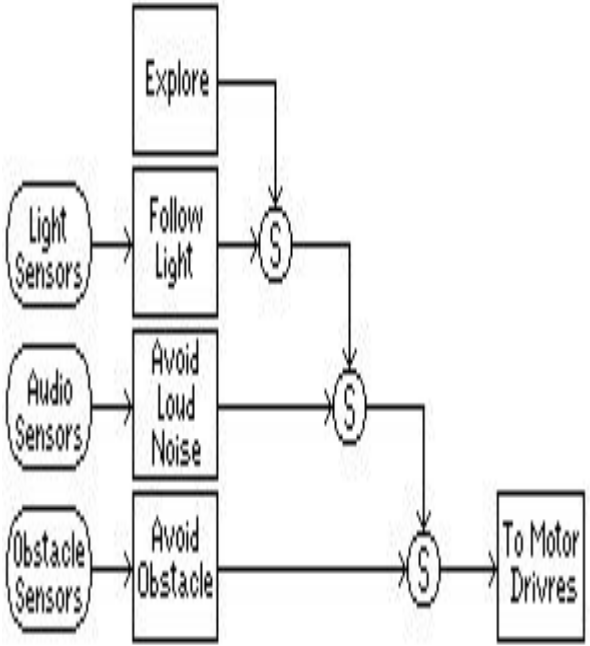

PLAN


SENSE
ACT

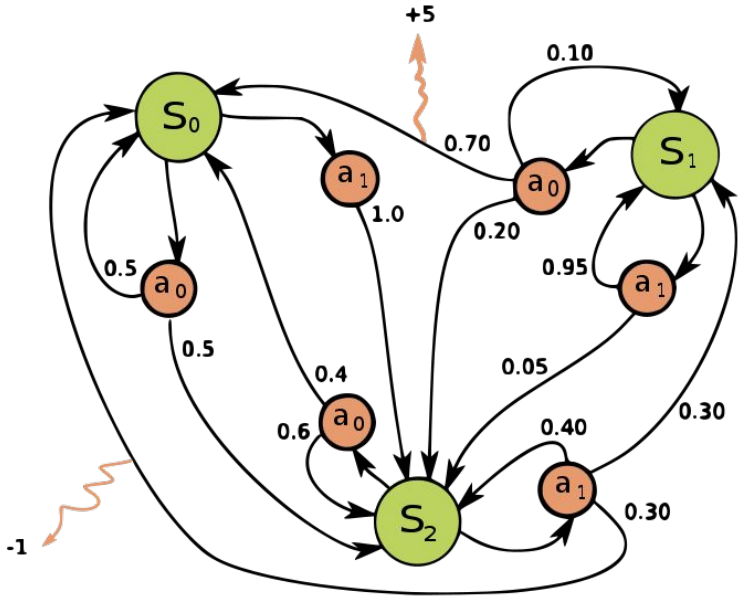
b.


PLAN
ACT
SENSE

c.


Explore
Light Sensors
Follow Light
S
Audio Sensors
Avoid Loud Noise
S
Obstacle Sensors
Avoid Obstacle
S
To Motor Drivres

MDP - (S,A,Pa,Ra)



$$P_a(s, s') = \Pr(s_{t+1} = s' \mid s_t = s, a_t = a)$$

$$a_t = \pi(s_t),$$

$$E\left[\sum_{t=0}^{\infty} \gamma^t R_{a_t}(s_t, s_{t+1})\right]$$

$$V(s) := \sum_{s'} P_{\pi(s)}(s, s') \left(R_{\pi(s)}(s, s') + \gamma V(s')\right)$$

$$\pi(s) := \operatorname{argmax}_a \left\{ \sum_{s'} P(s' \mid s, a) \left(R(s' \mid s, a) + \gamma V(s')\right) \right\}$$

Motion Planning

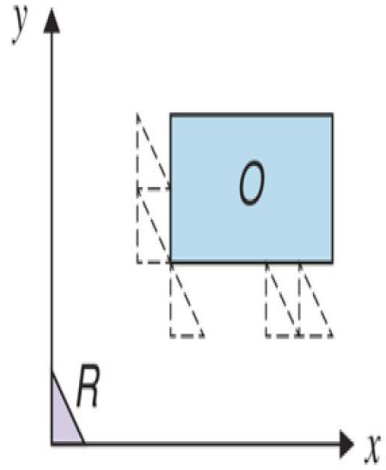
Configuration Space

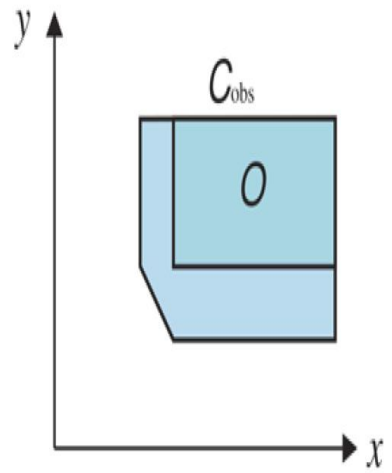
Free Space

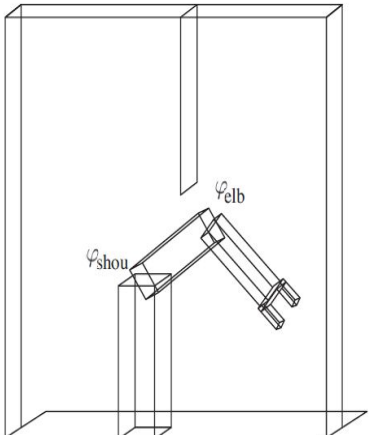
Degrees of Freedom

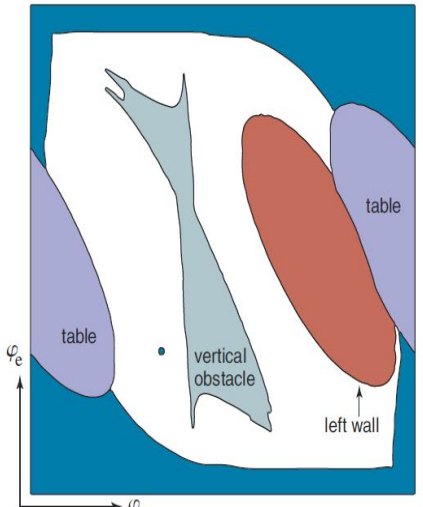
Completeness

Probabilistic Completeness

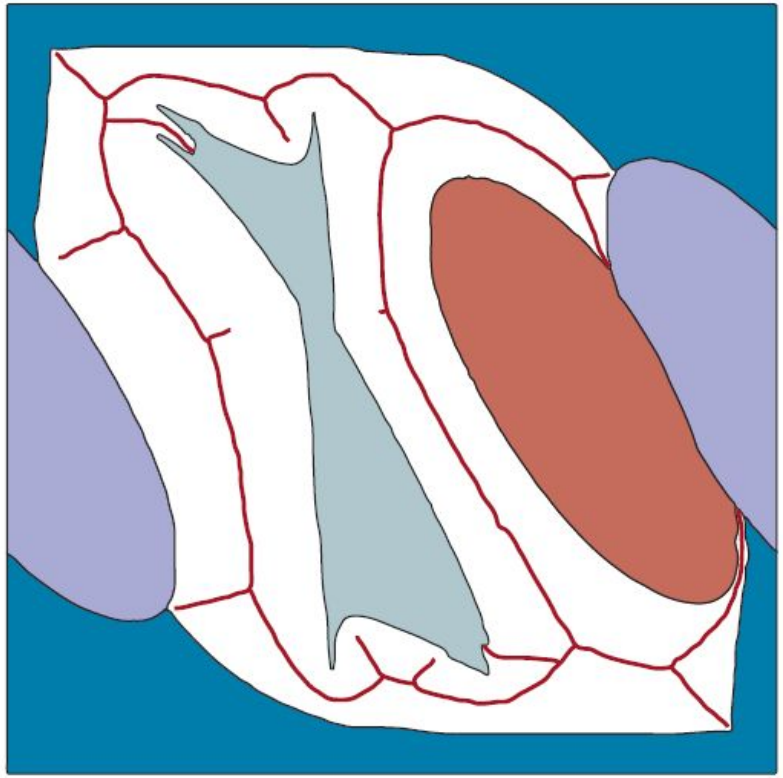


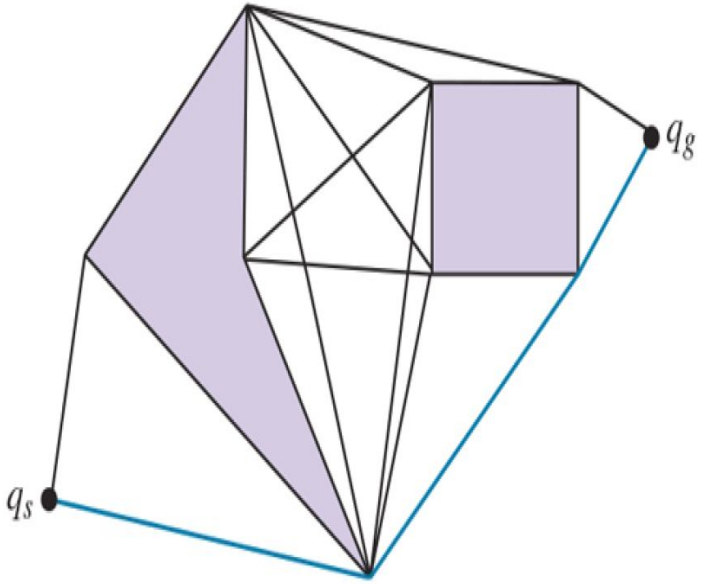






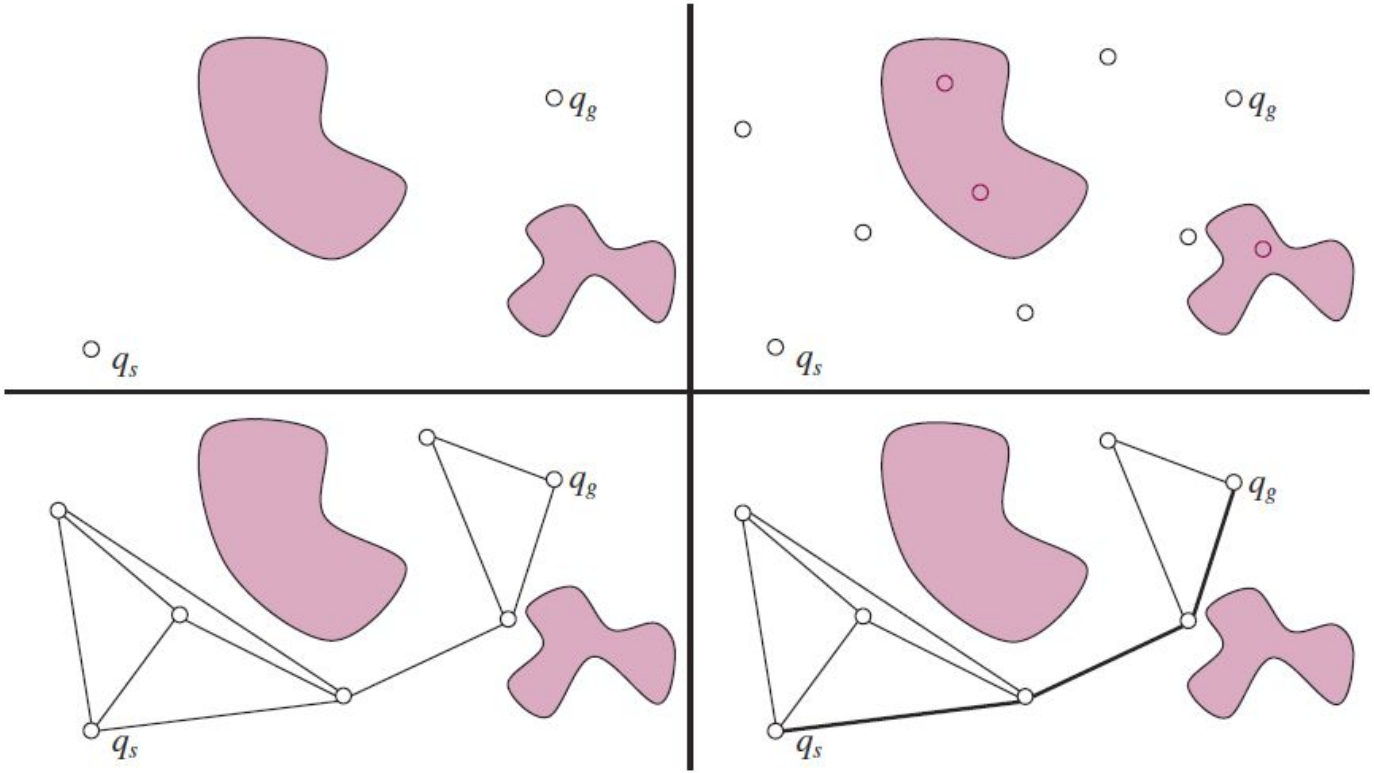
Voronoi Graph



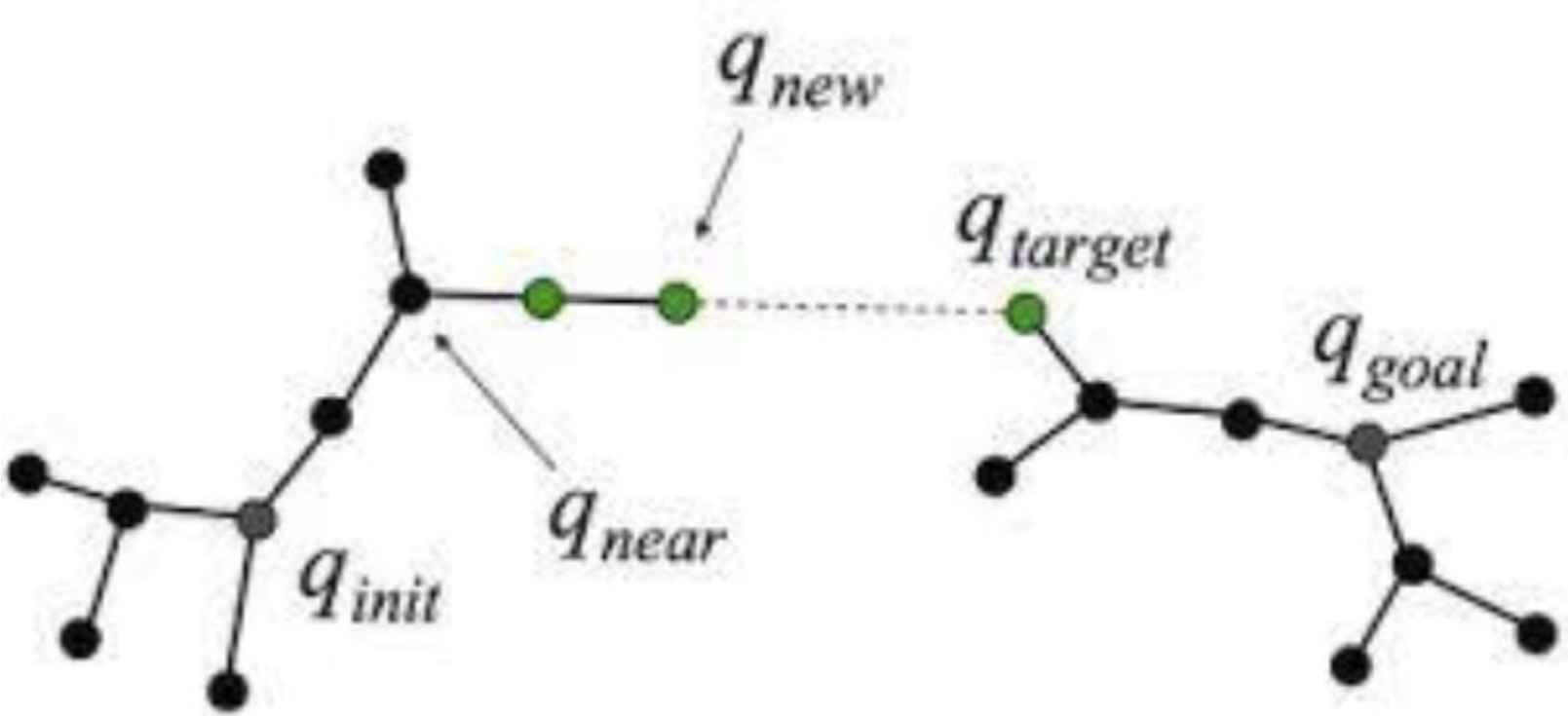


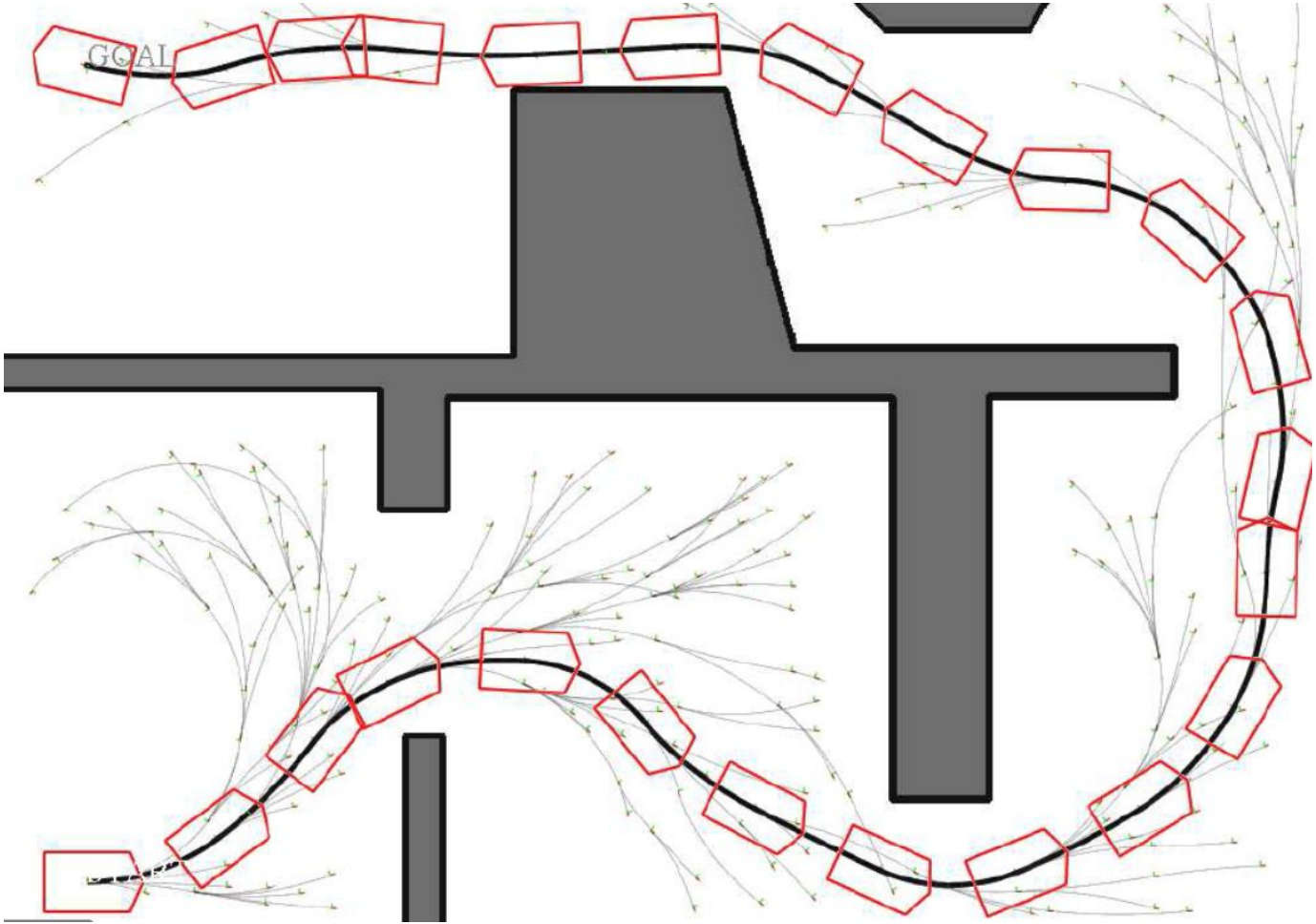
Visibility Graph

Probabilistic Roadmap

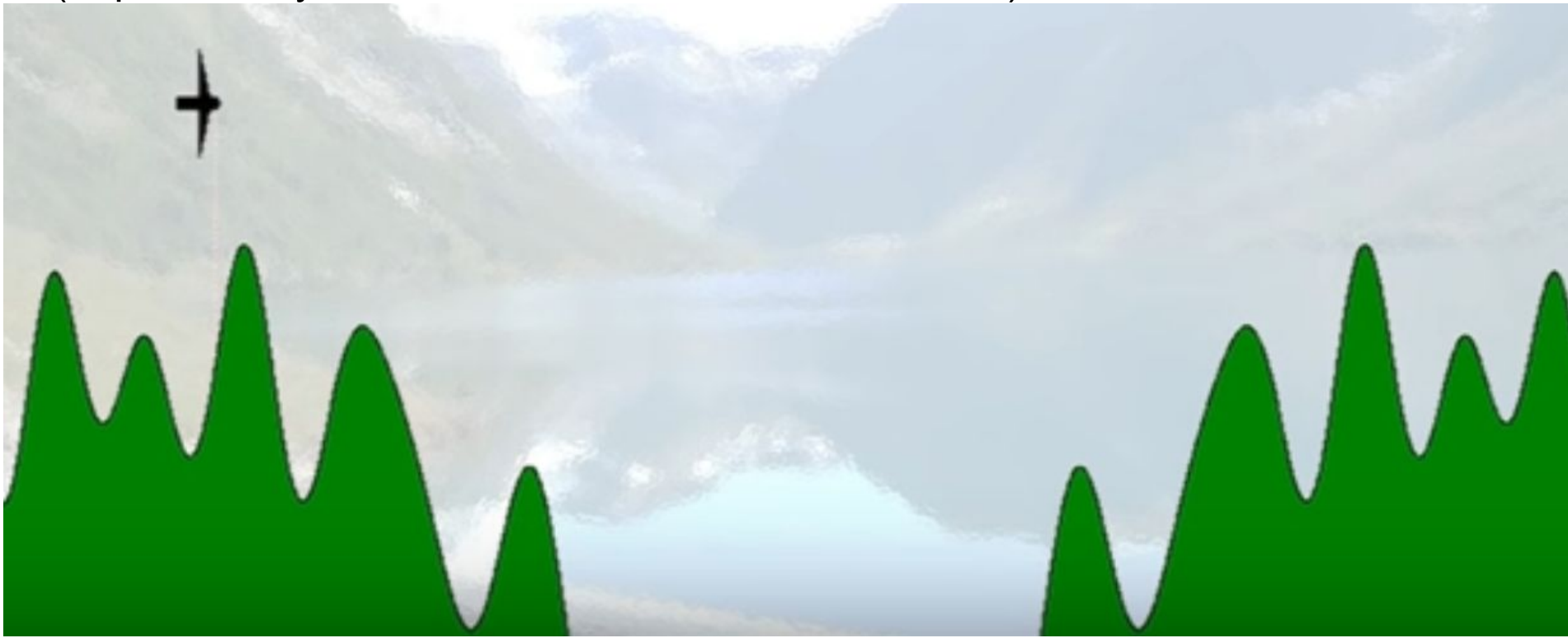


Bi-RRT

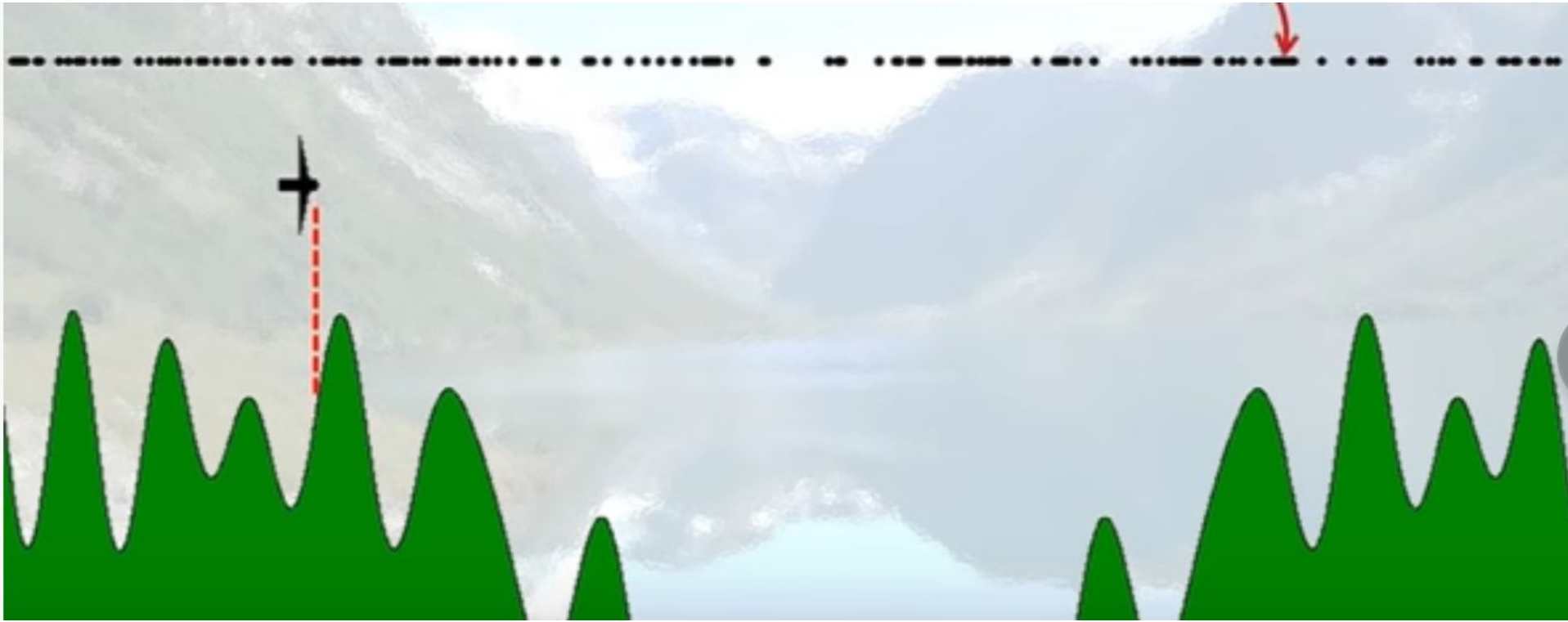


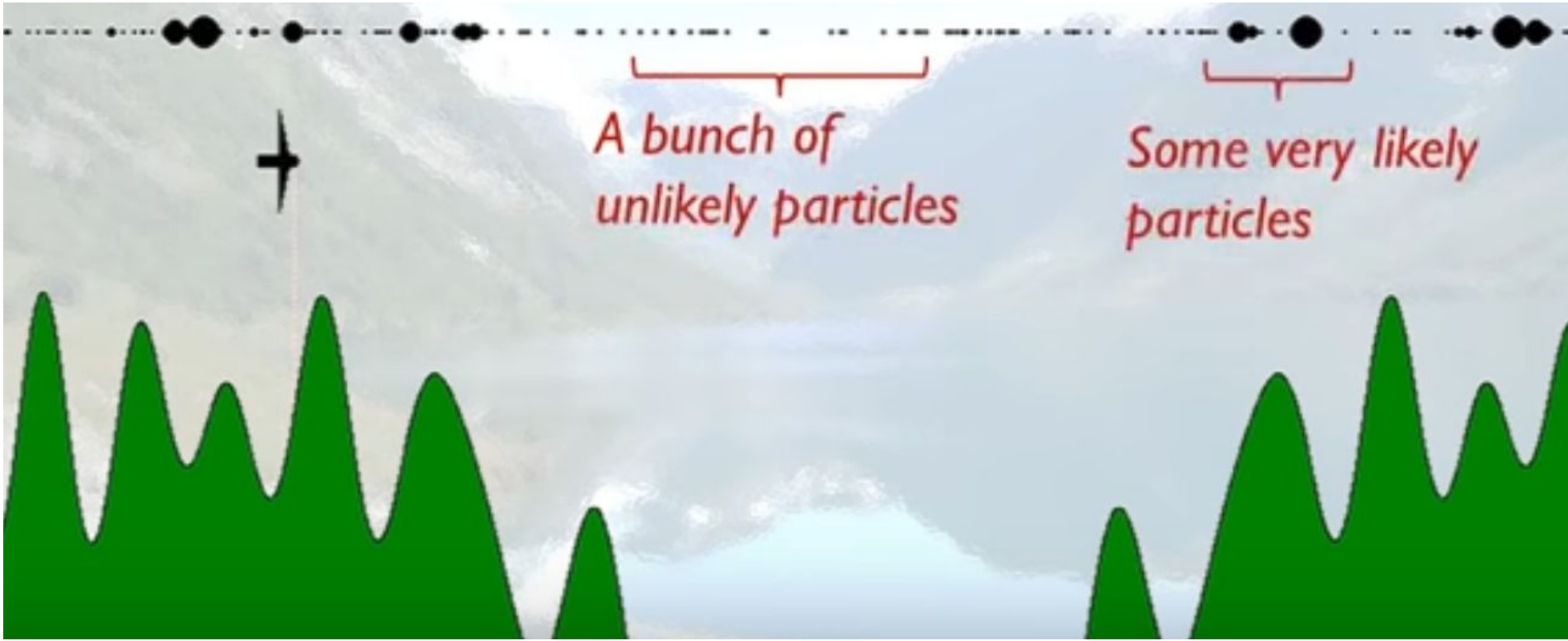

GOAL

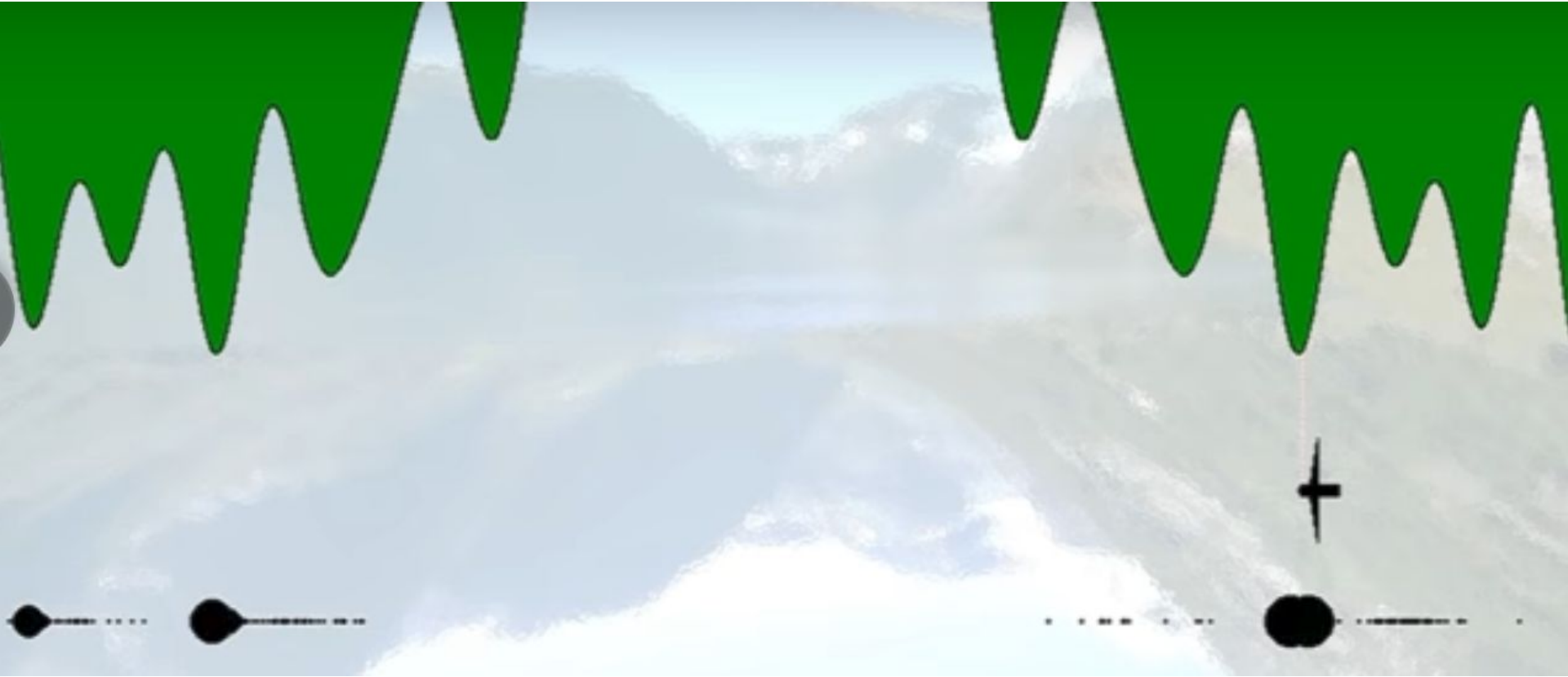
Particle Filter for localization
(https://www.youtube.com/watch?v=aUkBa1zMKv4)

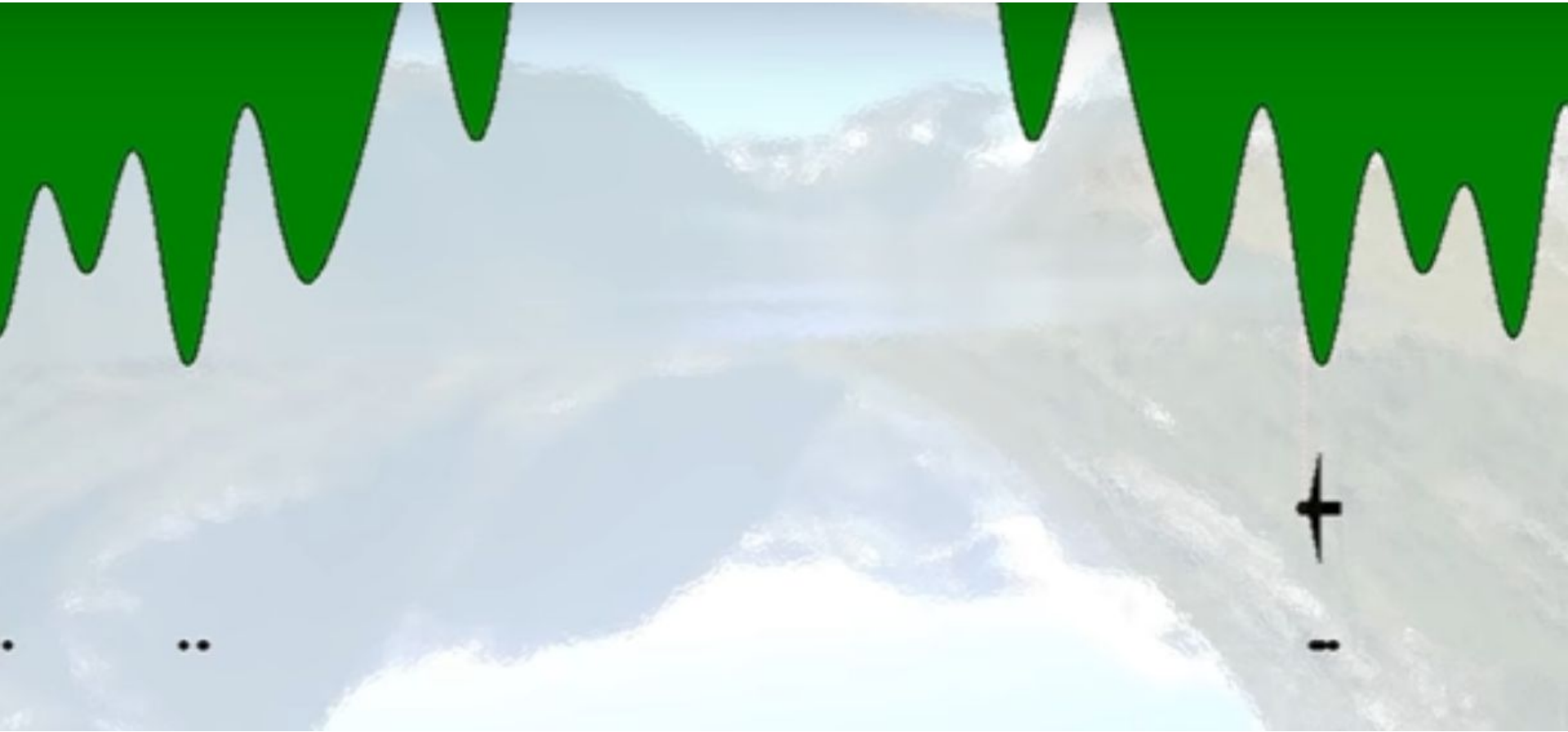


Random sampling




A bunch of
unlikely particles
Some very likely
particles





Thankyou