Trends in Robotics

Trends in Robotics/Motion Planning

Classical Robotics (mid-70's)
• exact models
• no sensing necessary

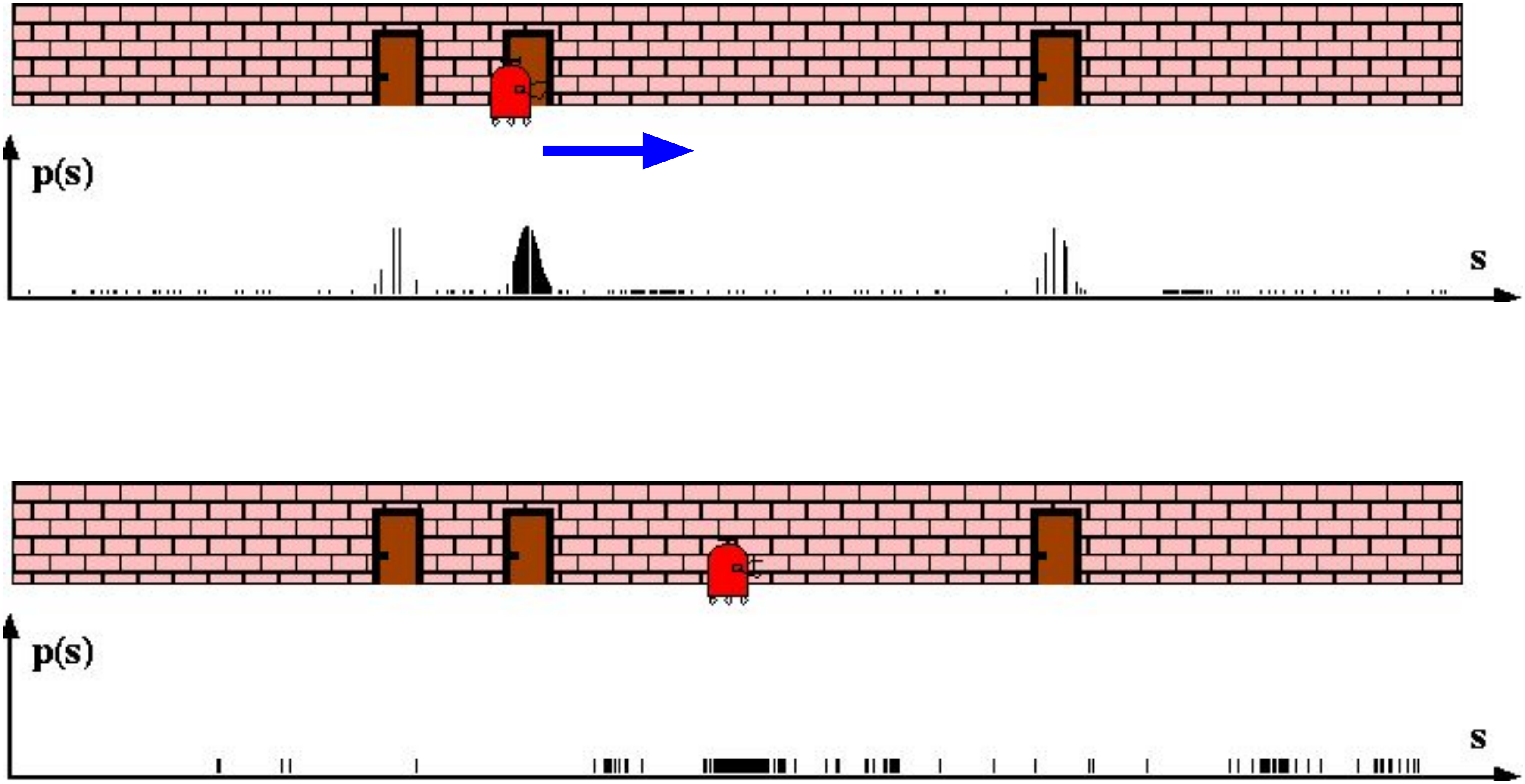
Reactive Paradigm (mid-80's)
• no models
• relies heavily on good sensing

Hybrids (since 90's)
• model-based at higher levels
• reactive at lower levels

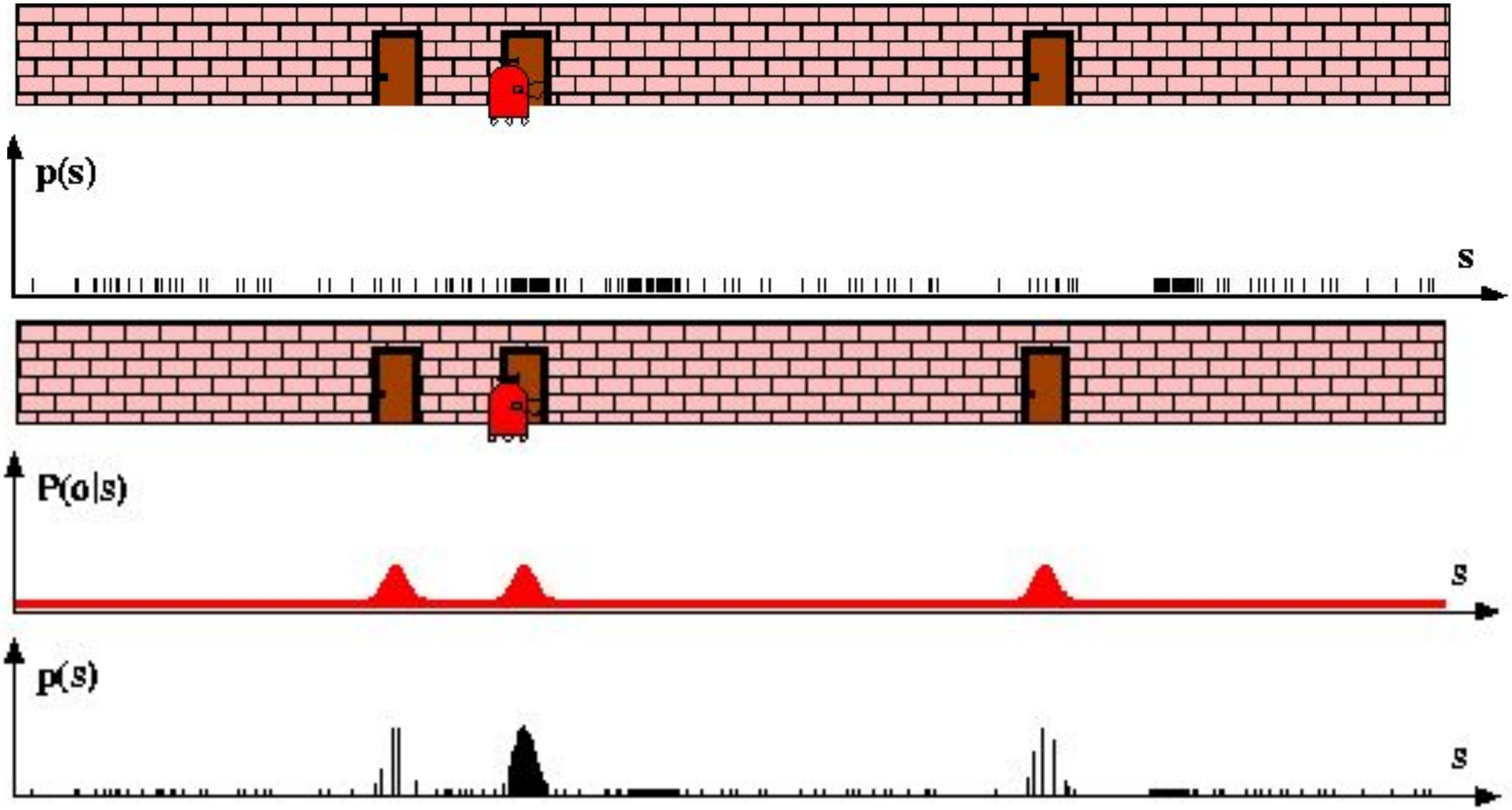
Probabilistic Robotics (since mid-90's)
• seamless integration of models and sensing
• inaccurate models, inaccurate sensors

Copied from G. Hager

Robot Motion



Sensor Information: Importance Sampling



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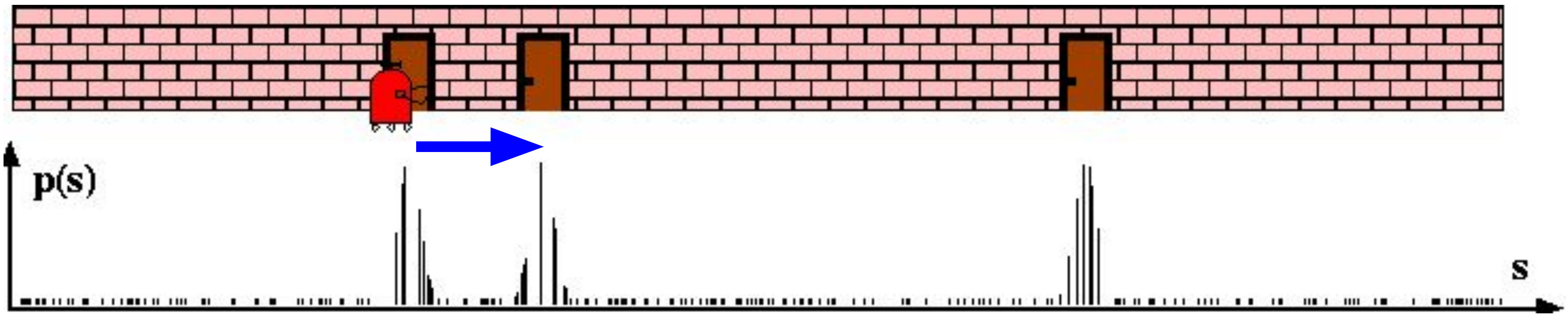
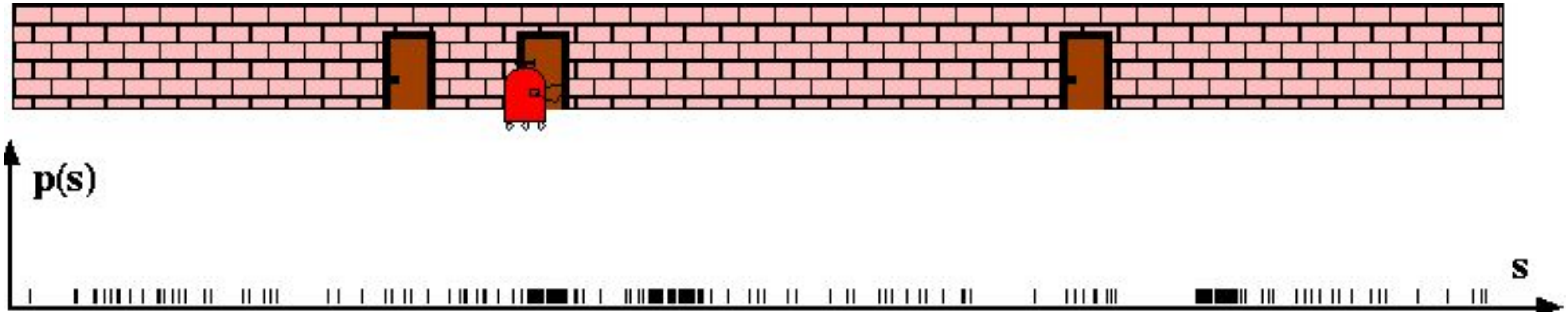
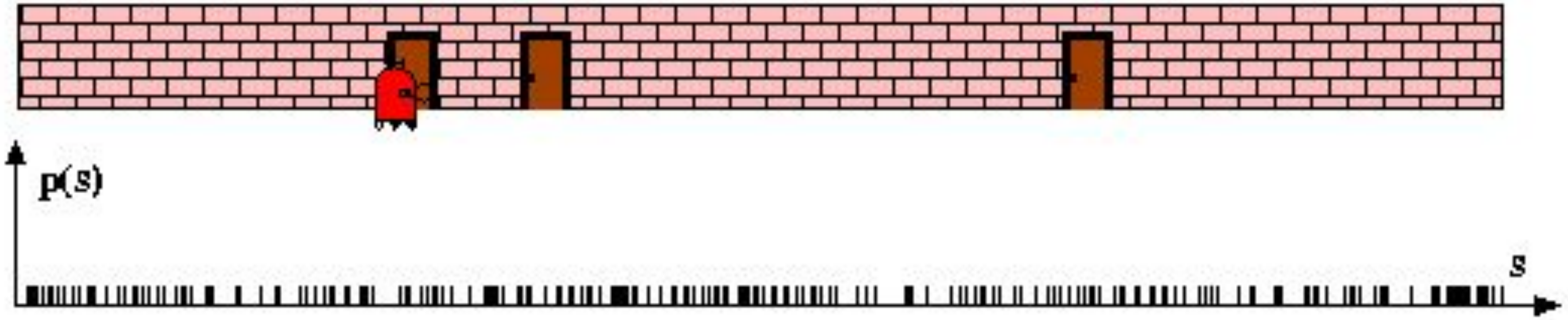




Particle Filters



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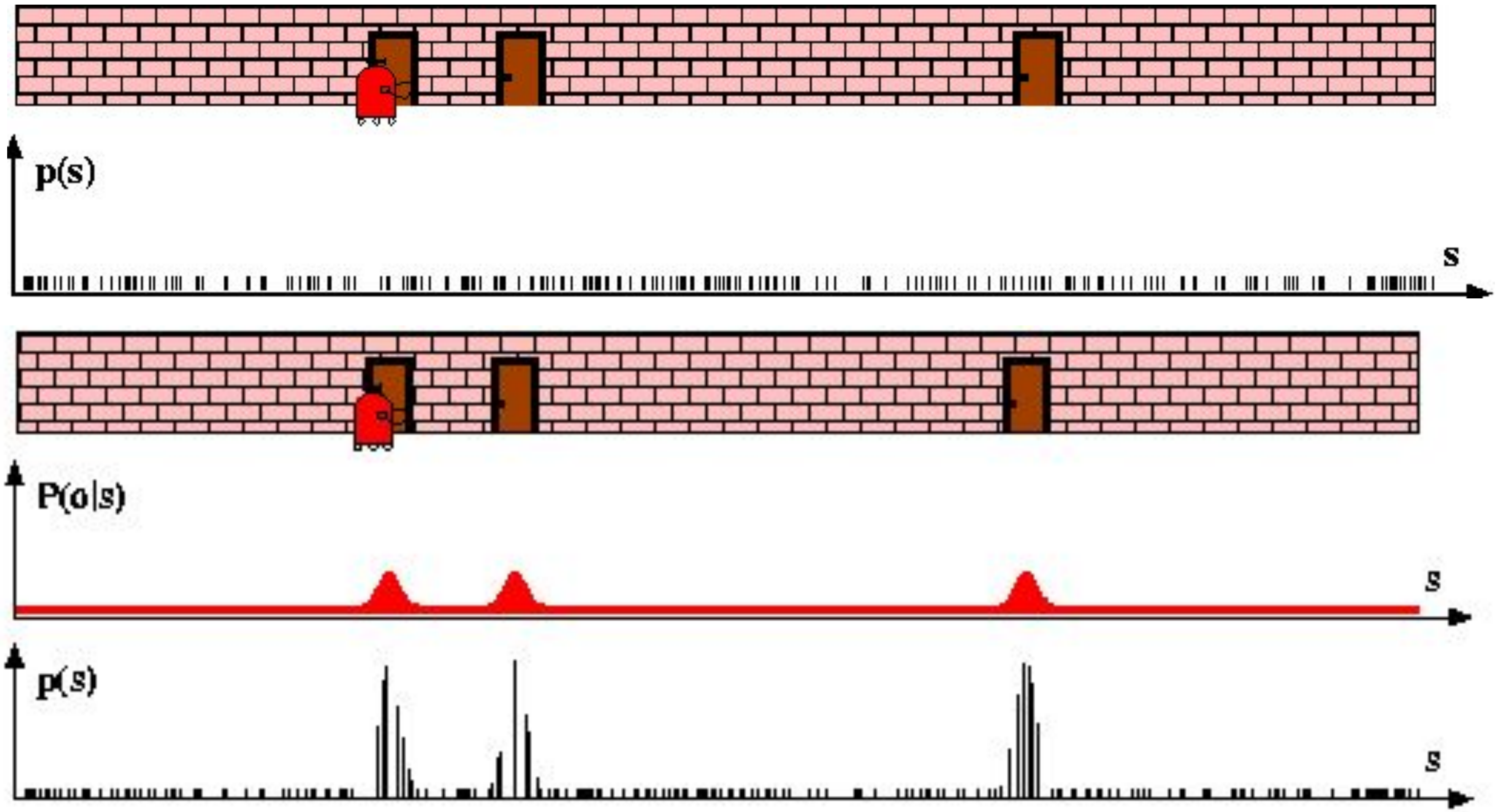
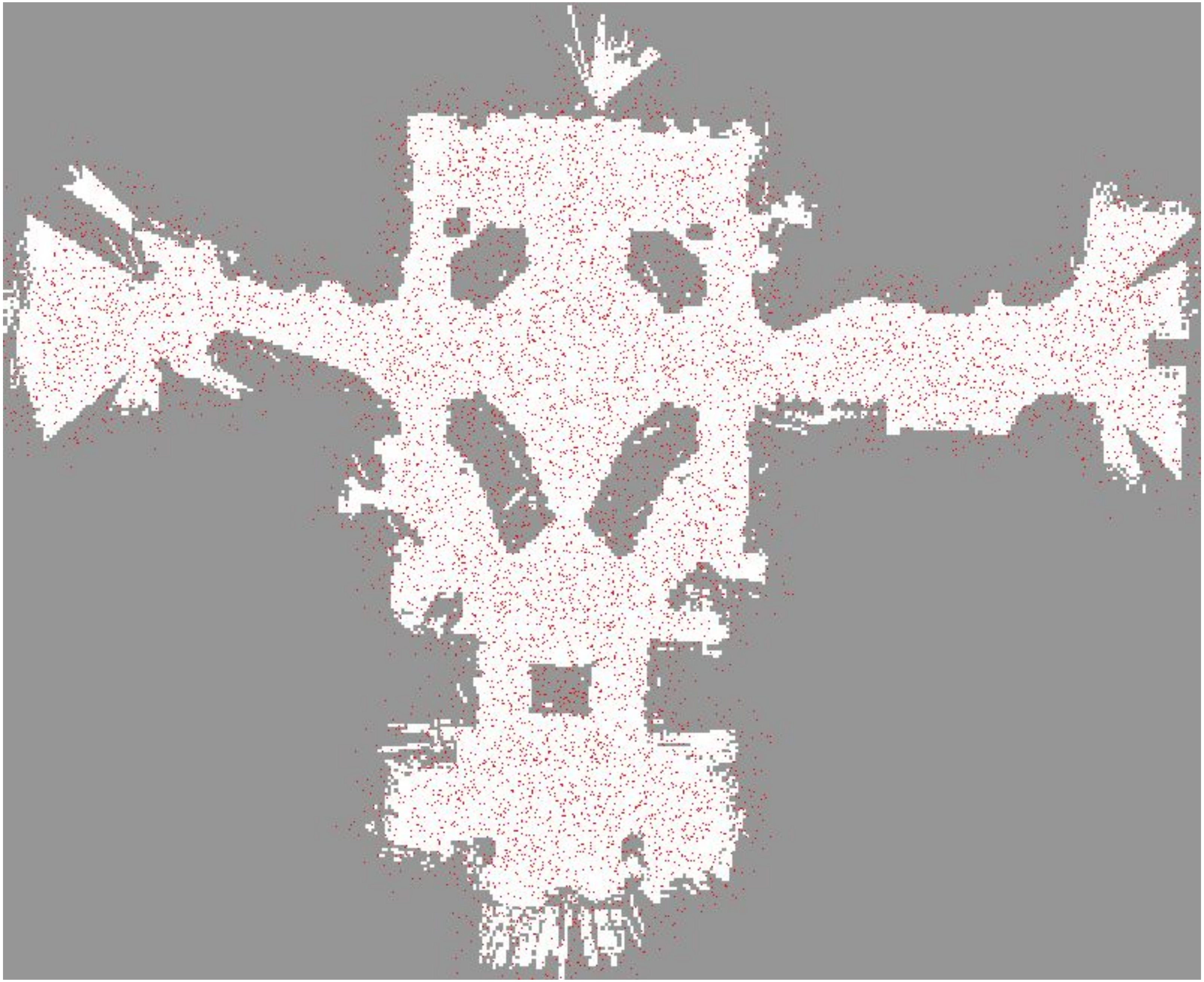
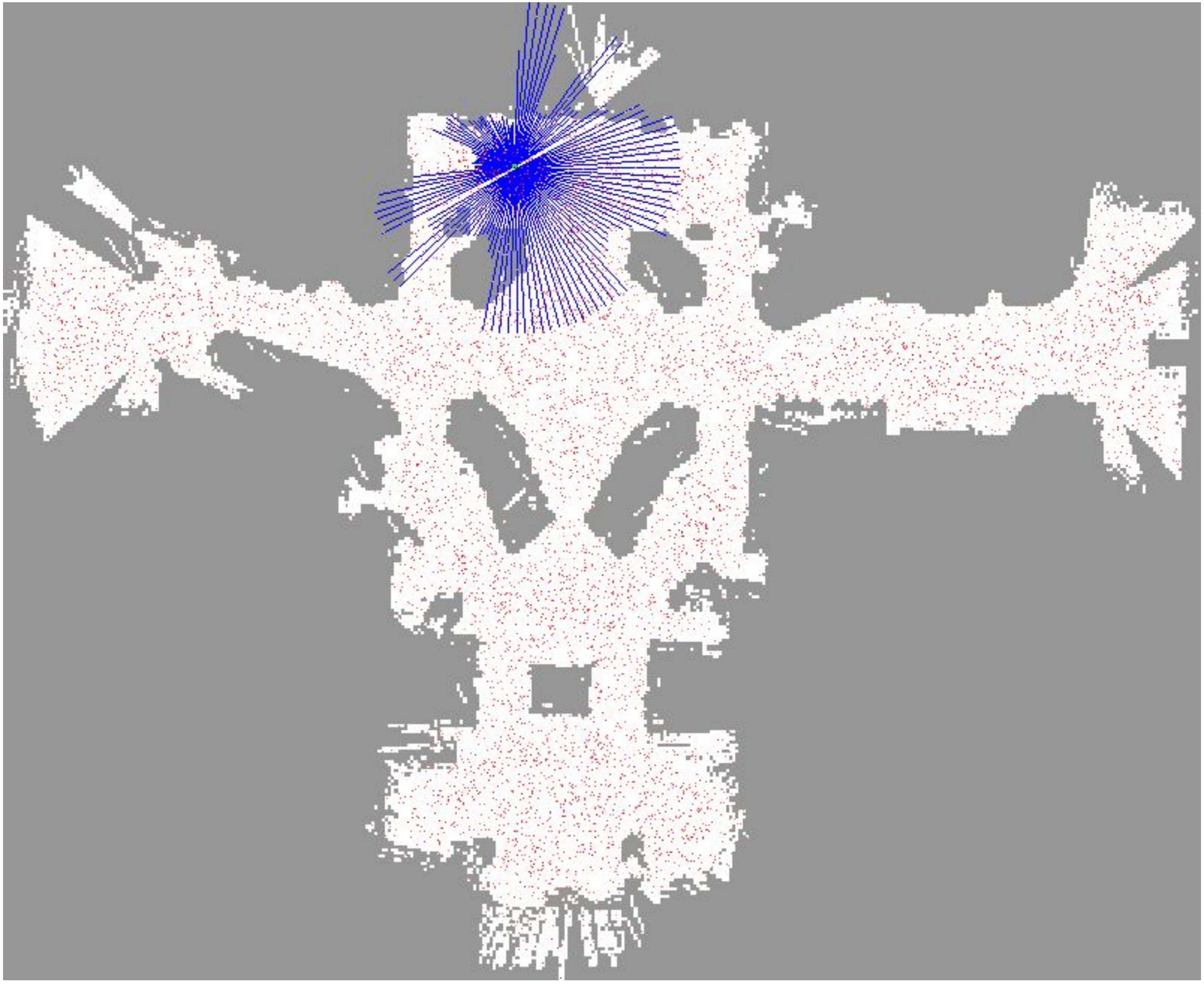
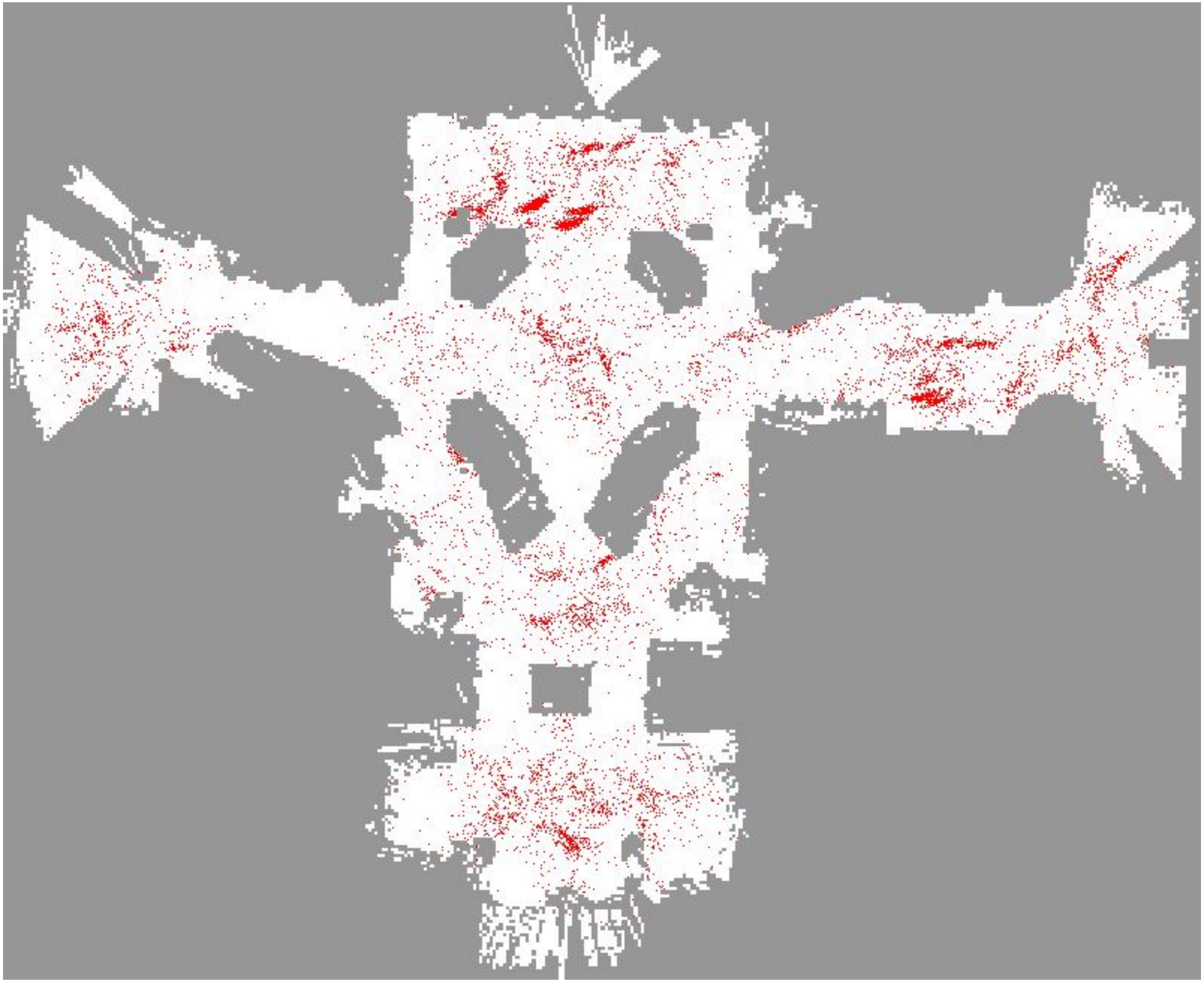
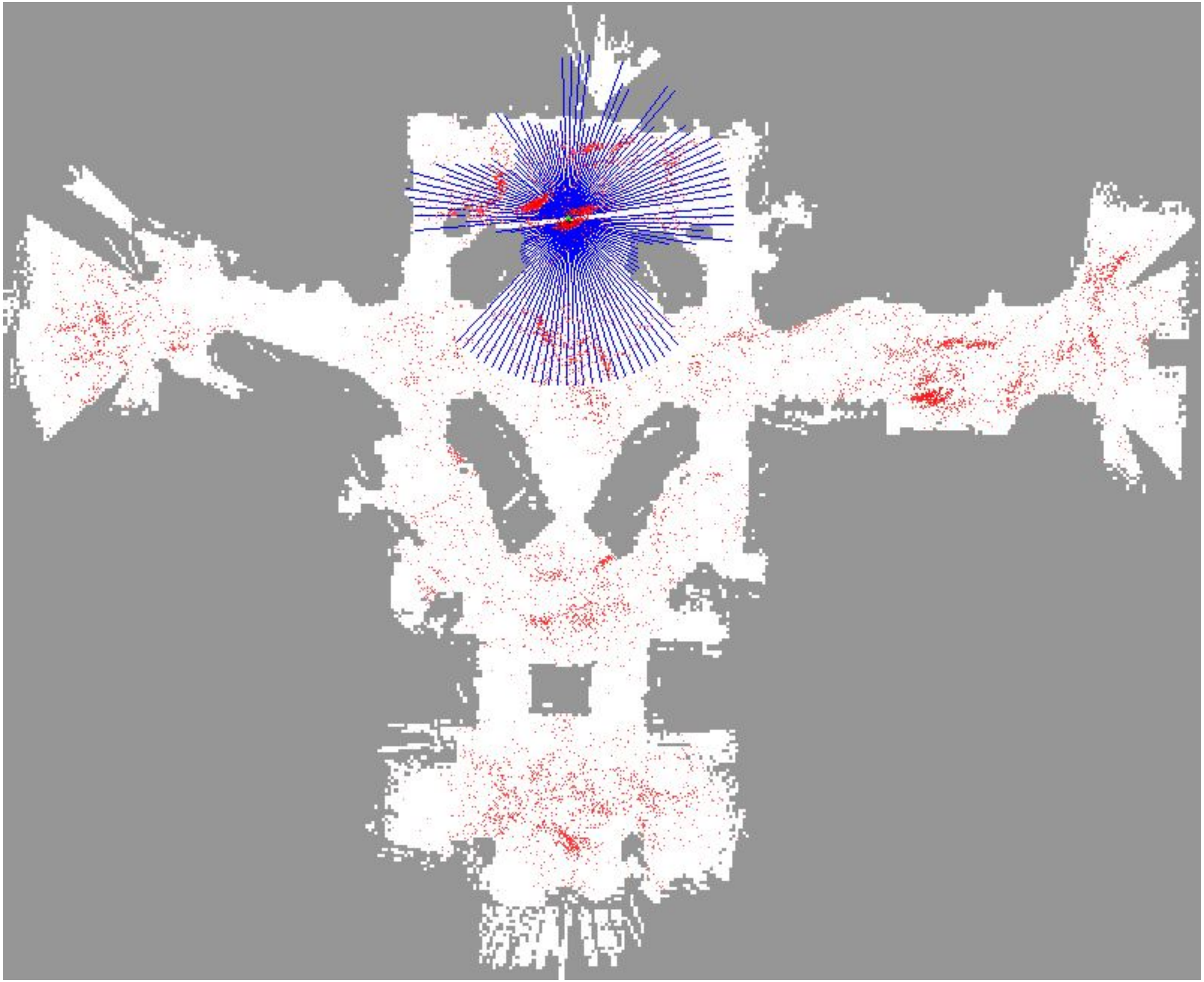
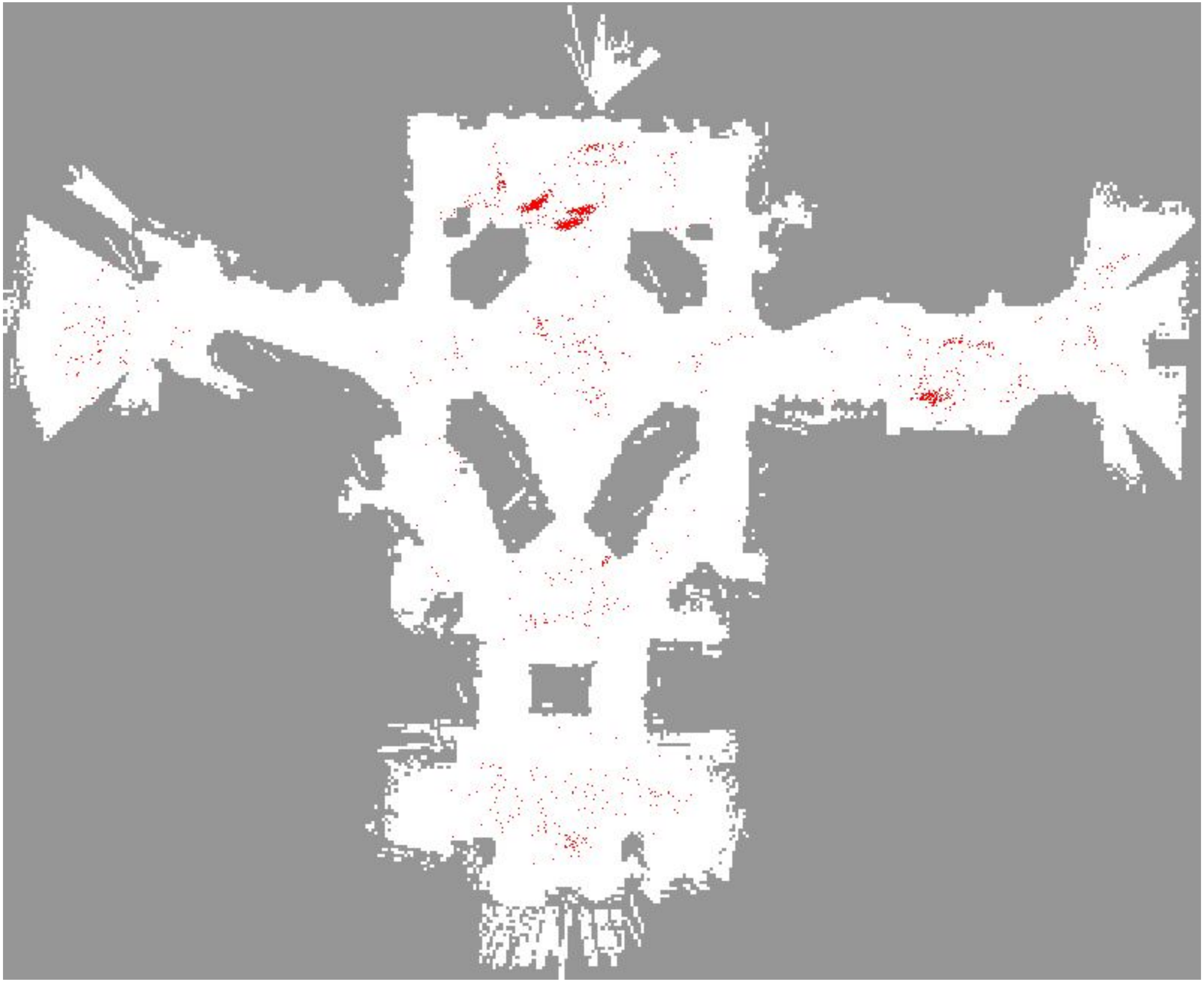


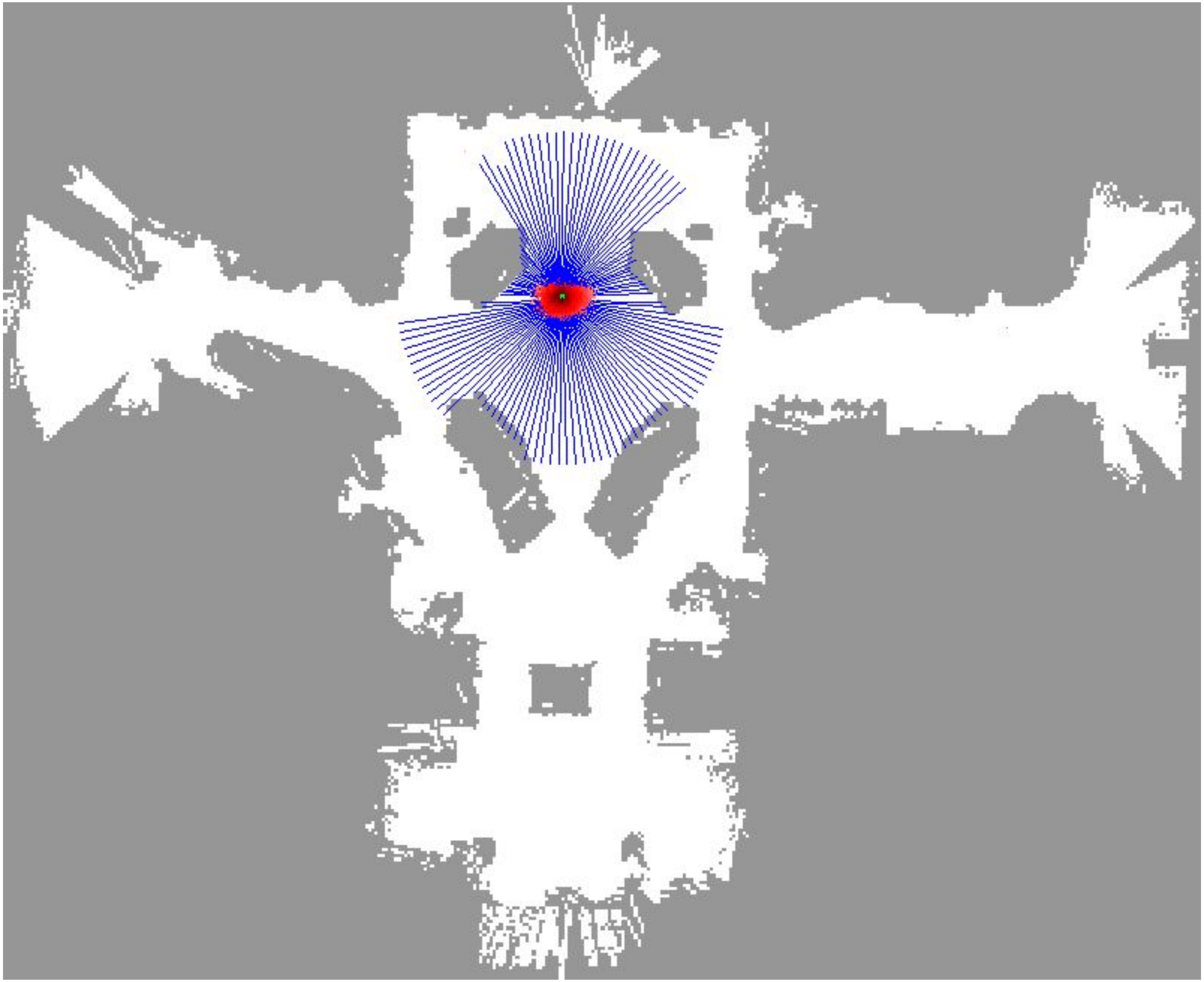


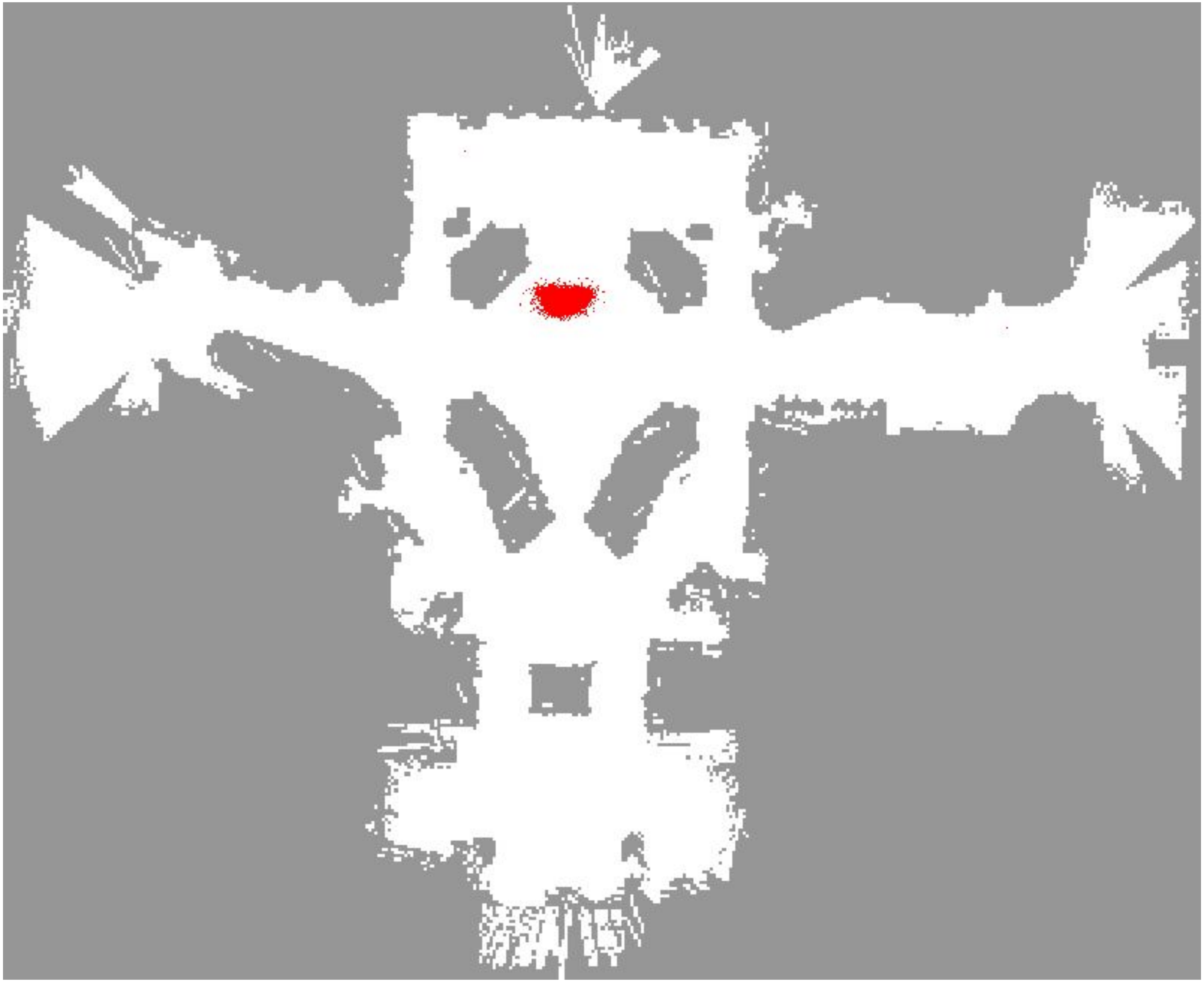


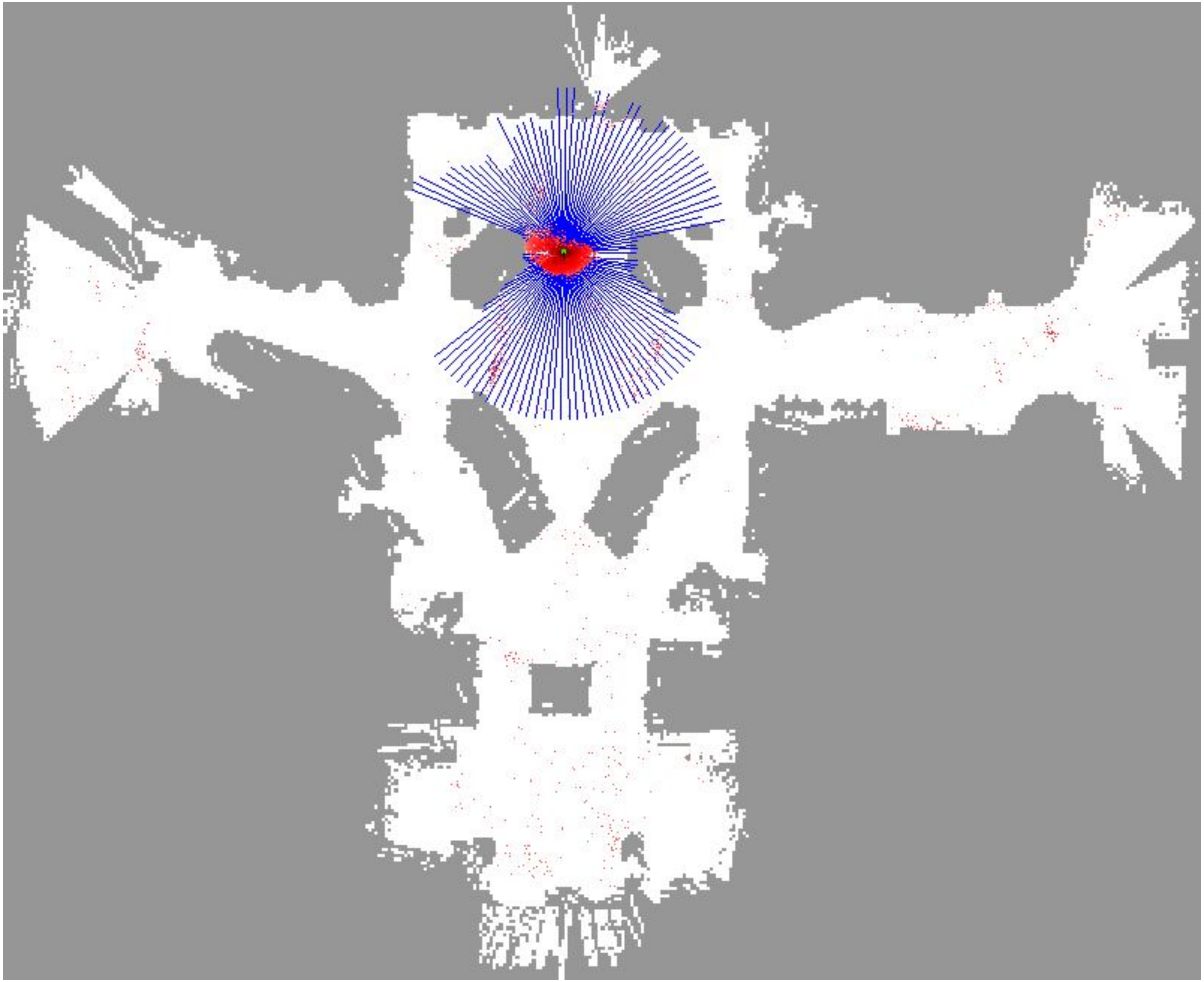


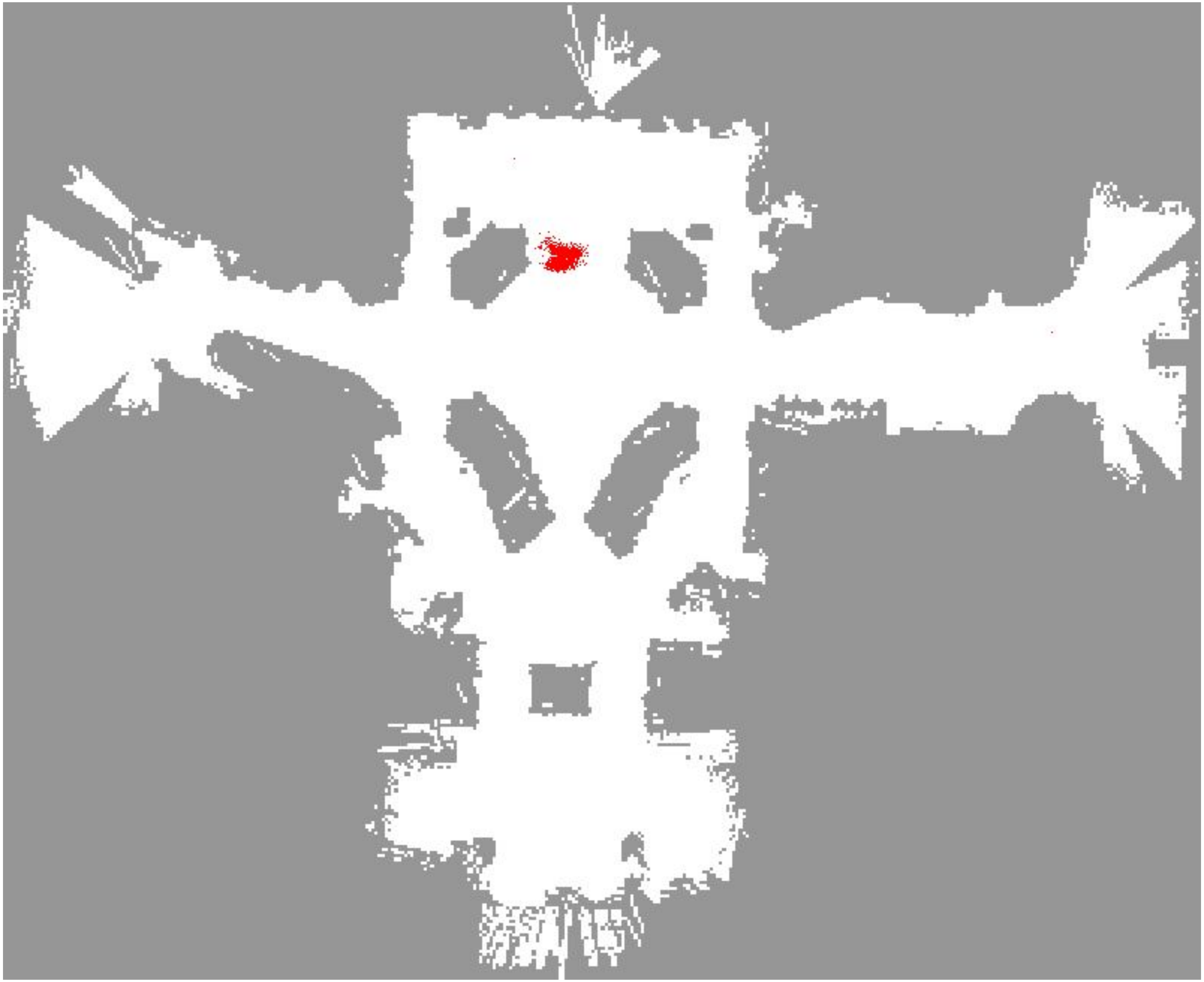












Subareas of Robotics

Sensing and Perception (perception)

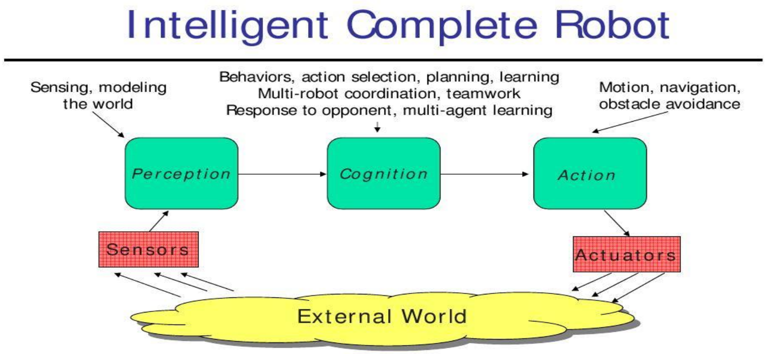
Range sensing, vision, filtering, sensor modeling, …

Motion and Control (action)

PID control, open/closed loop control, action modeling, walking, ...

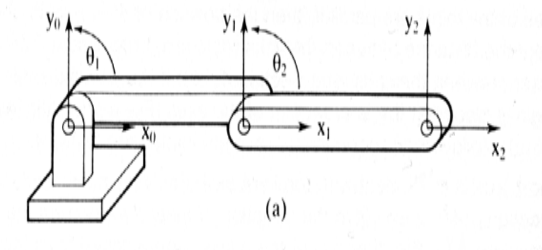
Decision Making (cognition)

Behavior architectures, planning, AI, developmental psychology, ...

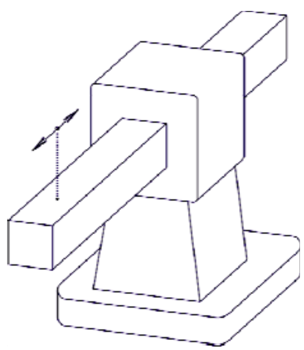


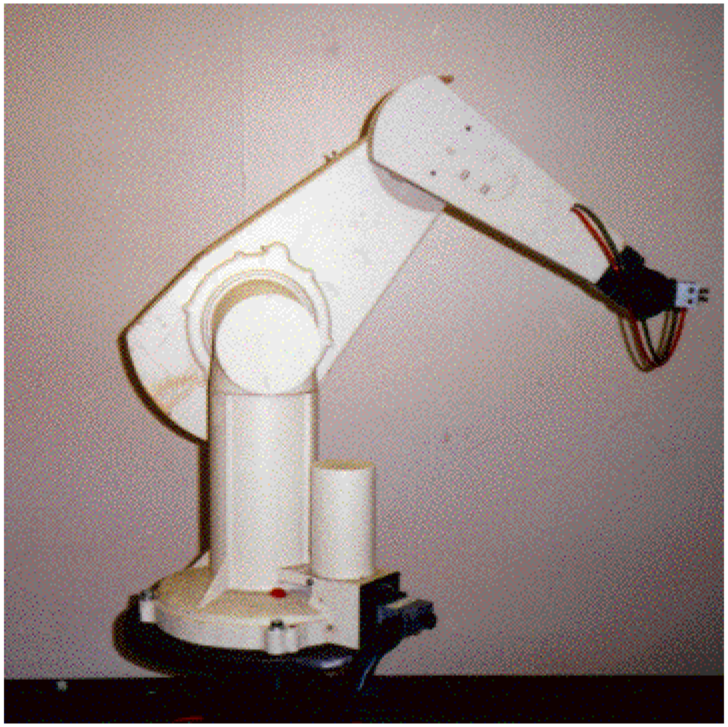
Robotic Arms

Revolute Joint



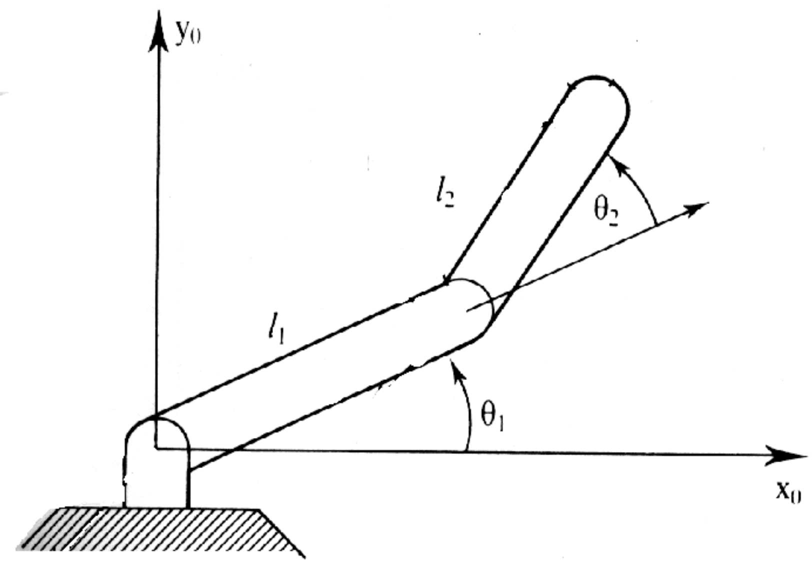
Prismatic Joint





Forward Kinematics

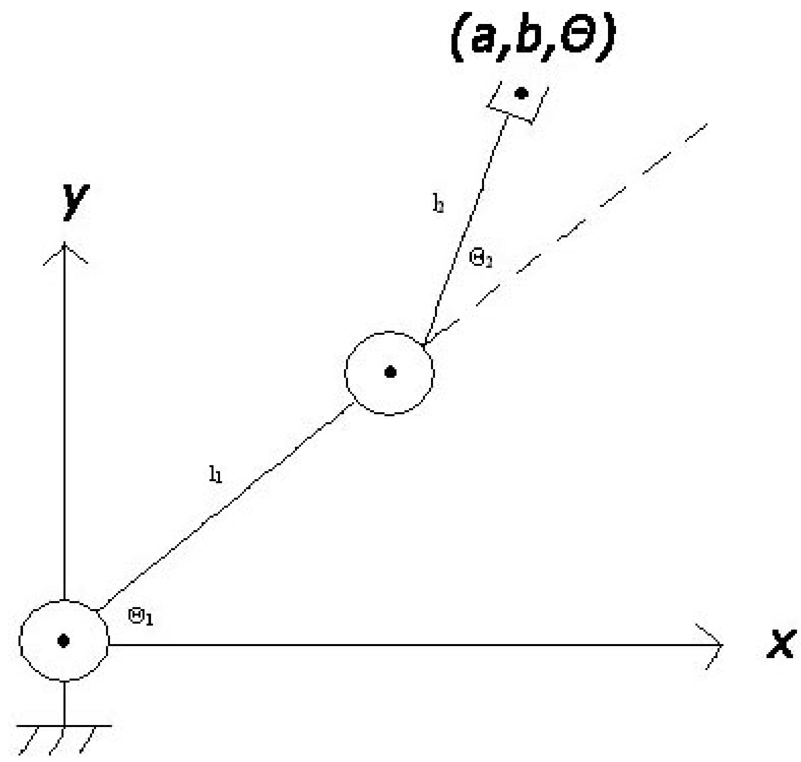
- The problem: determine the position of the end of the robotic arm given θ_1 and θ_2 and l1 and l2



- Geometric Approach
- Algebraic Approach

A simple example

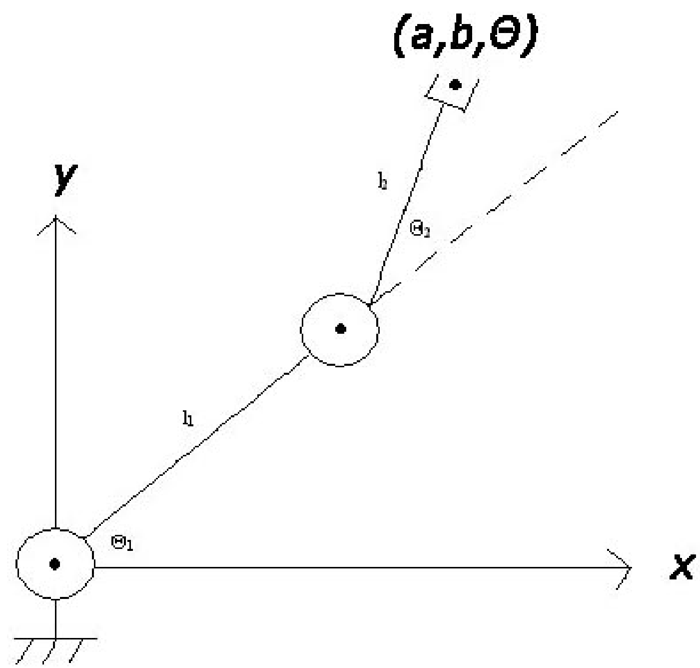
- Two links connected by rotational joints to a stable platform
- Given θ_1 and θ_2, solve for *a, b* and θ



Solution

- Can be solved trigonometrically:

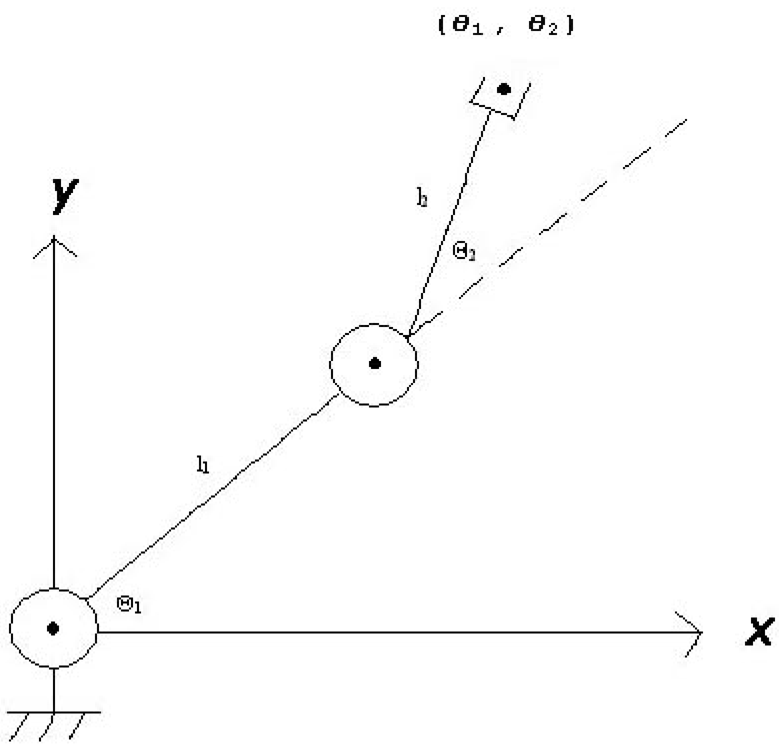
$$a = l_1 \cos(\theta_1) + l_2 \cos(\theta_1 + \theta_2)$$
$$b = l_1 \sin(\theta_1) + l_2 \sin(\theta_1 + \theta_2)$$
$$\Theta = \theta_1 + \theta_2$$



Inverse Kinematics

- Going backwards
- Find joint configuration given position & orientation of tool (end effector)
- More complex (path planning & dynamics)
- Usually solved either algebraically or geometrically
- Possibility of no solution, one solution, or multiple solutions

Another example

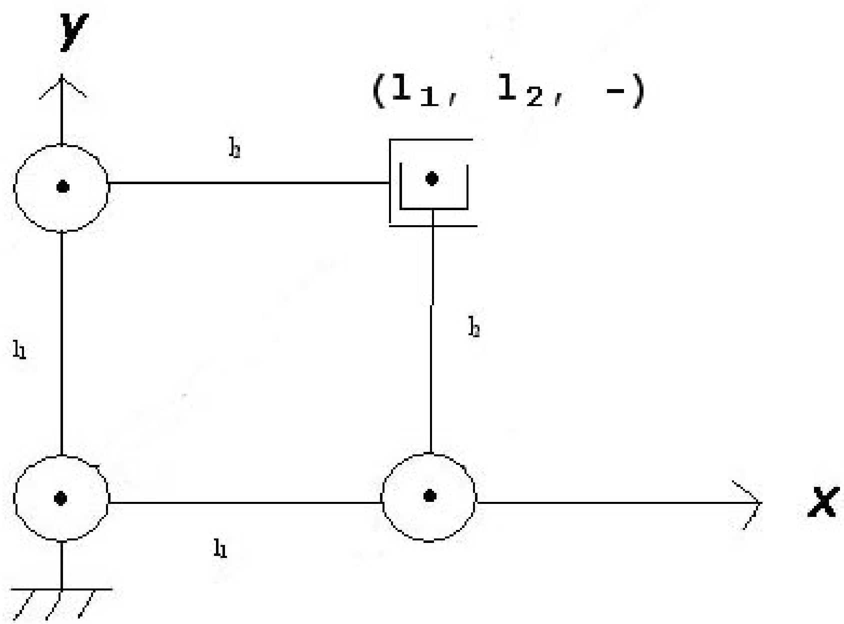


Lets assume l1 = l2

What is the configuration of each joint if the end effector is located at (l_1, l_2,-)?

(ie. Find θ_1 *and* θ_2)

Solution



$\theta_1=0$, $\theta_2 = 90$

Or

$\theta_1=90$, $\theta_2 = 0$

(Two Solutions)

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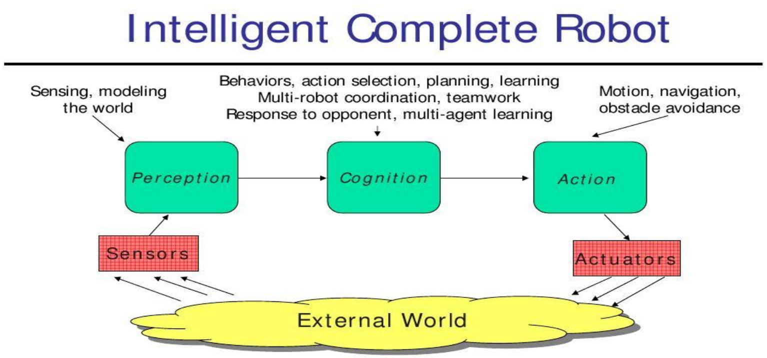

Control Laws and Behaviors

Rules for behaving in a qualitatively uniform environment.

- Following walls, seeking open space or targets.

Rich theory based on differential equations and dynamical systems.

Reality outside the model is treated as noise.

Compose multiple control laws to make behaviors.

High level: Planning

Social Implications

Robots may change our world dramatically

- How? For better? Or for worse?
- Lethal autonomous weapons?

Science fiction writers have thought about a lot of important possibilities.

- Few conclusions.
- Questions can be more important than answers.

Robotics

The topic is fundamentally important scientifically and technologically.

- Building intelligent agents
- Modeling the phenoma of mind and body

It's also very exciting and lots of fun!

Vision

- Raw vision
- Segmented
- Objects
- Together

- Color Learning
- Illumination invariance