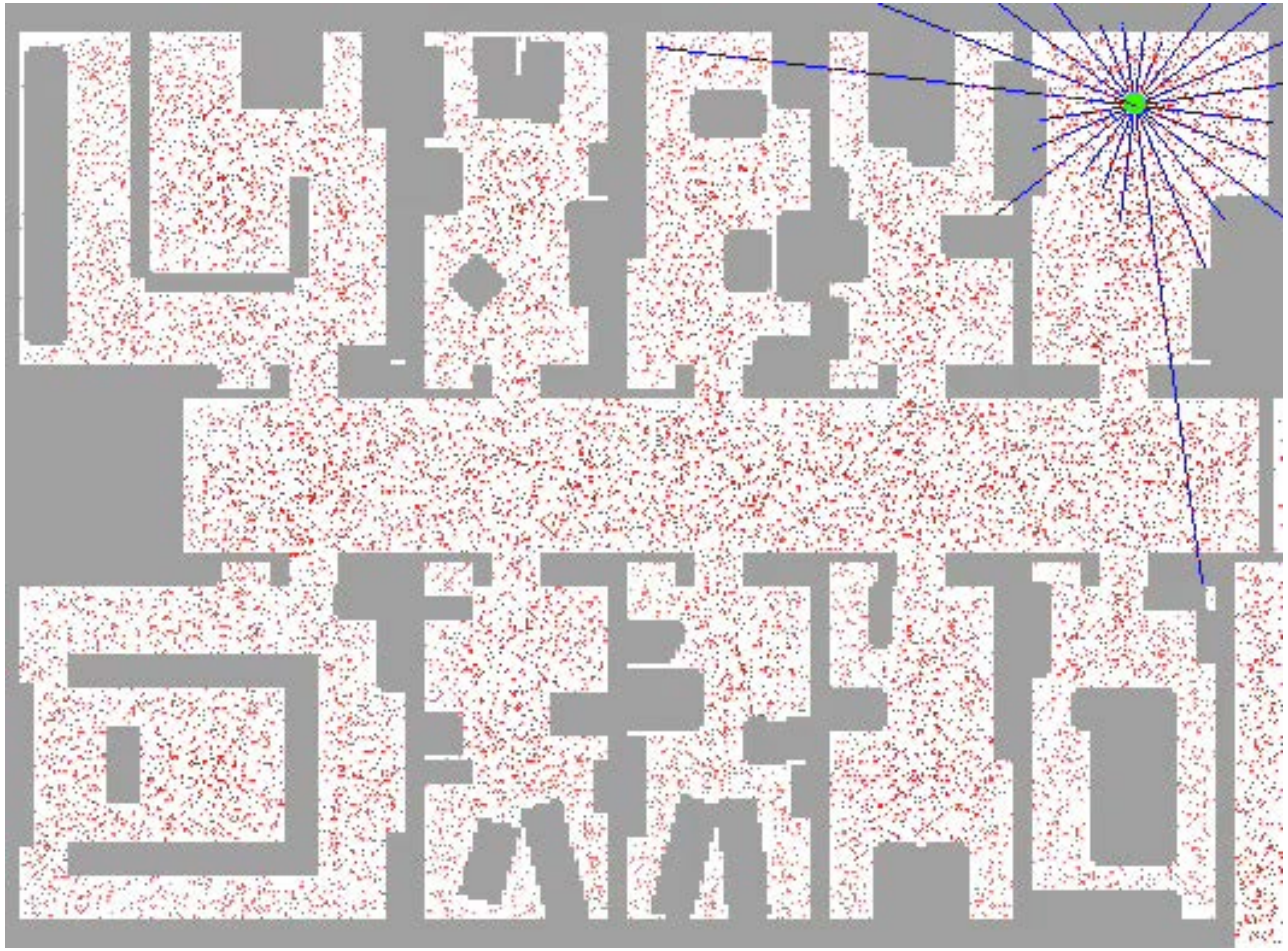
Lecture 20
Mobile Robotics - V - Localization



from Probabilistic Robotics

Course logistics

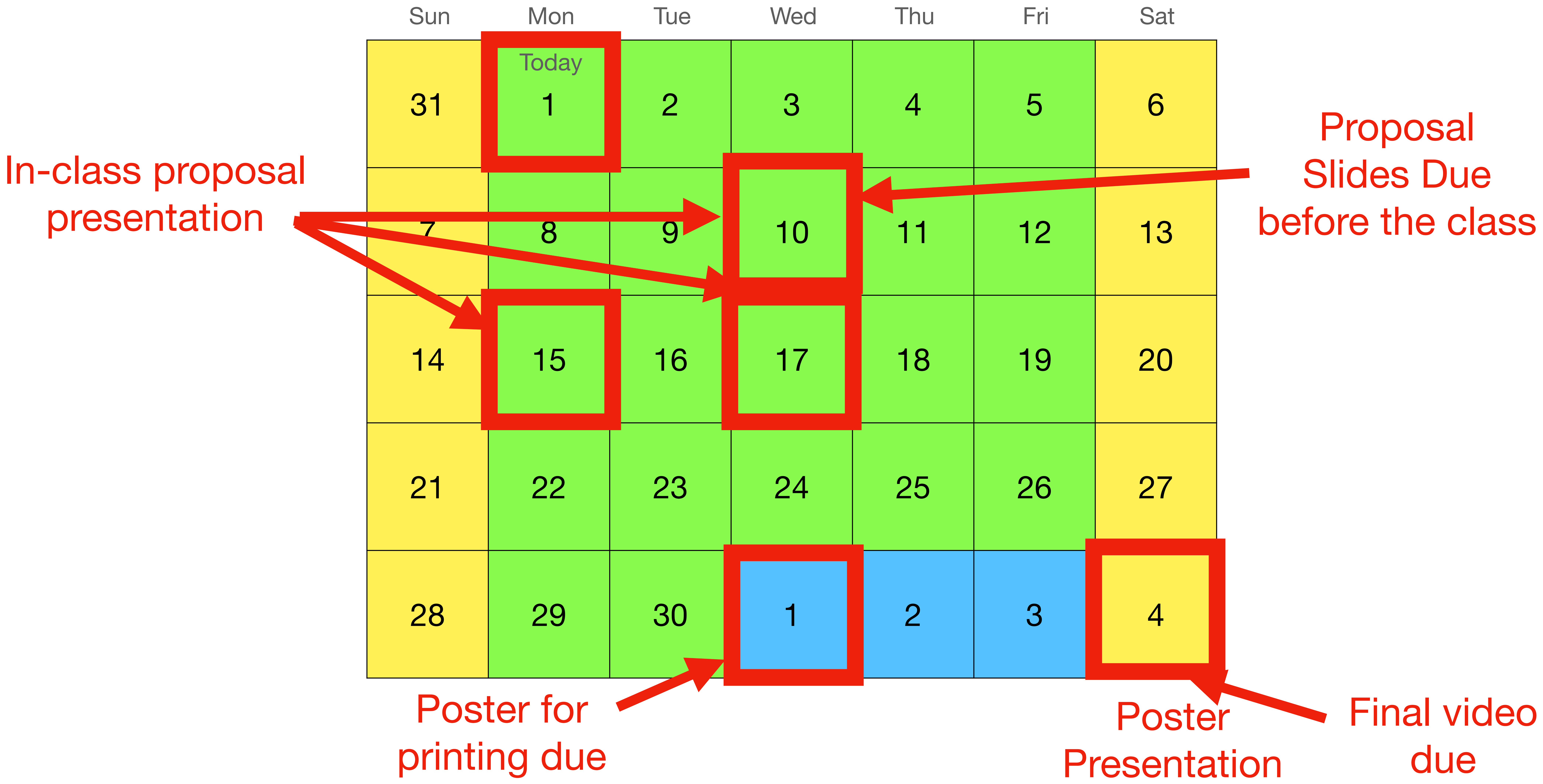
- Project 6 was posted on 03/20 and is due **04/01 (extended)**
- Quiz 10 will be posted tomorrow noon and will be due o
- Project 7:
  - Groups are formed.
  - Two parts (~1 hr each) - Instructions will be provide
    1. Beginner's guide.
    2. Real Robot Challenge.
  - Scheduler is shared with the class.
    - Please book your 2 1-hour sessions.
    - Both the parts needs to be completed by 04/15.
- No TA OHs between 03/28 and 04/12.
  - Karthik's OH will be available to discuss final projects.
  - Chahyon and Xun's OH are cancelled between 03/28 and 04/12. They maybe available upon request for the UNITE team.
- **Final Poster Session: 05/04/2024 - Saturday - 1pm - 4pm, Shepherd Labs 164 - mark your calendars**

Location: Shepherd Labs 164 (Drone Lab) - this place will not be available for experiments after the dedicated times shown below.
Note: Talk to your team members and find a slot that works best to do P7 experiments. You will need two sessions as a team to perform the tasks we created for you. Please do not overbook. Start with 2 1-hour sessions.
You will need to come in as a team to finish these tasks.
Course staff will be present to guide you through the process.
Your Group Numbers are available in the next Sheet.

03/28/2024			04/01/2024			04/03/2024			04/04/2024		
			Robot-0	2:30-3:30 pm	Group-4	Robot-0	2:30-3:30 pm	Group-4	Robot-0	2:00-3:00 pm	Group-9
			Robot-1	2:30-3:30 pm	Group-2	Robot-1	2:30-3:30 pm	Group-2	Robot-1	2:00-3:00 pm	Available
			Robot-2	2:30-3:30 pm	Group-5	Robot-2	2:30-3:30 pm	Group-6	Robot-2	2:00-3:00 pm	Available
			Robot-3	2:30-3:30 pm	Group-10	Robot-3	2:30-3:30 pm	Group-11	Robot-3	2:00-3:00 pm	Available
			Robot-4	2:30-3:30 pm	Group-1	Robot-4	2:30-3:30 pm	Group-13	Robot-4	2:00-3:00 pm	Group-1
			Robot-0	3:30-4:30 pm	Group-5	Robot-0	3:30-4:30 pm	Group-10	Robot-0	3:00-4:00 pm	Available
			Robot-1	3:30-4:30 pm	Available	Robot-1	3:30-4:30 pm	Group-12	Robot-1	3:00-4:00 pm	Group-8
			Robot-2	3:30-4:30 pm	Available	Robot-2	3:30-4:30 pm	Group-6	Robot-2	3:00-4:00 pm	Available
			Robot-3	3:30-4:30 pm	Available	Robot-3	3:30-4:30 pm	Available	Robot-3	3:00-4:00 pm	Available
			Robot-4	3:30-4:30 pm	Available	Robot-4	3:30-4:30 pm	Group-7	Robot-4	3:00-4:00 pm	Available

04/08/2024			04/09/2024			04/11/2024			04/15/2024		
Robot-0	2:30-3:30 pm	Available	Robot-0	2:00-3:00 pm	Available	Robot-0	2:00-3:00 pm	Available	Robot-0	2:30-3:30 pm	Available
Robot-1	2:30-3:30 pm	Available	Robot-1	2:00-3:00 pm	Available	Robot-1	2:00-3:00 pm	Available	Robot-1	2:30-3:30 pm	Available
Robot-2	2:30-3:30 pm	Available	Robot-2	2:00-3:00 pm	Available	Robot-2	2:00-3:00 pm	Available	Robot-2	2:30-3:30 pm	Available
Robot-3	2:30-3:30 pm	Available	Robot-3	2:00-3:00 pm	Available	Robot-3	2:00-3:00 pm	Available	Robot-3	2:30-3:30 pm	Available
Robot-4	2:30-3:30 pm	Available	Robot-4	2:00-3:00 pm	Available	Robot-4	2:00-3:00 pm	Available	Robot-4	2:30-3:30 pm	Available
Robot-0	3:30-4:30 pm	Available	Robot-0	3:00-4:00 pm	Available	Robot-0	3:00-4:00 pm	Available	Robot-0	3:30-4:30 pm	Available
Robot-1	3:30-4:30 pm	Available	Robot-1	3:00-4:00 pm	Group-7	Robot-1	3:00-4:00 pm	Group-7	Robot-1	3:30-4:30 pm	Available
Robot-2	3:30-4:30 pm	Available	Robot-2	3:00-4:00 pm	Available	Robot-2	3:00-4:00 pm	Available	Robot-2	3:30-4:30 pm	Available
Robot-3	3:30-4:30 pm	Available	Robot-3	3:00-4:00 pm	Available	Robot-3	3:00-4:00 pm	Available	Robot-3	3:30-4:30 pm	Available
Robot-4	3:30-4:30 pm	Available	Robot-4	3:00-4:00 pm	Available	Robot-4	3:00-4:00 pm	Available	Robot-4	3:30-4:30 pm	Available

Final (Open) Project timeline



Final (Open) Project timeline

- Proposal Slides: (template will be provided)
  - 1-4 Slides
  - Title, Motivation, Input - Output, Evaluation, Deliverables, Timeline, Who is doing what?
  - Where does your project stand not the 3-axes (robots, objects, tasks)?
  - Backup plan
- In-class proposal presentation (<8mins) :
  - Teams will get feedback from the class
- Final video:
  - Describing the project idea and the outcome.
- Poster presentation: (template will be provided)
  - Presenting the project idea and the outcome to audience.

- Final Project: 15%
  - Project proposal slides + presentation: 2%
  - Final project video: 5%
  - Poster presentation (evaluation by judges): 3%

Final Project (Open ended)

Think along these axes to decide your final project!

Evaluating your implementation/system with quantitative results are VERY important!

Objects

Rearrangment of a set of objects

You may use:

- Kineval codebase
- Other sim environments (pybullet, Gazebo, DRAKE, Isaac sim)
- Turtlebot3 (provided only upon compelling proposal, only 5 are available)
- Other robots you may have access to.

Multi-robot task execution

Long horizon tasks

Tasks

Robots

Continuing previous Lecture
PF and localization

Particle Filter

Particle_filter$(\mathcal{X}_{t-1}, u_t, z_t)$**:**

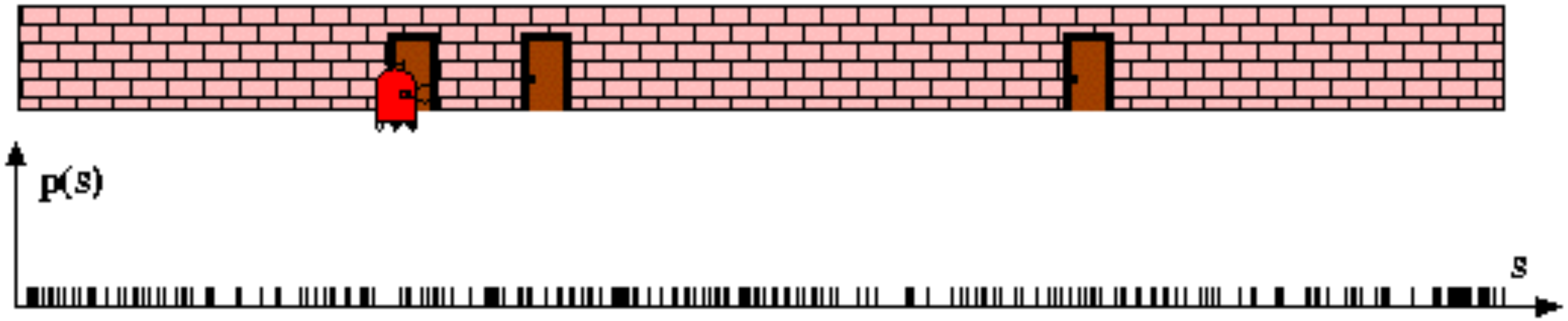
$\bar{\mathcal{X}}_t = \mathcal{X}_t = \emptyset$
for $j = 1$ to J do
    sample $x_t^{[j]} \sim \pi(x_t)$
    $w_t^{[j]} = \frac{p(x_t^{[j]})}{\pi(x_t^{[j]})}$
    $\bar{\mathcal{X}}_t = \bar{\mathcal{X}}_t + \langle x_t^{[j]}, w_t^{[j]} \rangle$
endfor
for $j = 1$ to J do
    draw $i \in 1, \ldots, J$ with probability $\propto w_t^{[i]}$
    add $x_t^{[i]}$ to $\mathcal{X}_t$
endfor
return $\mathcal{X}_t$

Particle Filter for Localization

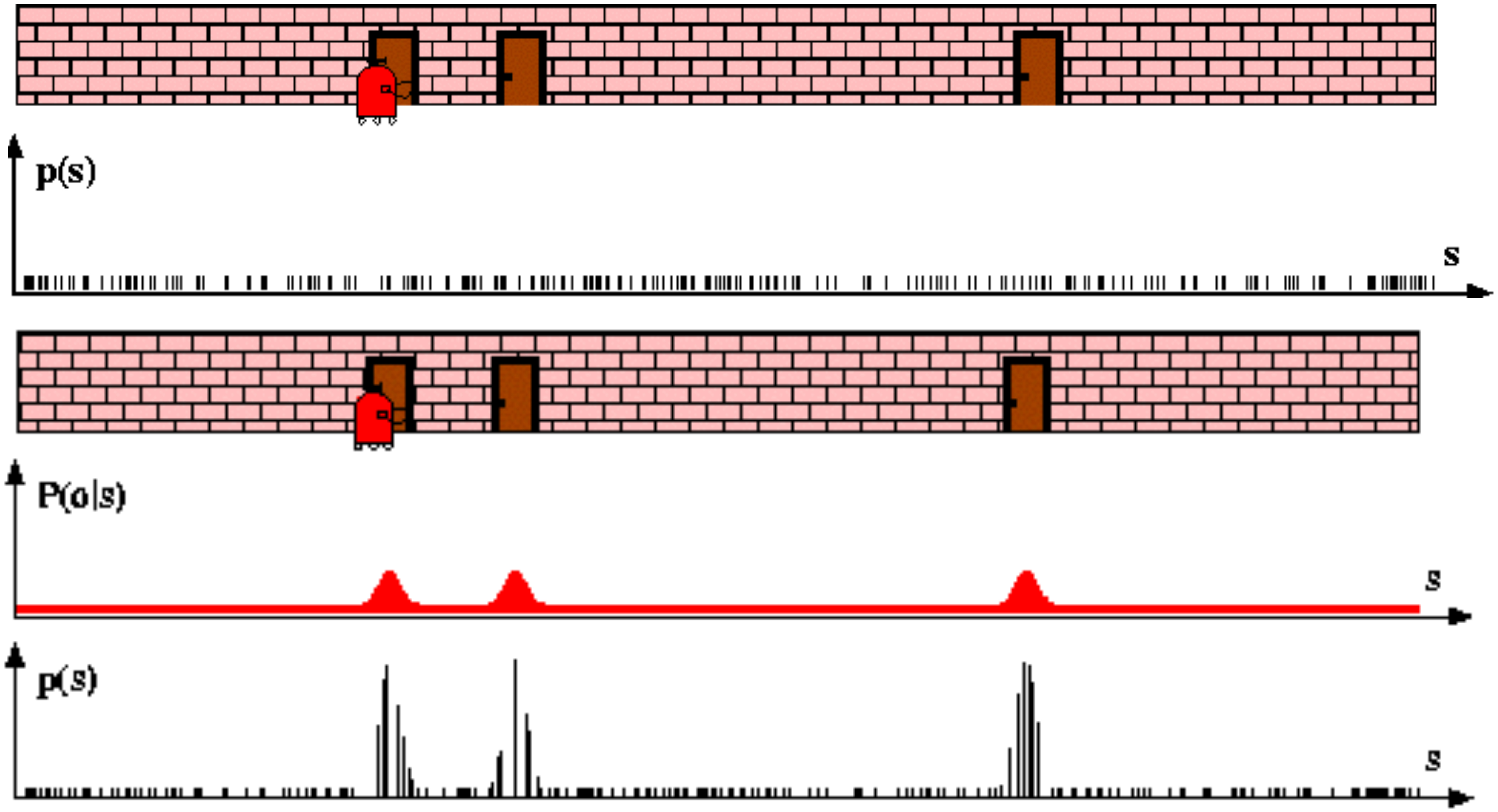
Particle_filter$(\mathcal{X}_{t-1}, u_t, z_t)$**:**

$\bar{\mathcal{X}}_t = \mathcal{X}_t = \emptyset$
for $j = 1$ to J do
    sample $x_t^{[j]} \sim p(x_t \mid u_t, x_{t-1}^{[j]})$
    $w_t^{[j]} = p(z_t \mid x_t^{[j]})$
    $\bar{\mathcal{X}}_t = \bar{\mathcal{X}}_t + \langle x_t^{[j]}, w_t^{[j]} \rangle$
endfor
for $j = 1$ to J do
    draw $i \in 1, \ldots, J$ with probability $\propto w_t^{[i]}$
    add $x_t^{[i]}$ to $\mathcal{X}_t$
endfor
return $\mathcal{X}_t$

Particle Filters

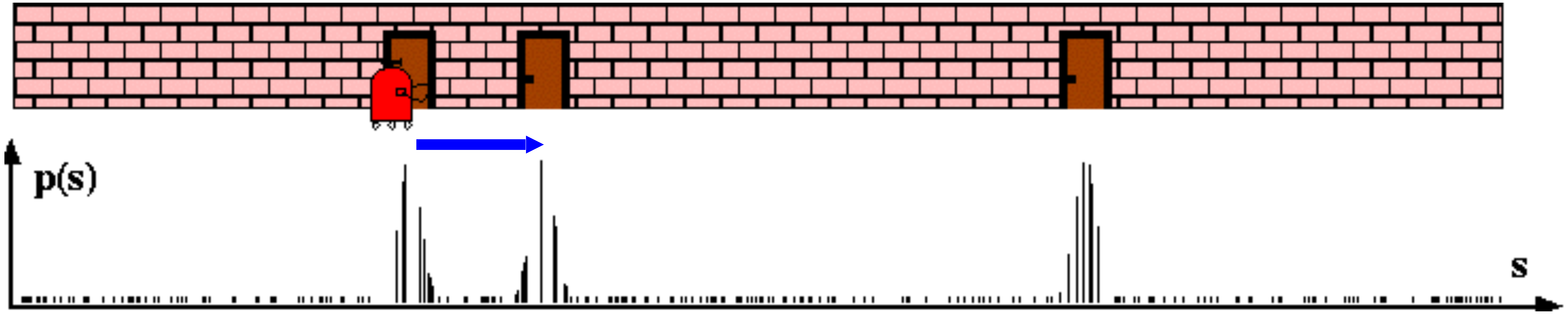


Sensor Information: Importance Sampling

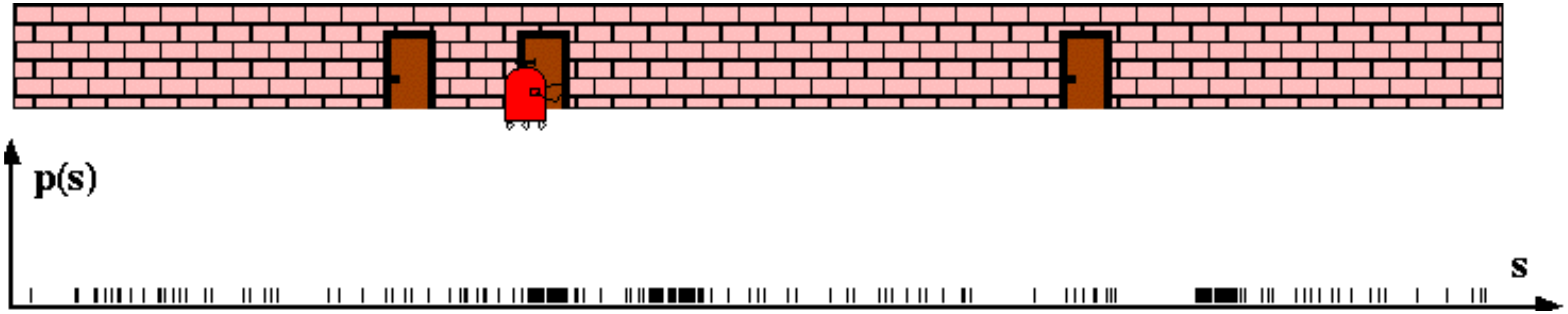


Slide borrowed from Dieter Fox

Robot Motion

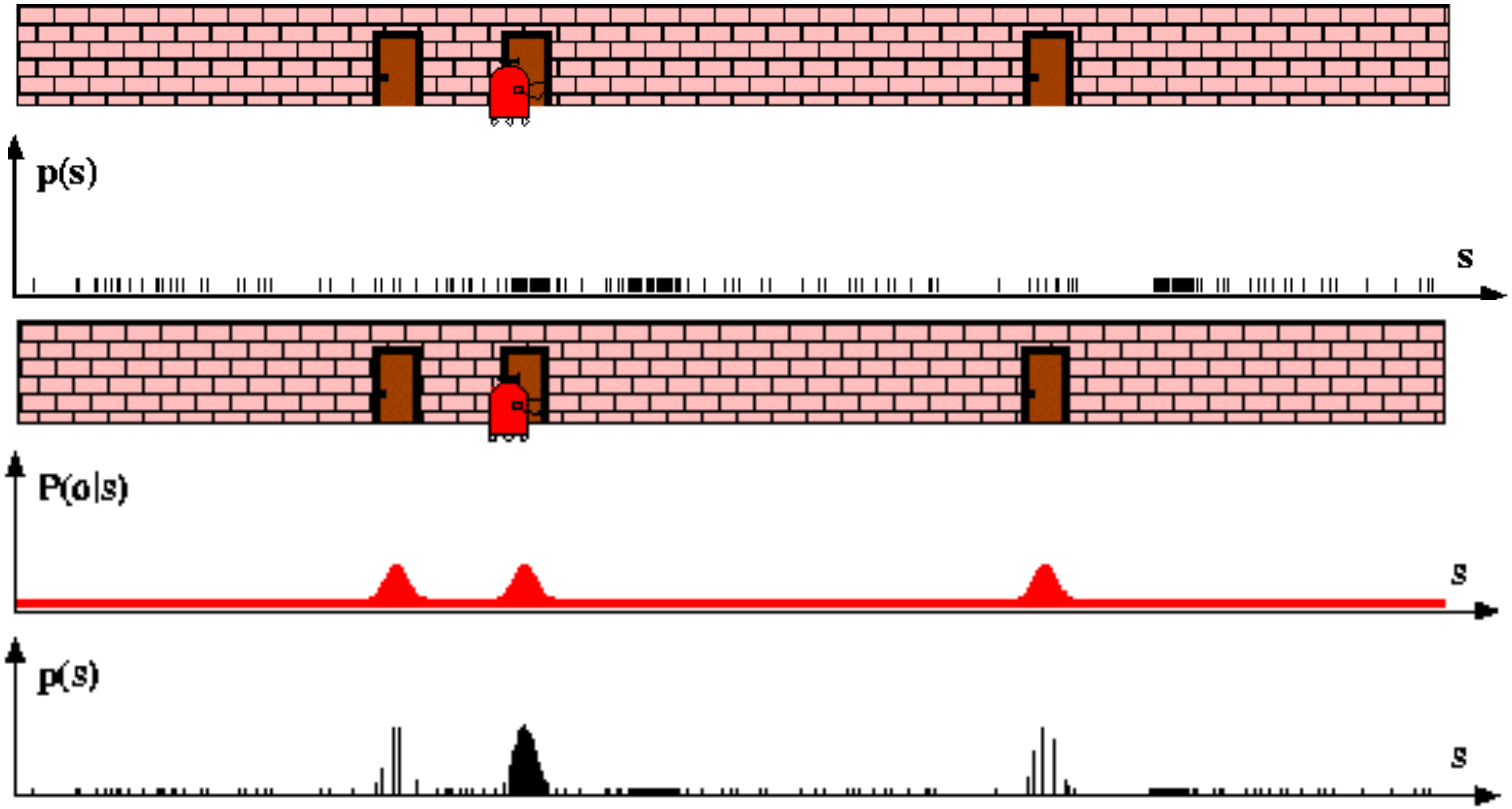


Resampling Step +
Control Input

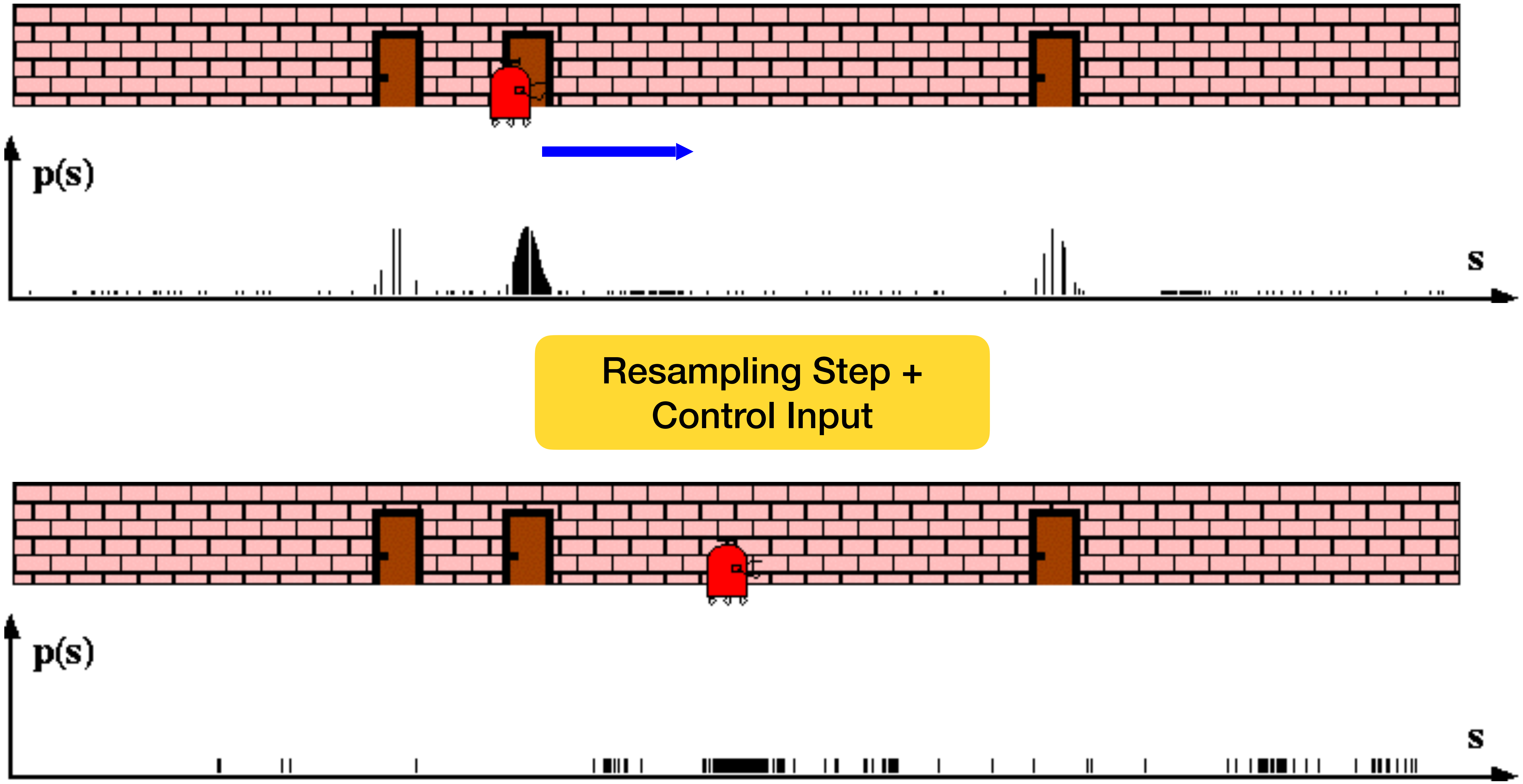


Slide borrowed from Dieter Fox

Sensor Information: Importance Sampling

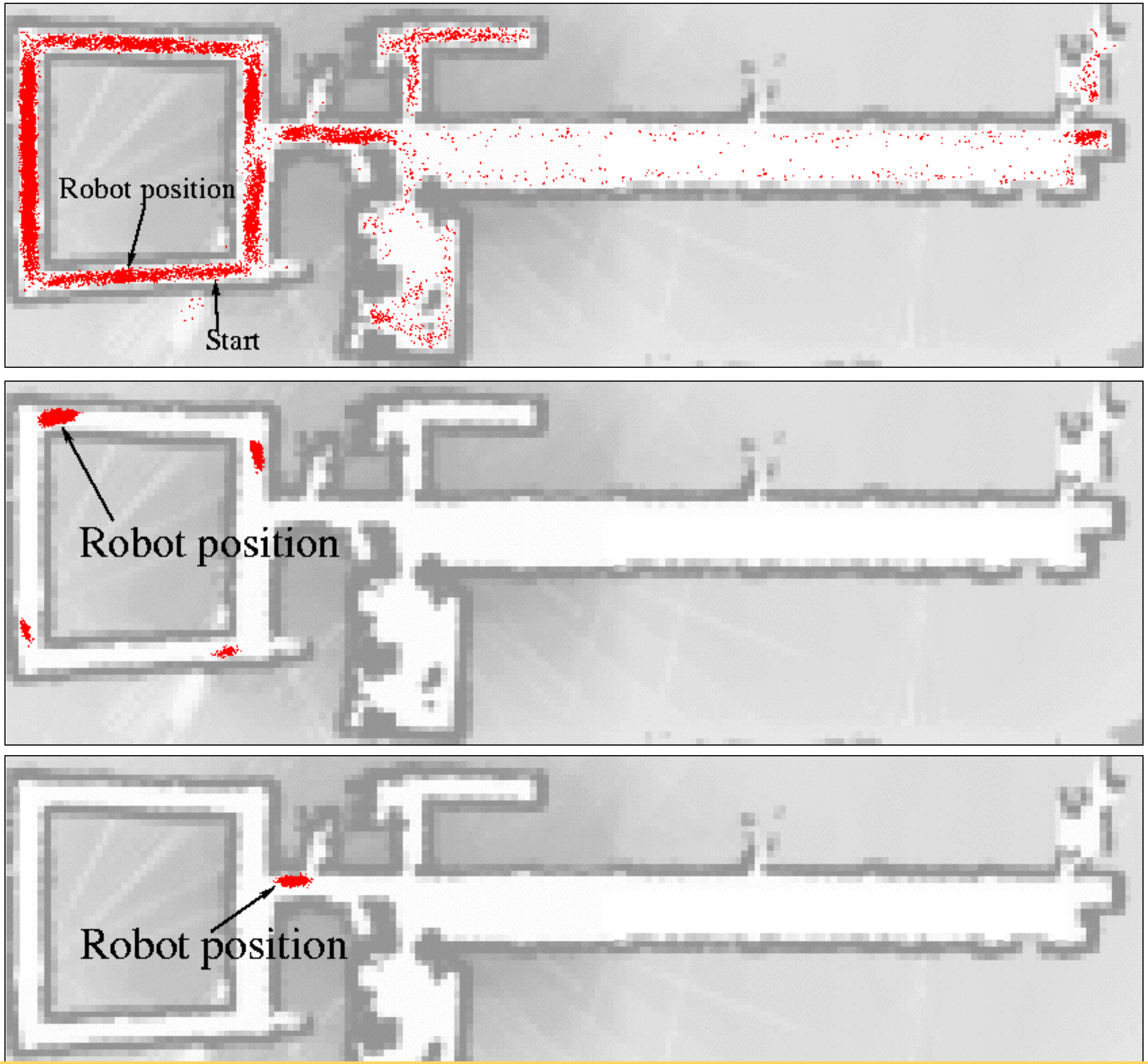


Robot Motion

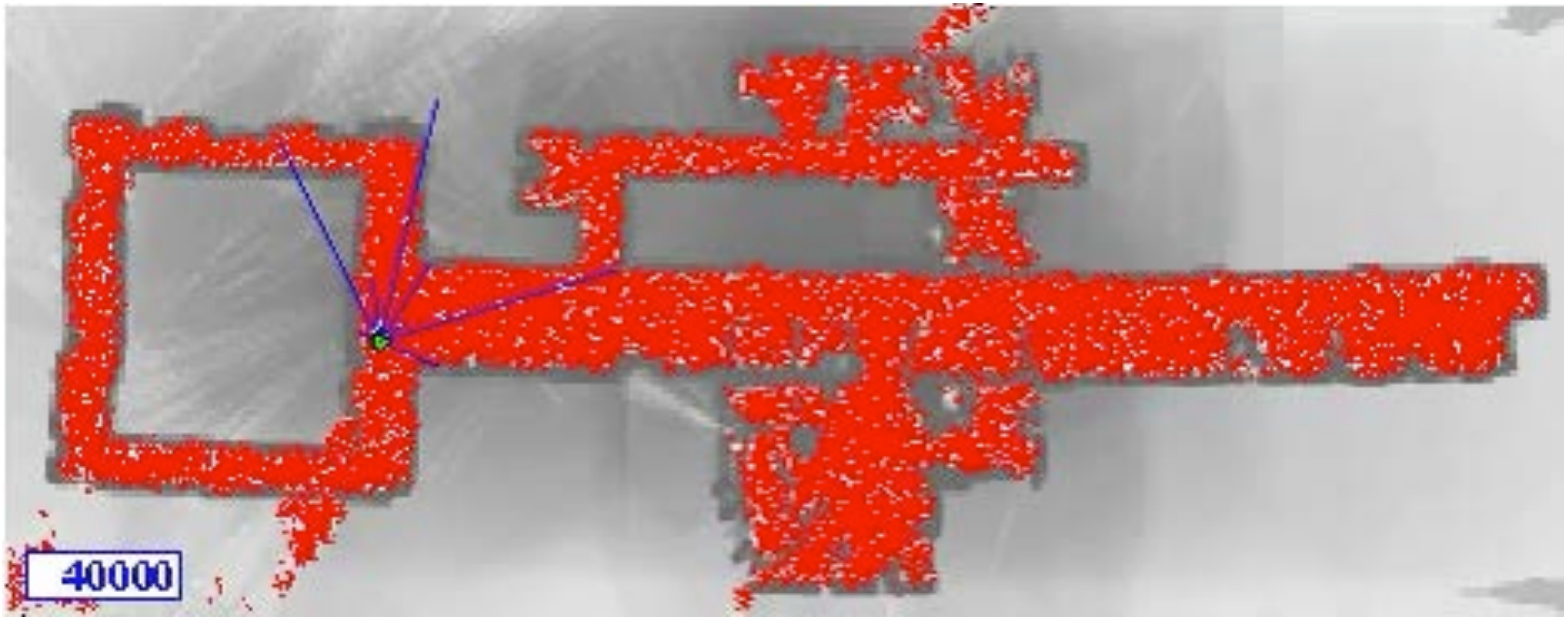


Why have constant number of particles through out?

Adaptive Sampling

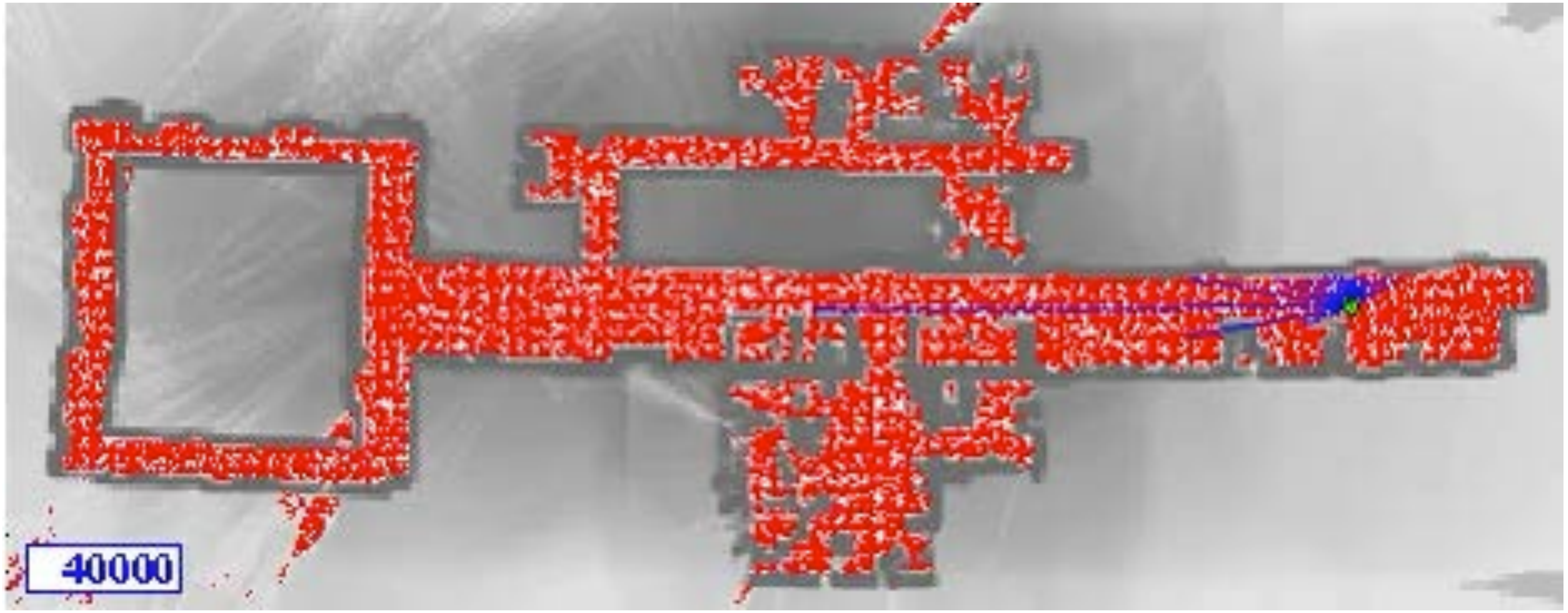


KLD-Sampling Sonar

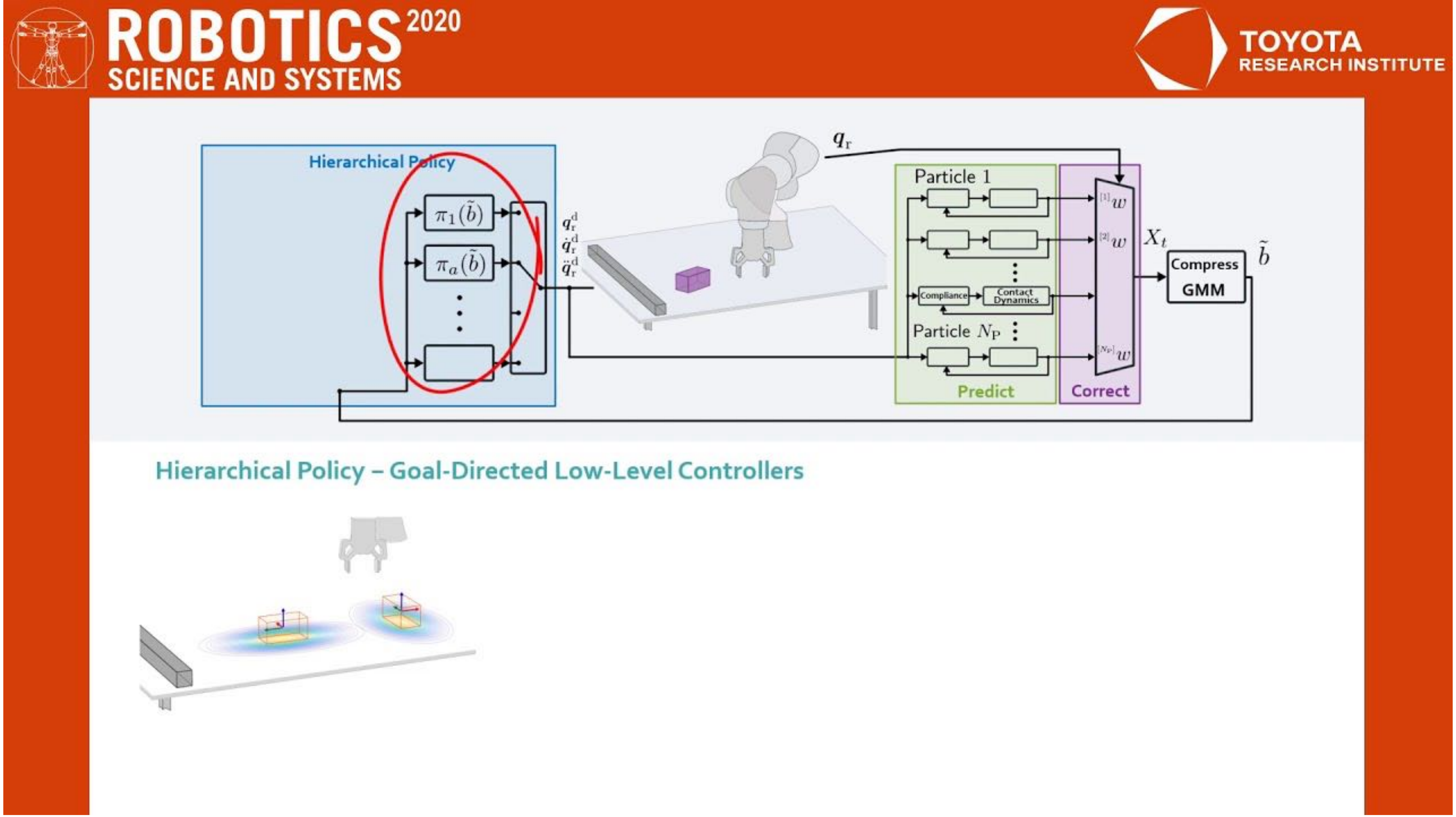


Adapt number of particles on the fly based on statistical approximation measure

KLD-Sampling Laser



What if the localization is not about the robot?



"Controlling Contact-Rich Manipulation Under Partial Observability"

Florian Wirnshofer (Siemens AG)*; Philipp Sebastian Schmitt (Siemens AG); Georg von Wichert (Siemens AG); Wolfram Burgard (University of Freiburg)

RSS 2020

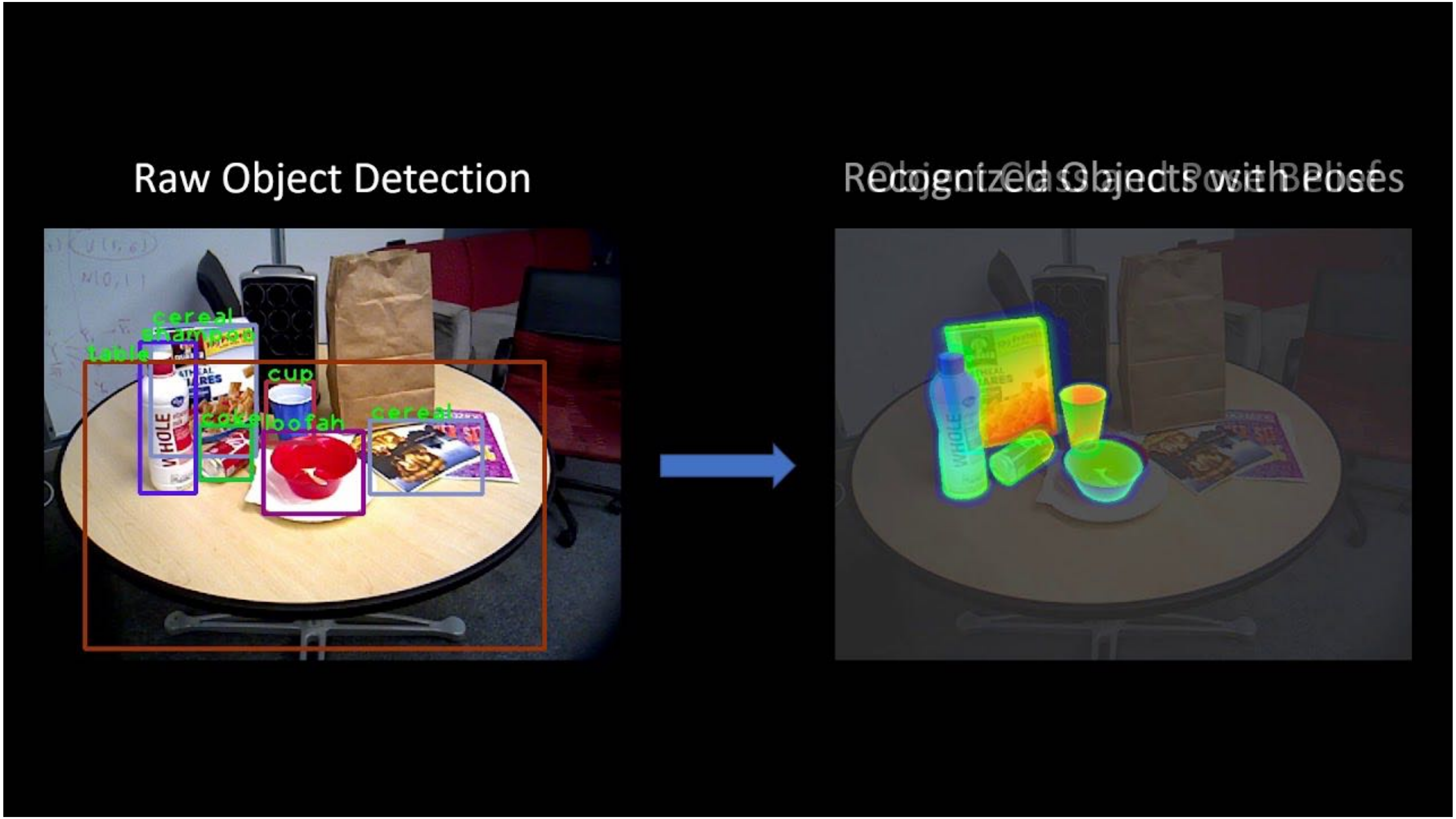
Zhiqiang Sui, Lingzhu Xiang, Odest Chadwicke Jenkins, Karthik Desingh,
"Goal-directed Robot Manipulation through Axiomatic Scene Estimation," IJRR 2017.

Physically Plausible Scene Estimation for Manipulation in Clutter

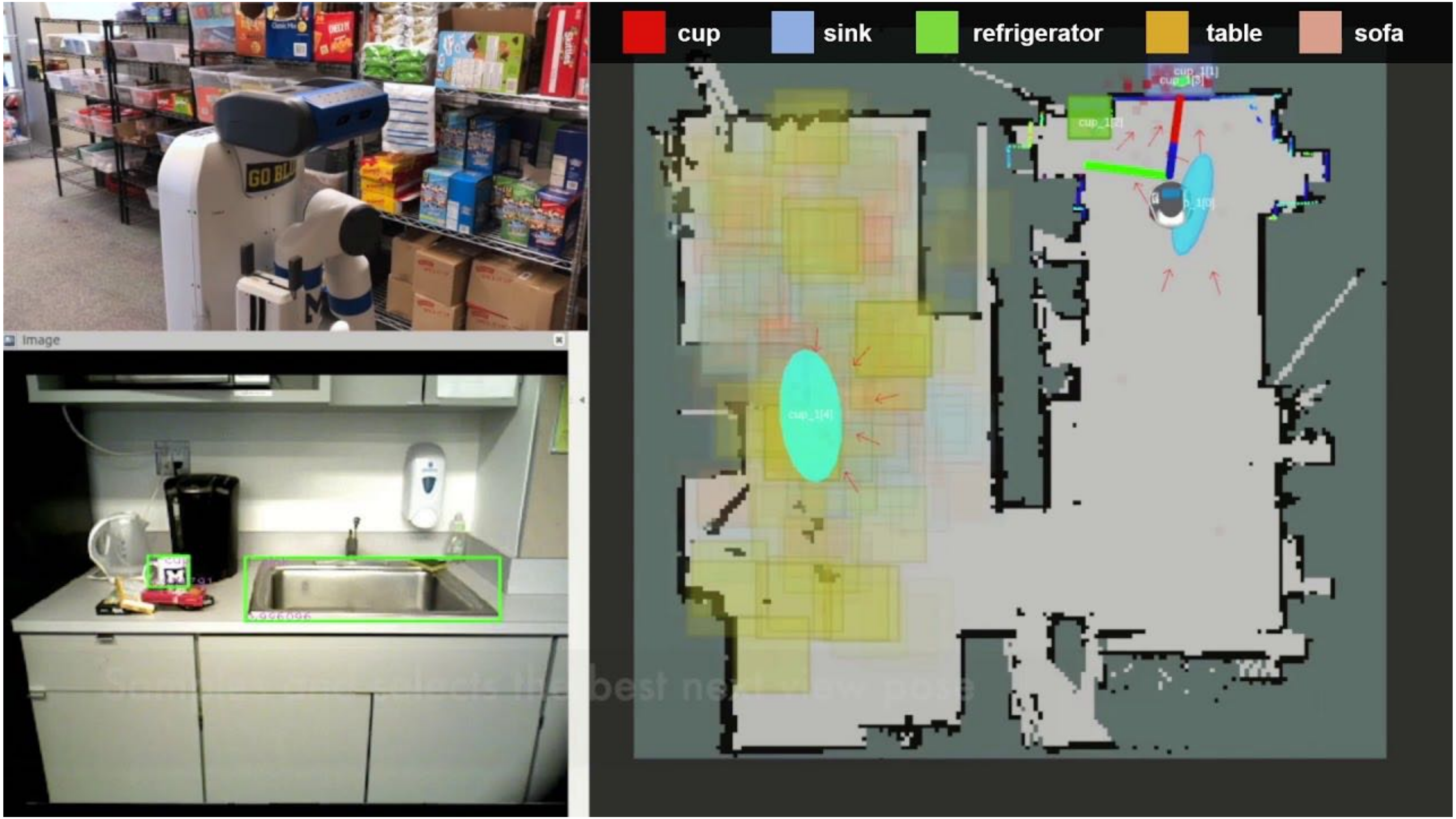
Karthik Desingh[1], Odest Chadwicke Jenkins[1], Lionel Reveret[2], Zhiqiang Sui[1]

[1]University of Michigan, Ann Arbor, USA
[2]INRIA RhÔne-Alpes, Saint Ismier, France

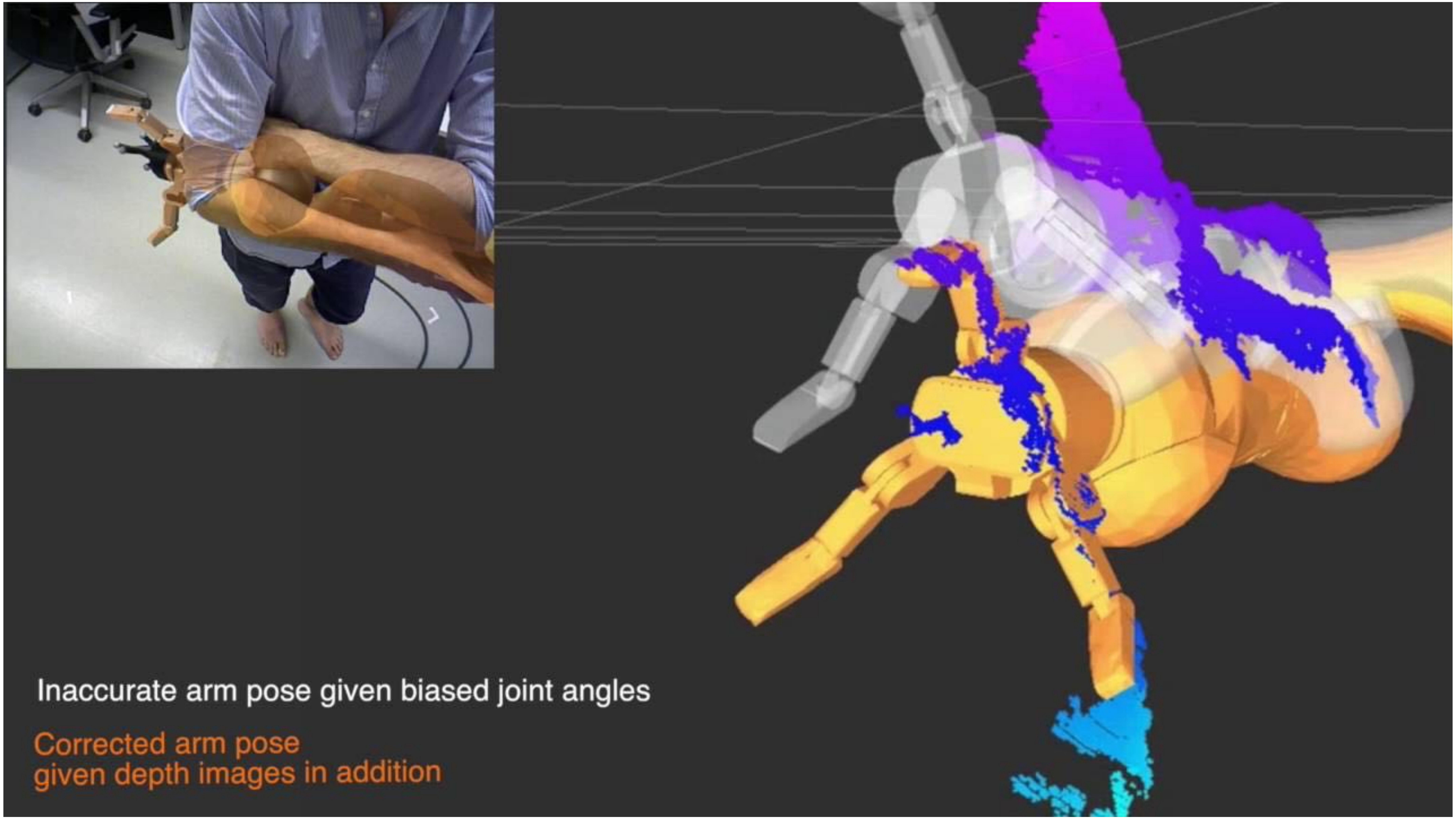
Karthik Desingh, Odest Chadwicke Jenkins, Lionel Reveret, Zhiqiang Sui, "Physically Plausible Scene Estimation for Manipulation in Clutter," Humanoids 2016.



Zhen Zeng, Yunwen Zhou, Odest Chadwicke Jenkins, Karthik Desingh, "Semantic Mapping with Simultaneous Object Detection and Localization," IROS 2018



Zhen Zeng, Adrian Röfer, Odest Chadwicke Jenkins, "SLiM: Semantic Linking Maps for Active Visual Object Search.," ICRA 2020



Probabilistic Articulated Real-Time Tracking for Robot Manipulation. Garcia Cifuentes, Cristina and Jan Issac and Manuel Wüthrich and Stefan Schaal and Jeannette Bohg. IEEE Robotics and Automation Letters (RA-L) 2017.

Next Lecture:
Mapping