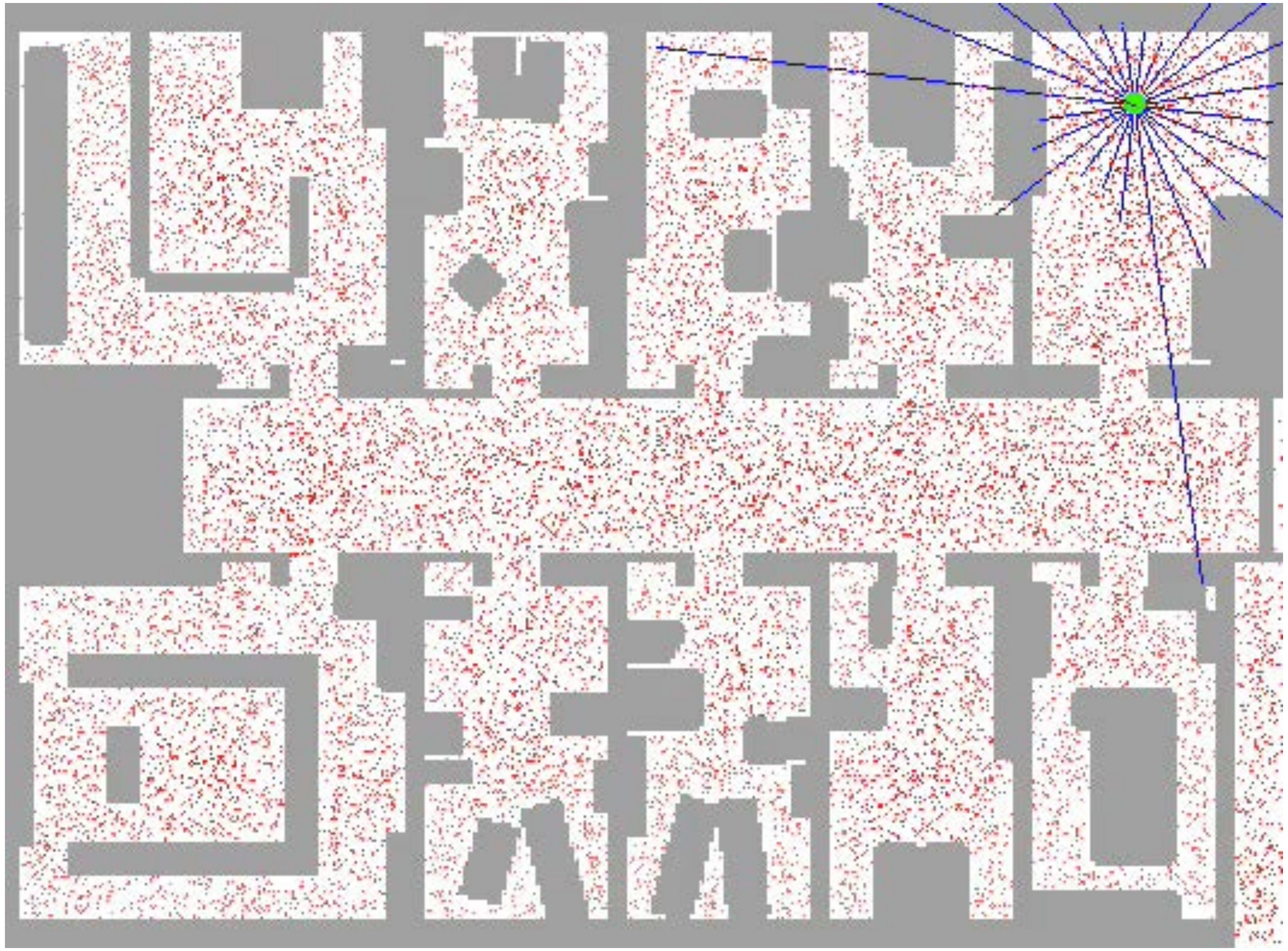
Lecture 20
Mobile Robotics - V - Localization



from Probabilistic Robotics

Course logistics

- Quiz 10 will be posted tomorrow and will be due on Wed noon.
- Project 7:
  - Groups are formed.
  - Two parts (~1 hr each) - Instructions will be provided.
    1. Tutorial 1
    2. Tutorial 2
  - Scheduler is shared with the class.
    - Please book your 2 1-hour sessions **ASAP**.
    - Both the parts needs to be completed by 04/23 as a team.
- No TA OHs between 04/07 and 04/23.
  - They will be available on demand.
  - Karthik's OH will be available to discuss final projects.
- **Final Poster Session: 05/05/2025 - Monday - 12:30pm - 2:30pm, 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.
Your Group Numbers are available in the next Sheet.

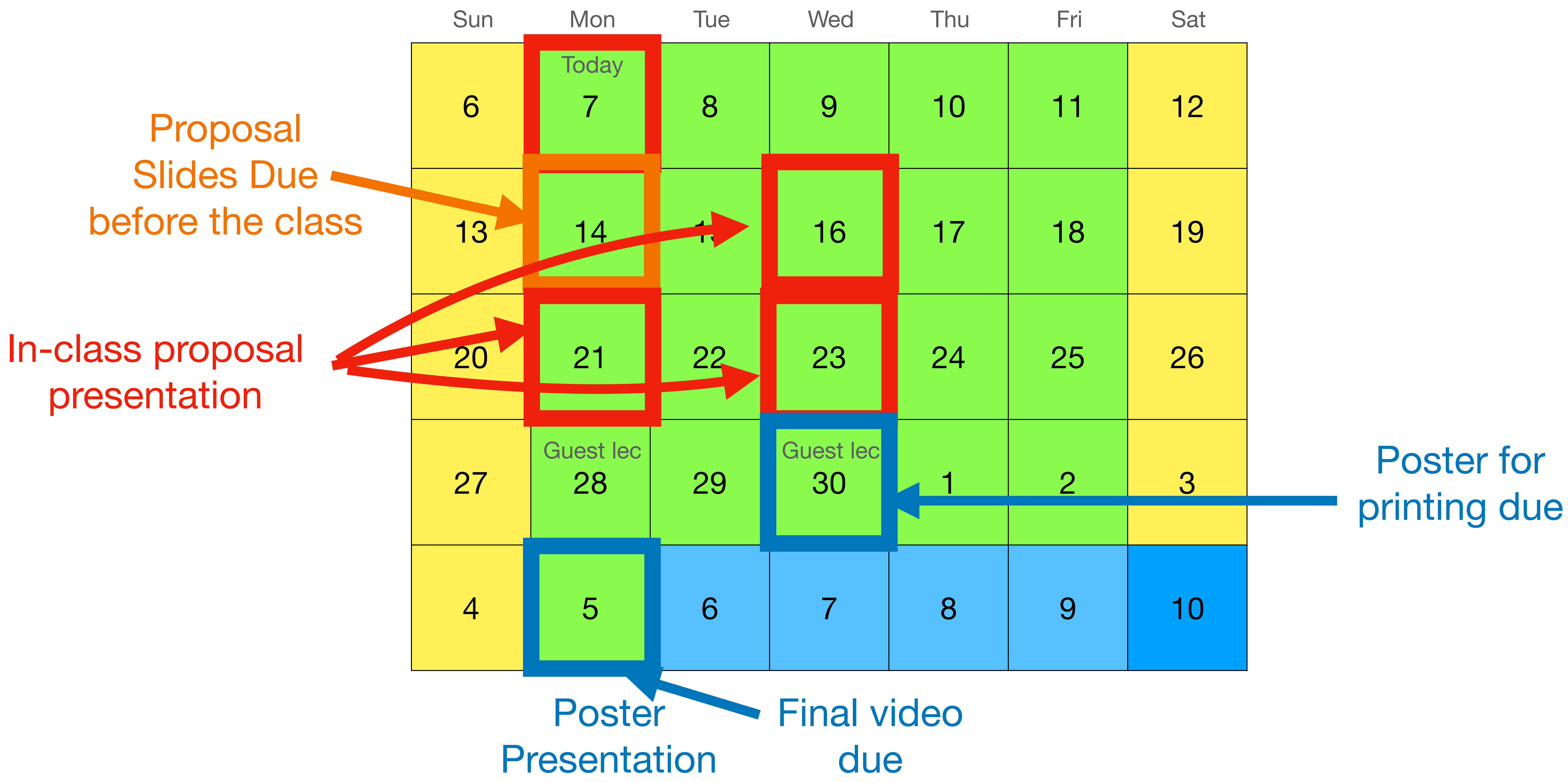
Tutorial 1	Robot-0	17:00 -18:00	Group-12
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Available
Tutorial 1	Robot-0	18:00 -19:00	Group-9
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Available

Wednesday, April 9, 2025			
Tutorial 1	Robot-0	16:00 -17:00	Group-4
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Available
Tutorial 1	Robot-0	17:00 -18:00	Available
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Group-8

Thursday, April 10, 2025			
Tutorial 1	Robot-0	16:00 -17:00	Available
	Robot-1		Available
	Robot-2		Group-6
	Robot-3		Available
	Robot-4		Group-1
Tutorial 2	Robot-0	17:00 -18:00	Group-12
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Group-1

Friday, April 11, 2025			
Tutorial 1	Robot-0	11:30 -12:30	Group-2
	Robot-1		Group-7
	Robot-2		Group-15
	Robot-3		Available
	Robot-4		Group-14
Tutorial 2	Robot-0	12:30 -13:30	Available
	Robot-1		Available
	Robot-2		Available
	Robot-3		Available
	Robot-4		Group-8

Final (Open) Project timeline



Final (Open) Project timeline

- Proposal Slides: (template is 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: 3%
- Final project video: 6%
- Poster presentation (evaluation by judges): 6%

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*

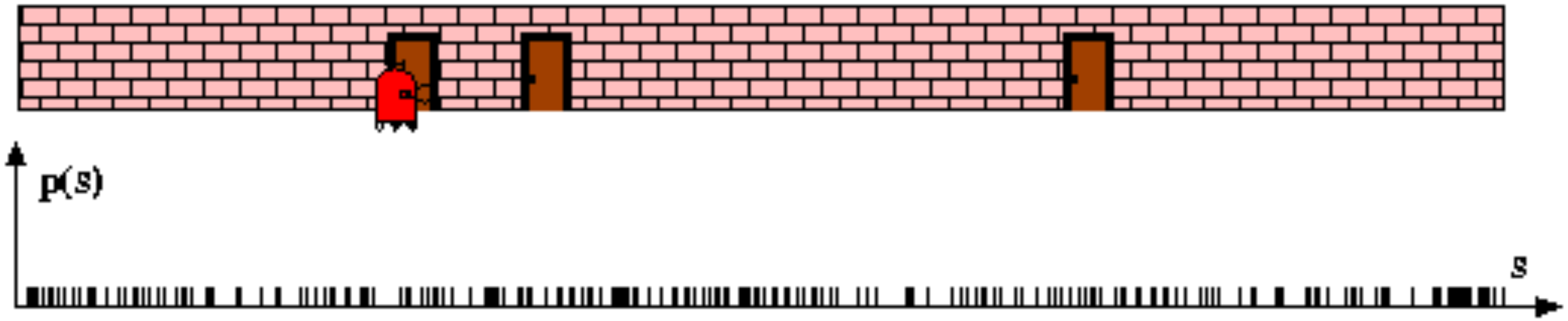
  draw $i \in 1, \ldots, J$ *with probability* $\propto w_t^{[i]}$

  add $x_t^{[i]}$ *to* $\mathcal{X}_t$

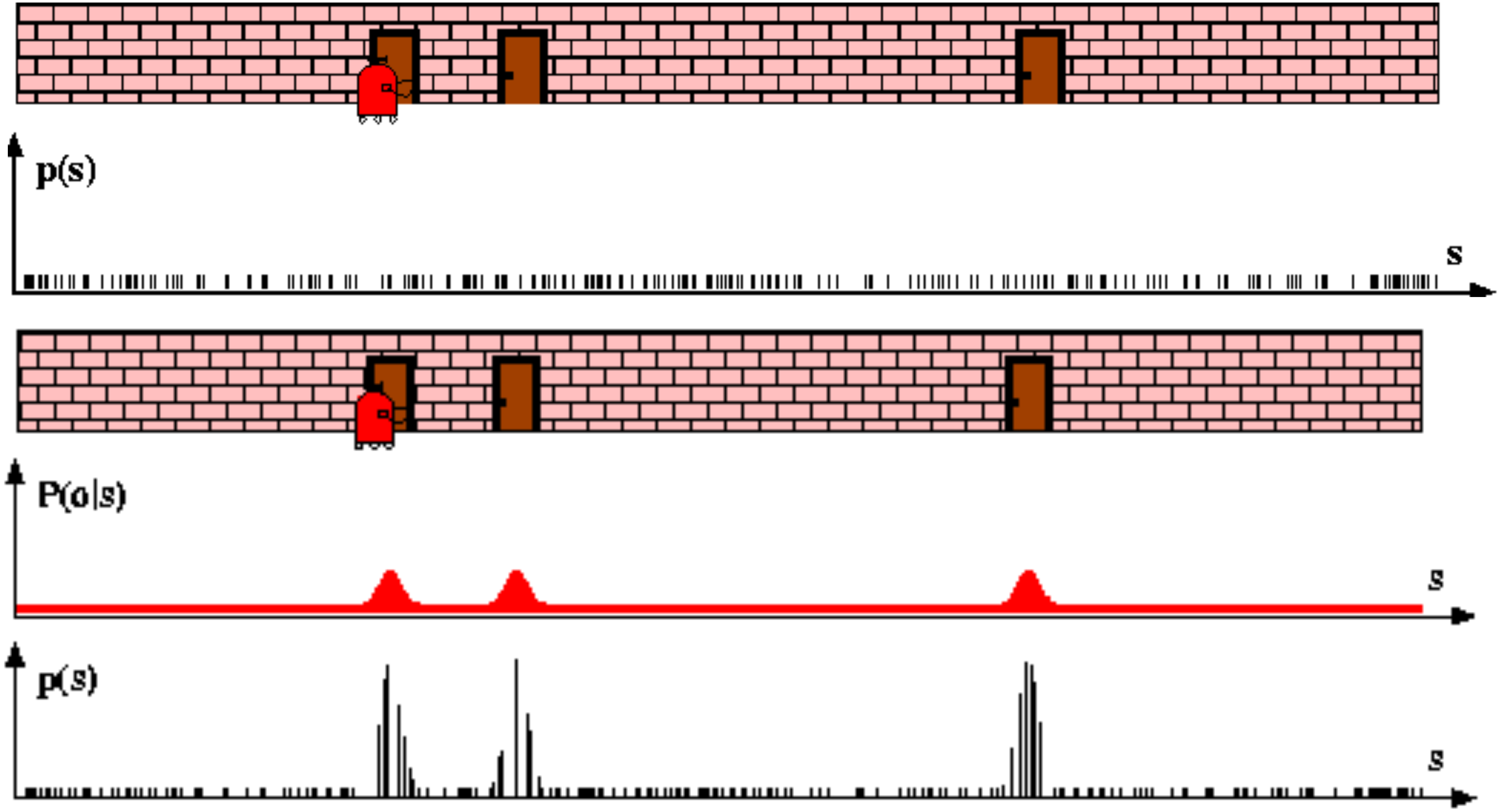
endfor

return $\mathcal{X}_t$

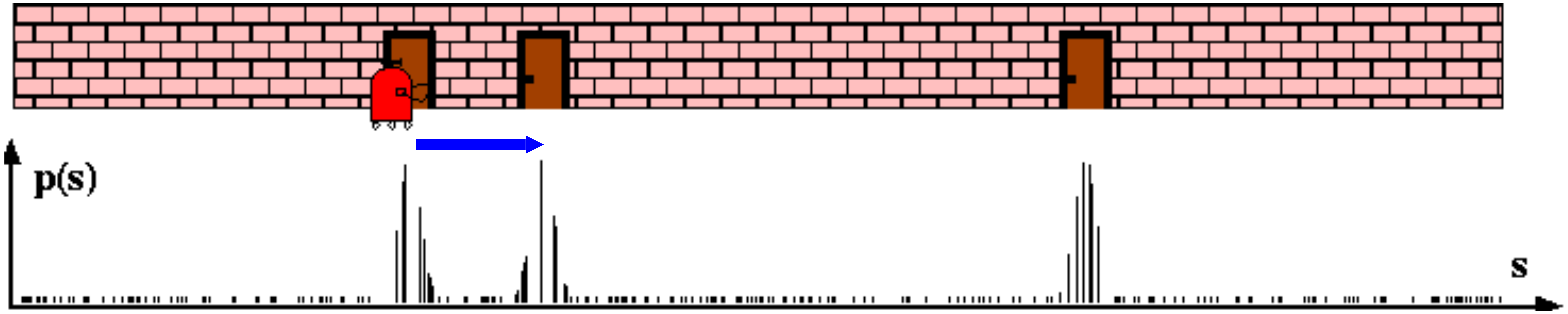
Particle Filters



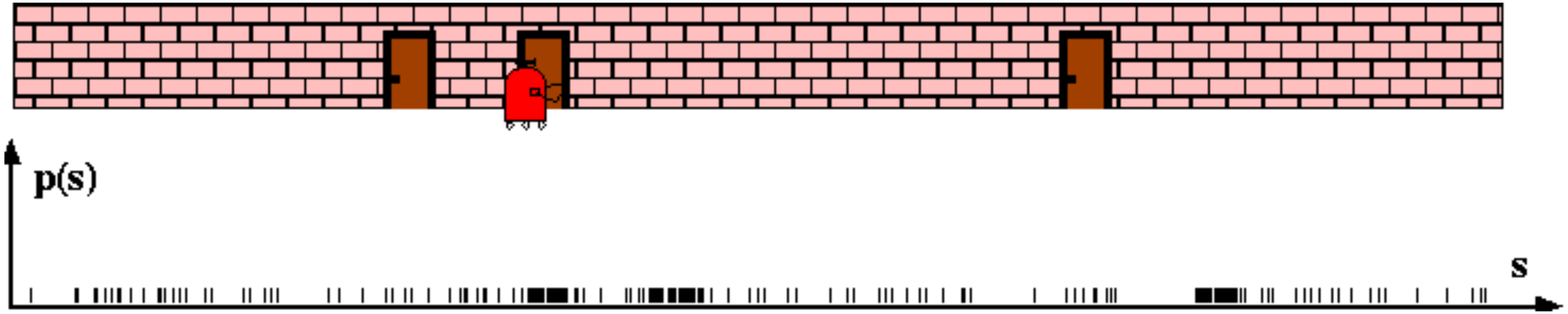
Sensor Information: Importance Sampling



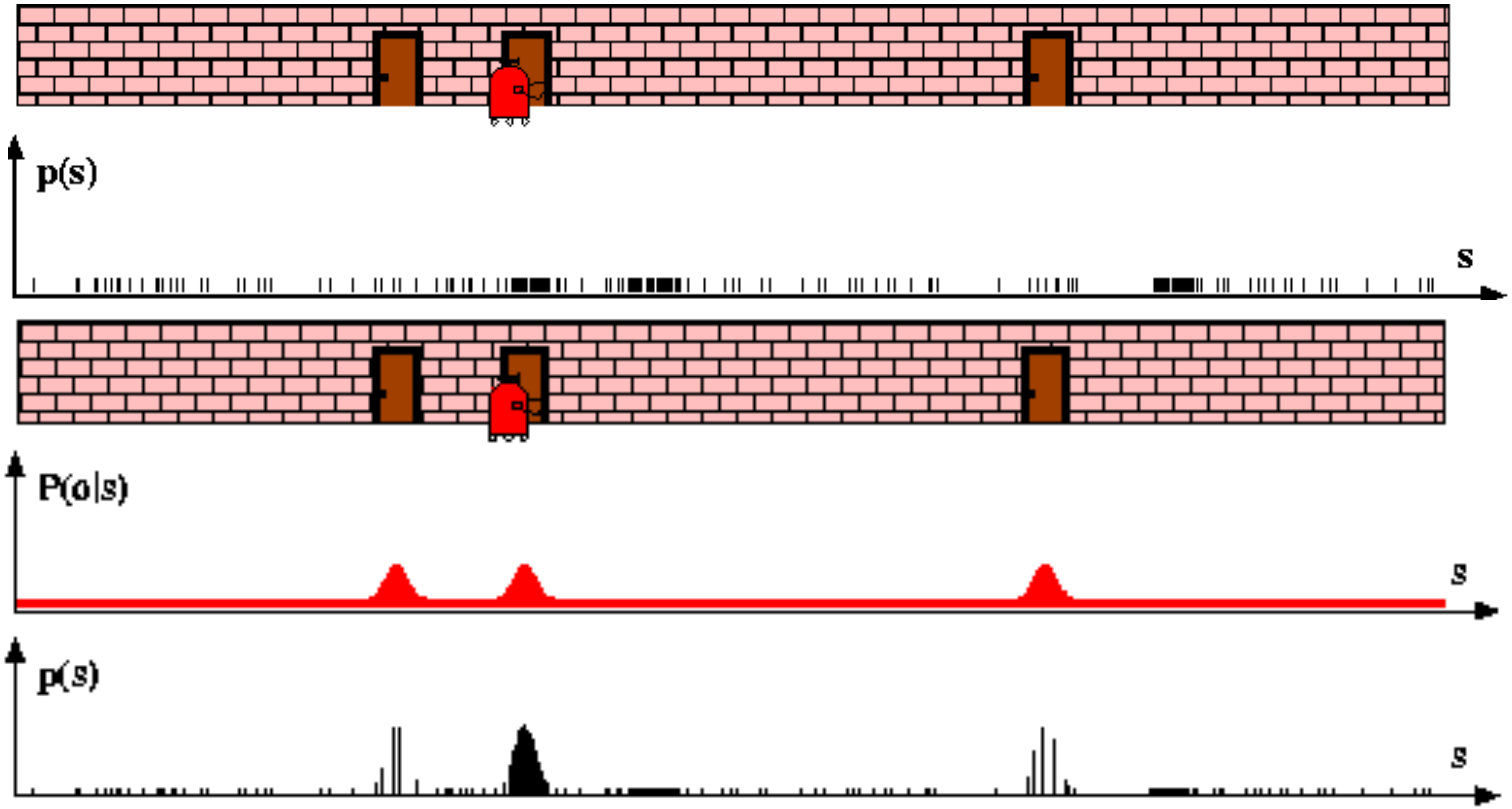
Robot Motion



Resampling Step +
Control Input

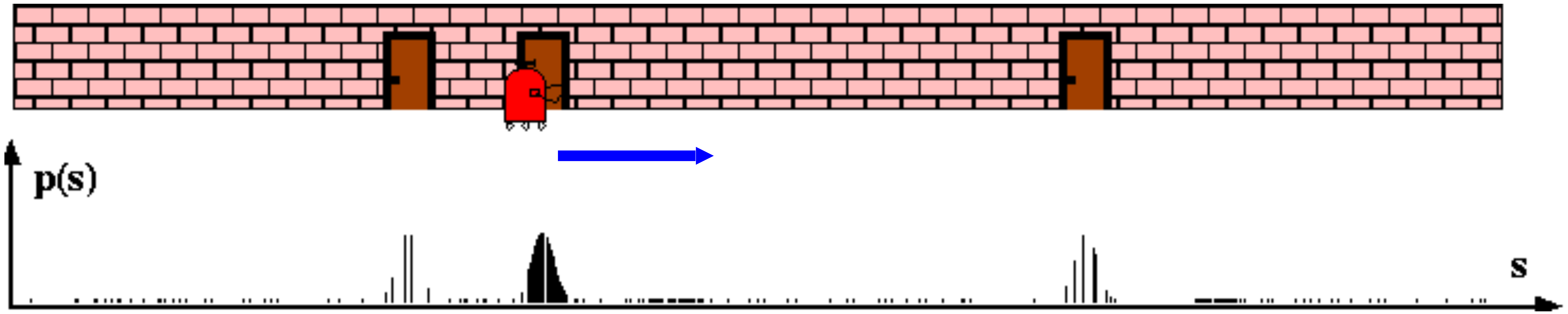


Sensor Information: Importance Sampling

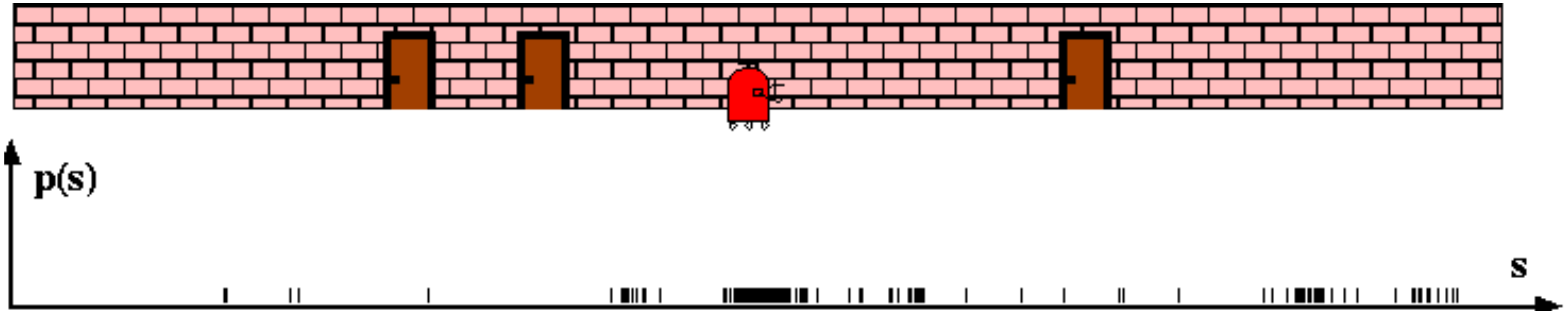


Slide borrowed from Dieter Fox

Robot Motion



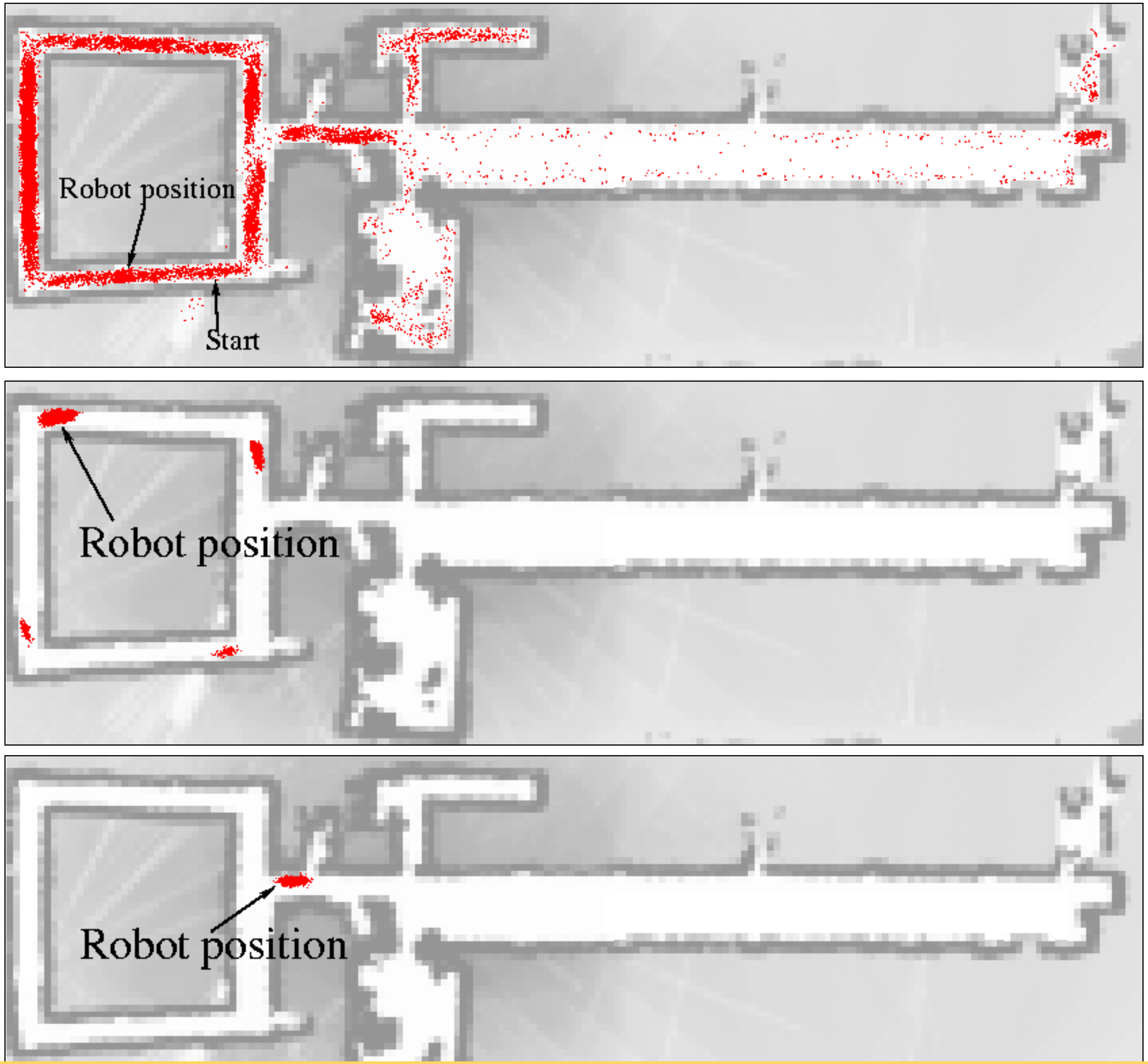
Resampling Step +
Control Input



Slide borrowed from Dieter Fox

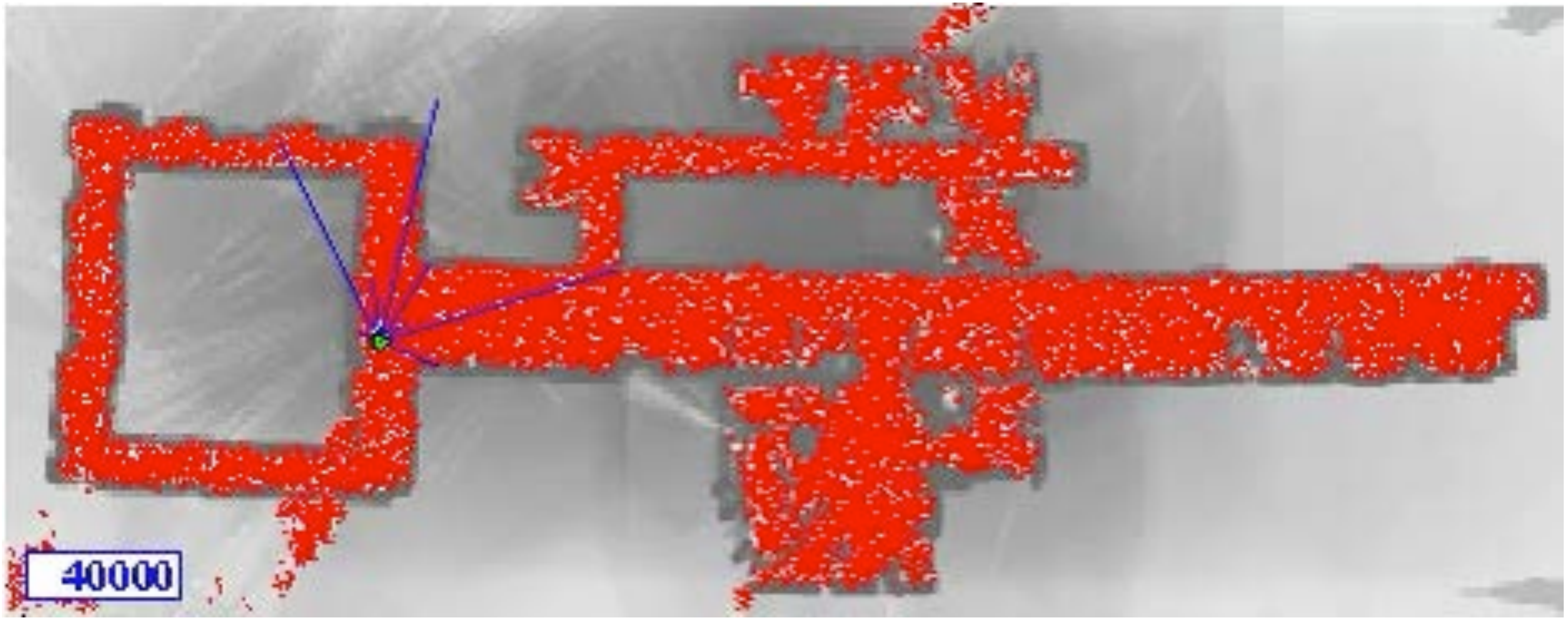
Why have constant number of particles through out?

Adaptive Sampling



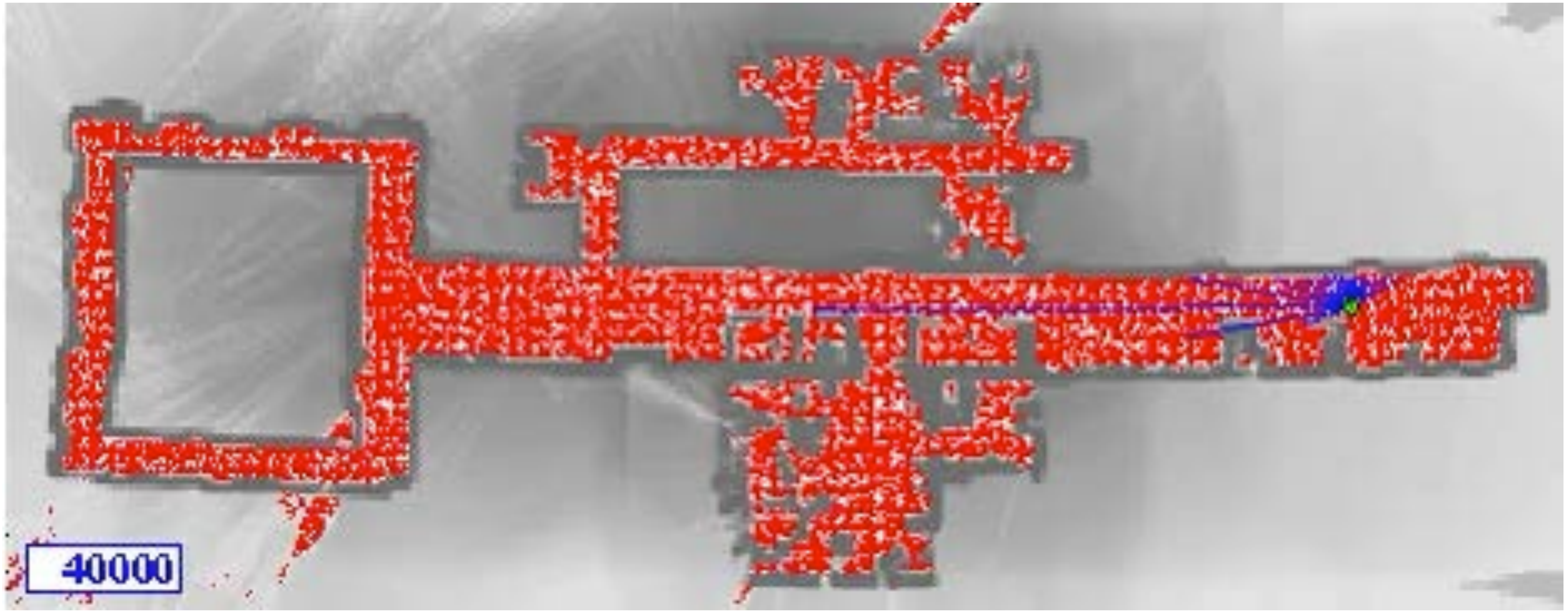
Slide borrowed from Dieter Fox

KLD-Sampling Sonar

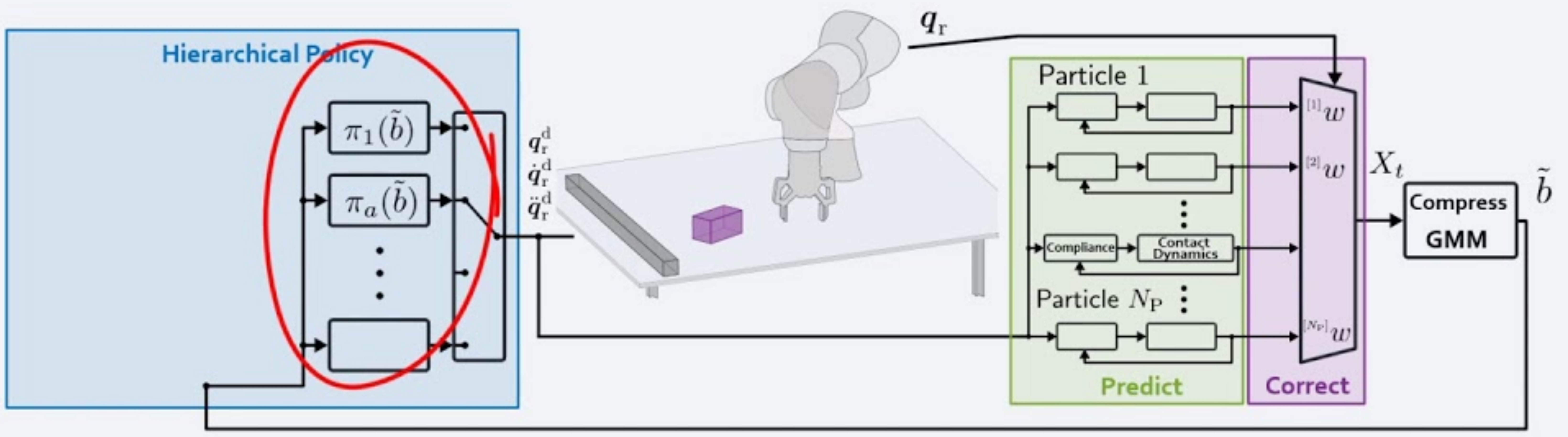


Adapt number of particles on the fly based on statistical approximation measure

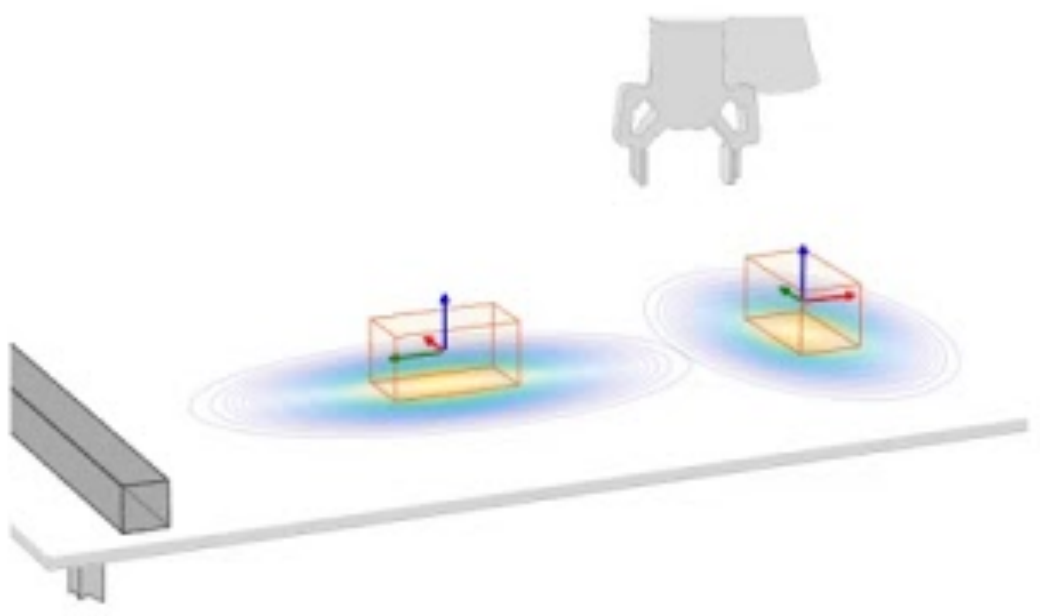
KLD-Sampling Laser



What if the localization is not about the robot?



Hierarchical Policy – Goal-Directed Low-Level Controllers



"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

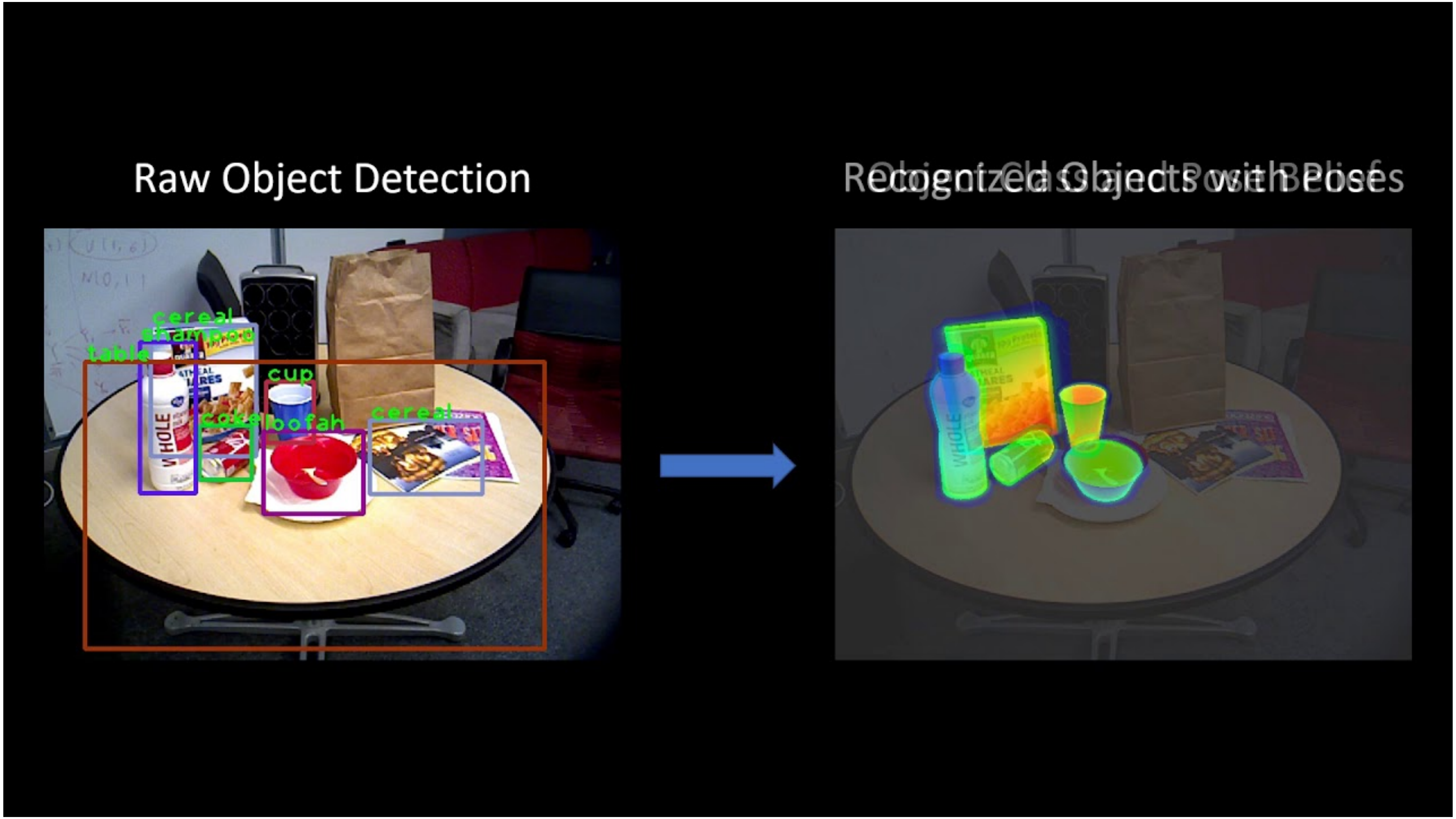
Zhiqiang Sui, Lingzhu Xiang, Odest Chadwicke Jenkins, Karthik Desingh,
"Goal-directed Robot Manipulation through Axiomatic Scene Estimation," IJRR 2017.

Physically Plausible Scene Estimation for Manipulation in Clutter

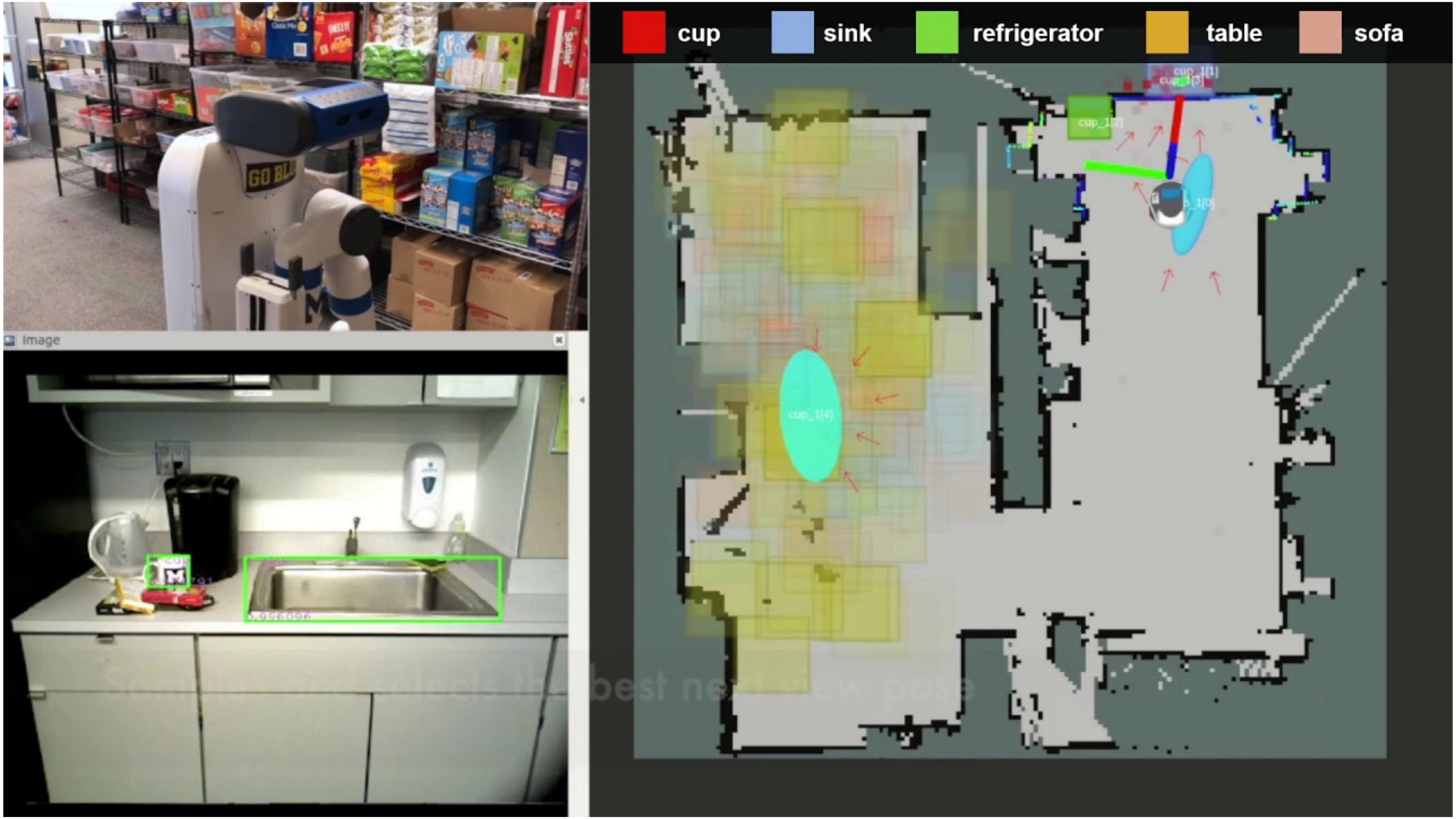
Karthik Desingh[1], Odest Chadwicke Jenkins[1], Lionel Reveret[2], Zhiqiang Sui[1]

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

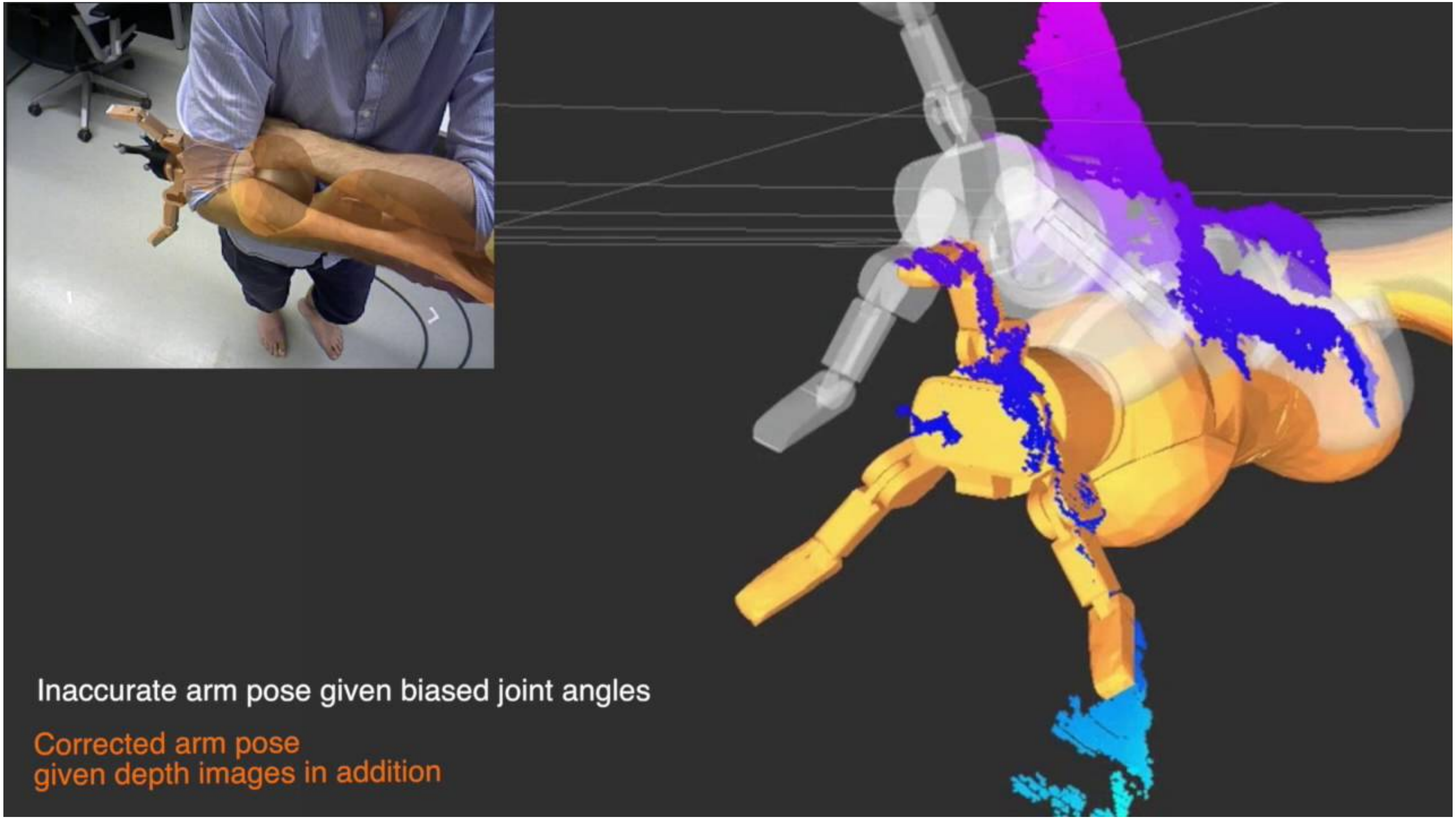
Karthik Desingh, Odest Chadwicke Jenkins, Lionel Reveret, Zhiqiang Sui, "Physically Plausible Scene Estimation for Manipulation in Clutter," Humanoids 2016.



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.

Karthik Desingh, Shiyang Lu, Anthony Opipari, Odest Chadwicke Jenkins, "Efficient Nonparametric Belief Propagation for Pose Estimation and Manipulation of Articulated Objects," Published: Science Robotics Journal May 2019

Next Lecture:
Mapping

Talk to me about your final project ideas!

Book your P7 lab sessions ASAP

See the post on Edstem