Disclaimer

These slides are intended as presentation aids for the lecture. They contain information that would otherwise be to difficult or time-consuming to reproduce on the board. But they are incomplete, not self-explanatory, and are not always used in the order they appear in this presentation. As a result, these slides should not be used as a script for this course. I recommend you take notes during class, maybe on the slides themselves. It has been shown that taking notes improves learning success.

Reading for this set of slides

- Planning Algorithms (Steve LaValle)
  - 4 The Configuration Space (4.1 – 4.3)
  - 5 Sampling-based Motion Planning (5.1, 5.5, 5.6, also skim the remaining sections)
- Brendan Burns and Oliver Brock. Toward Optimal Configuration Space Sampling. Proceedings of Robotics: Science and Systems, pp. 105-112, 2005.

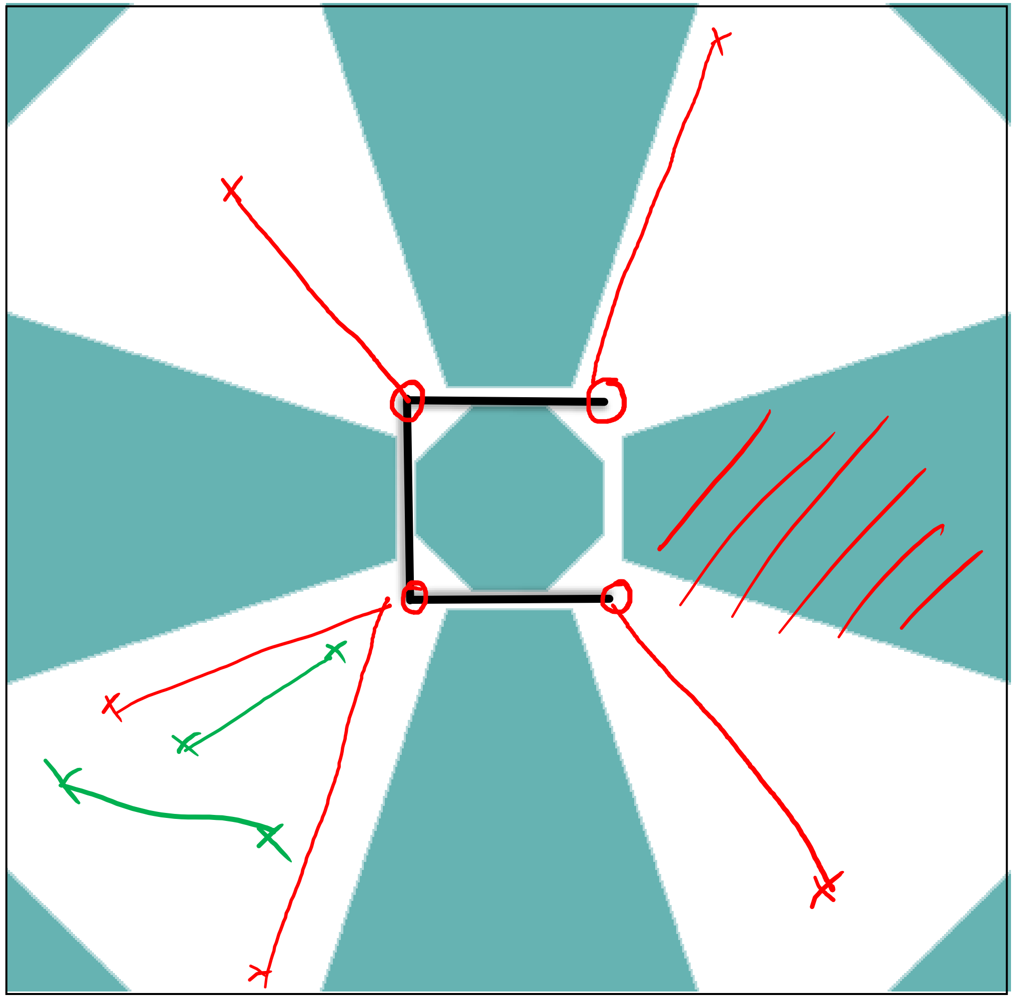
Please note that this set of slides is intended as support for the lecture, not as a stand-alone script. If you want to study for this course, please use these slides in conjunction with the indicated chapters in the text books. The textbooks are available online or in the TUB library (many copies that can be checked out for the entire semester. There are also some aspects of the lectures that will not be covered in the text books but can still be part of the homework or exam. For those It is important that you attend class or ask somebody about what was covered in class.

Robotics

PRM: Addressing the Narrow Passage Problem

TU Berlin
Oliver Brock

An Ideal Roadmap



RANDOM SAMPLING

↓

"CLEVER" SAMPLING

An Ideal Roadmap

- Any point in C-space should be connectable to the roadmap
- If there is a path between two points in C-space the roadmap should contain a path between them after they were connected to the roadmap

- How can such a roadmap be obtained through sampling?

Exploration versus Exploitation

RANDOM

Exploration seeks **understanding of the state space**, irrespective of a particular task. In motion planning, the process **exploration** seeks to understand the connectivity of the configuration space, irrespective of solving a particular motion planning problem.

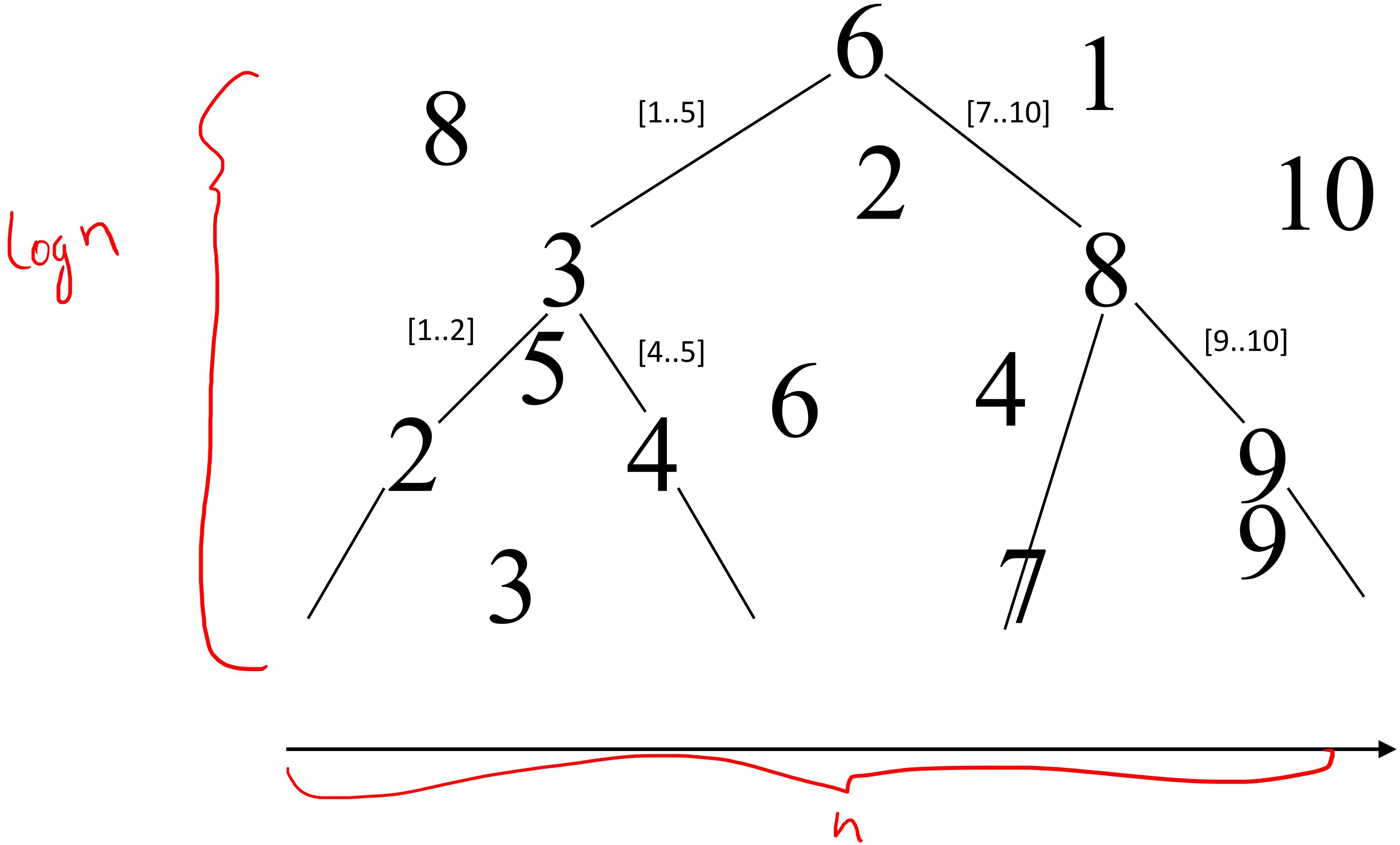
PRM

Guided exploration seeks **efficient understanding of the state space**, irrespective a particular task, by **leveraging available information**.

REFINEMENT
(STAGE 2 OF PRMs)

POTENTIAL FIELD APPROACH

Exploitation strives to **accomplish a particular task** as **efficiently as possible** by **leveraging available information**. In motion planning, **exploitation** seeks a valid path for a **particular task**, based on available information.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1
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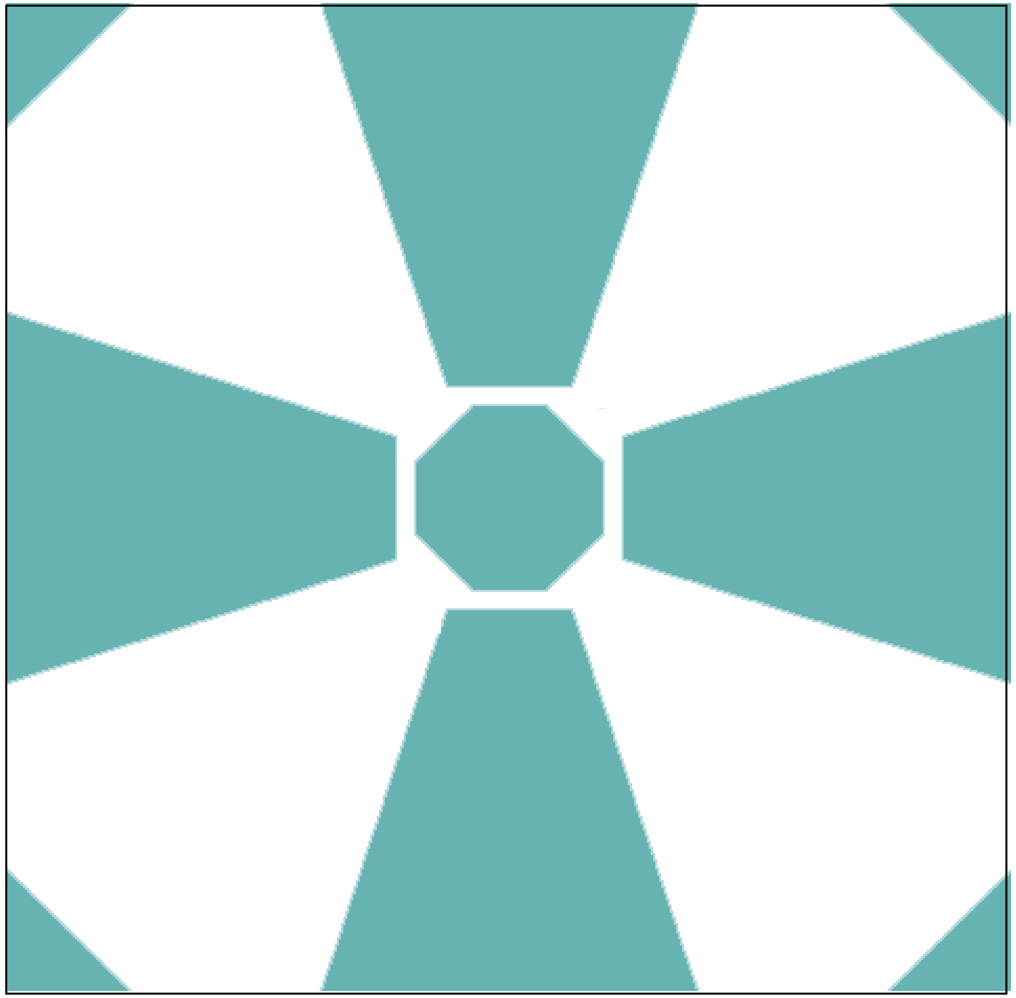
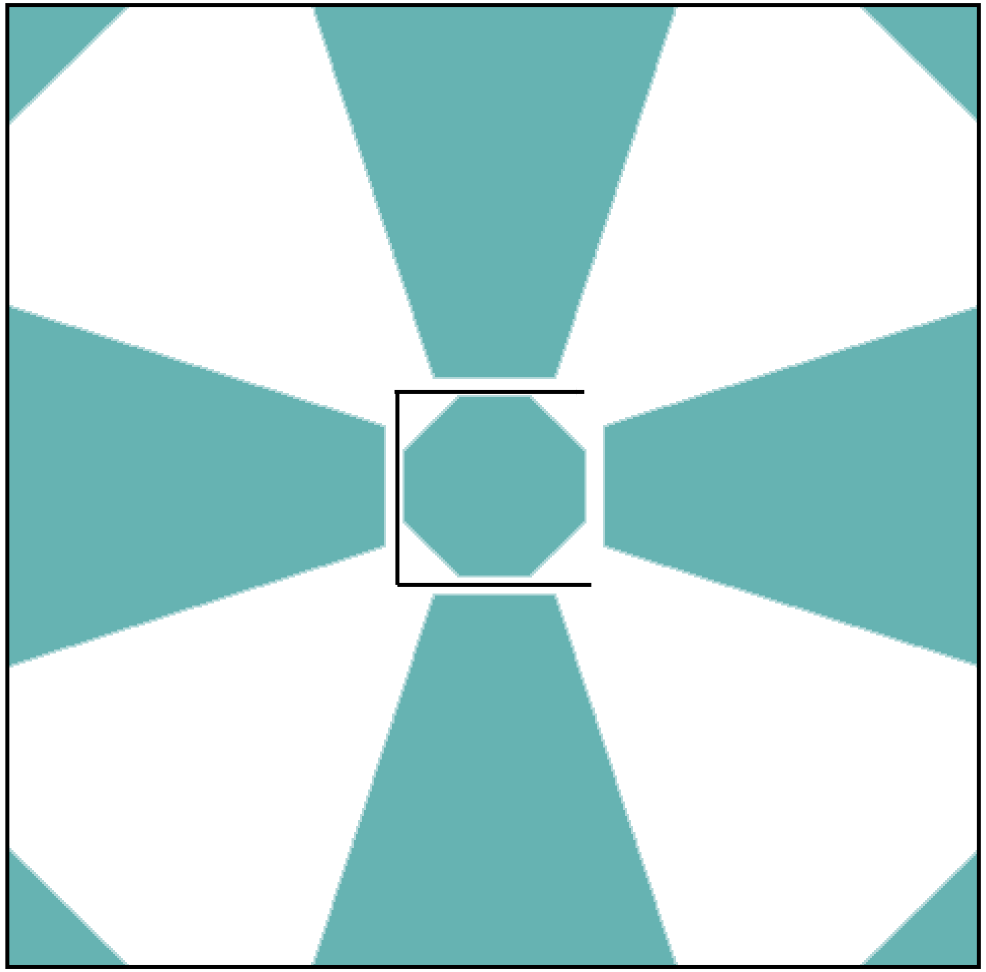
log n
n

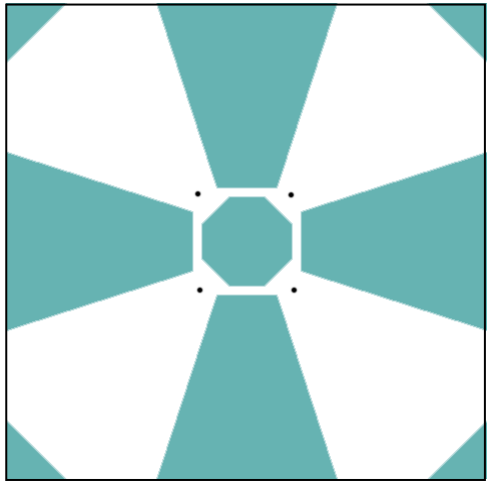
Perfect Sampling



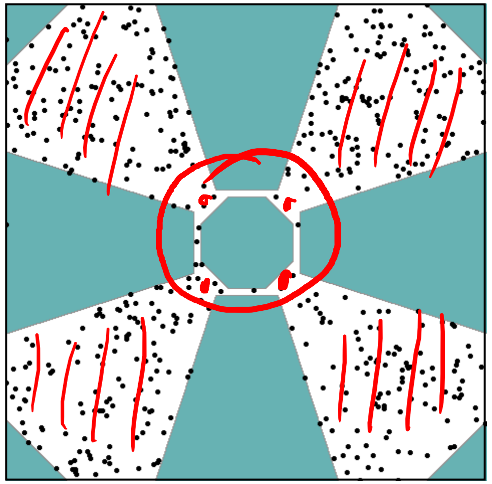
Perfect Roadmap



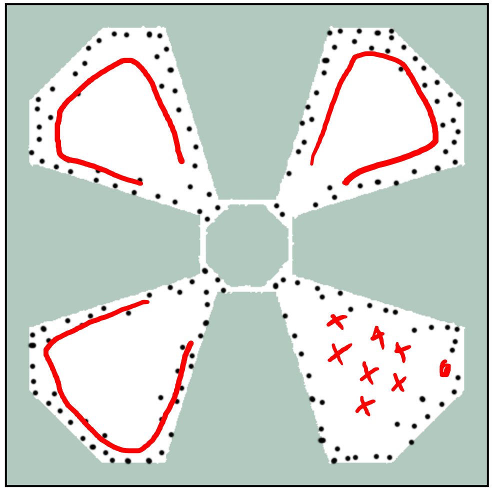
Different Sampling Strategies



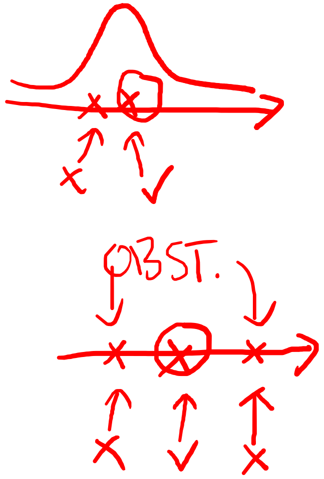
ideal

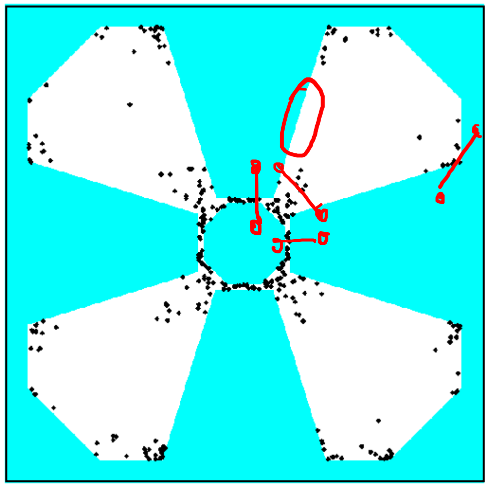


uniform

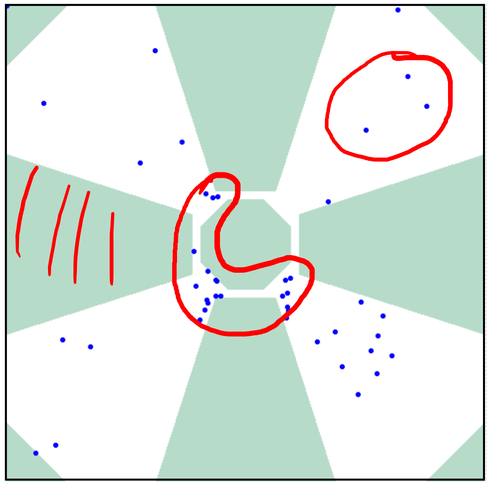


Gaussian





bridge



utility

?

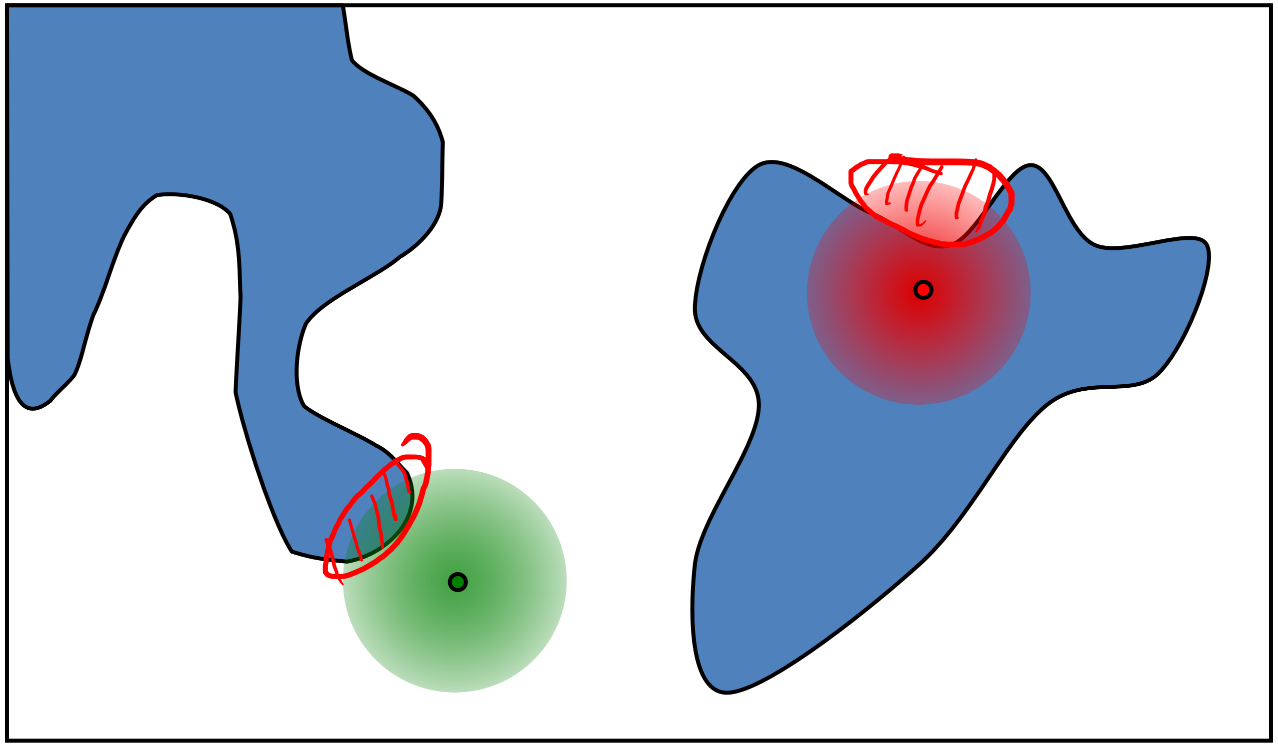
Key to Good Sampling: Exploiting Structure

INFORMATION

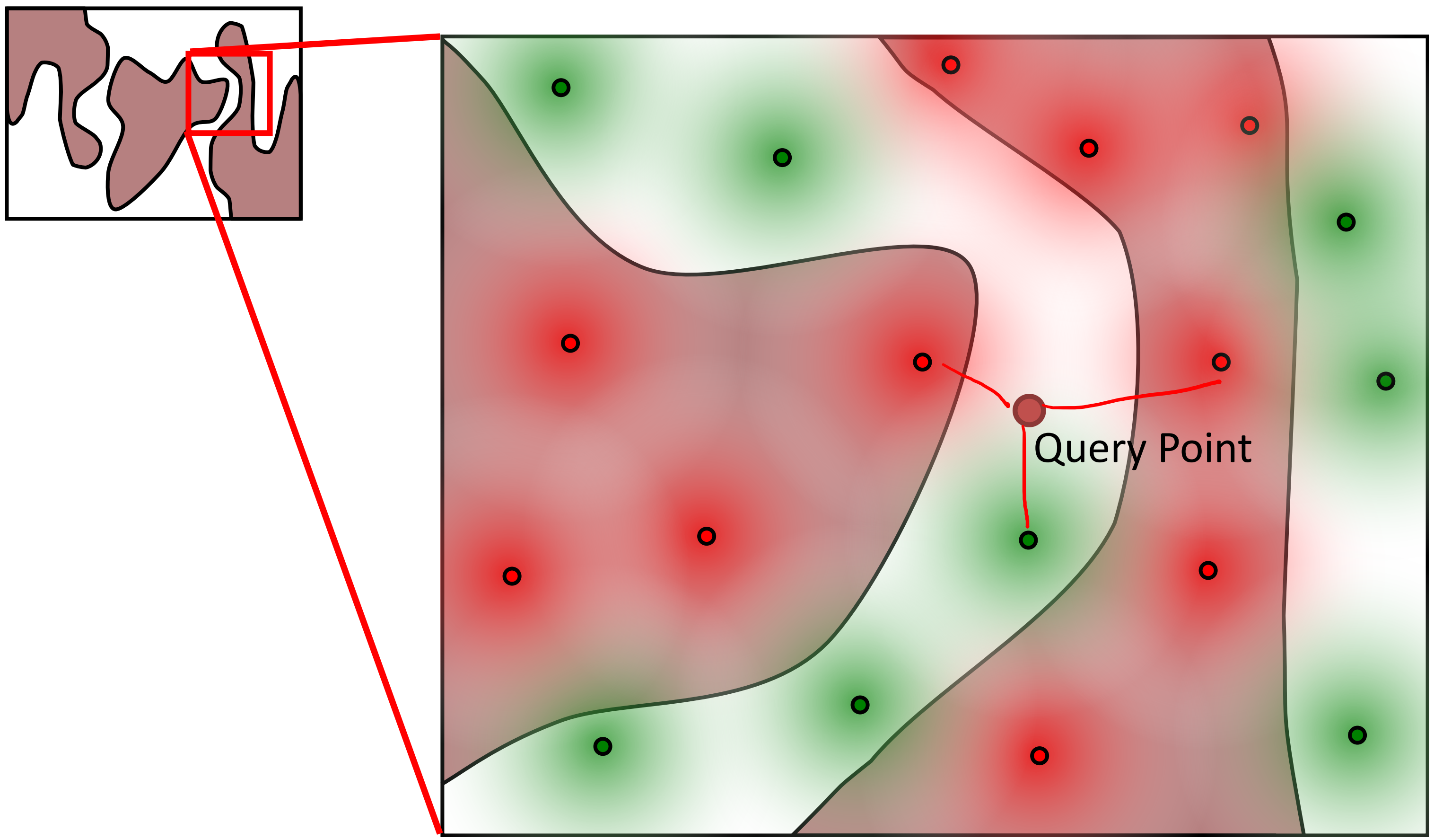
- *Identify* underlying structure ✓
- *Represent* information about structure ✓
- *Exploit* information ✓
- *Structure* can come from
  - sampling ✓
  - problem description ✓

Learning Structure through Sampling

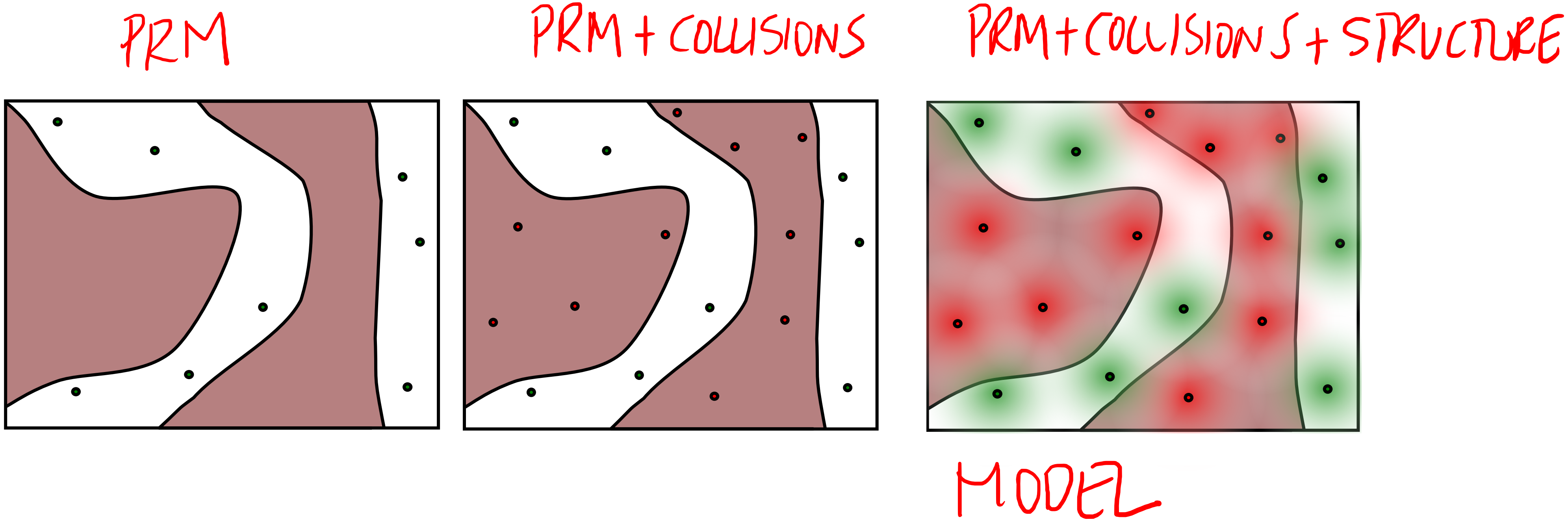
A non-parametric model of C-space



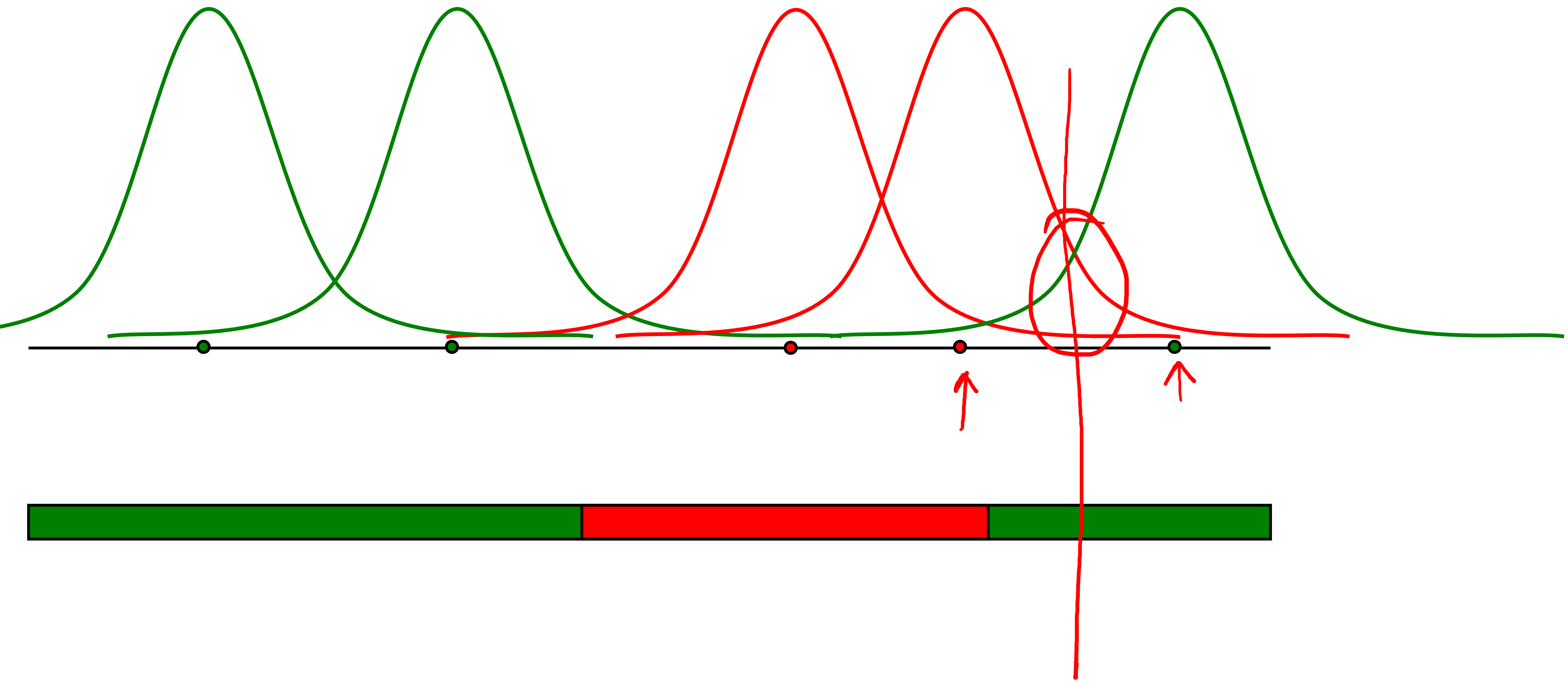
Building a Model of Configuration Space



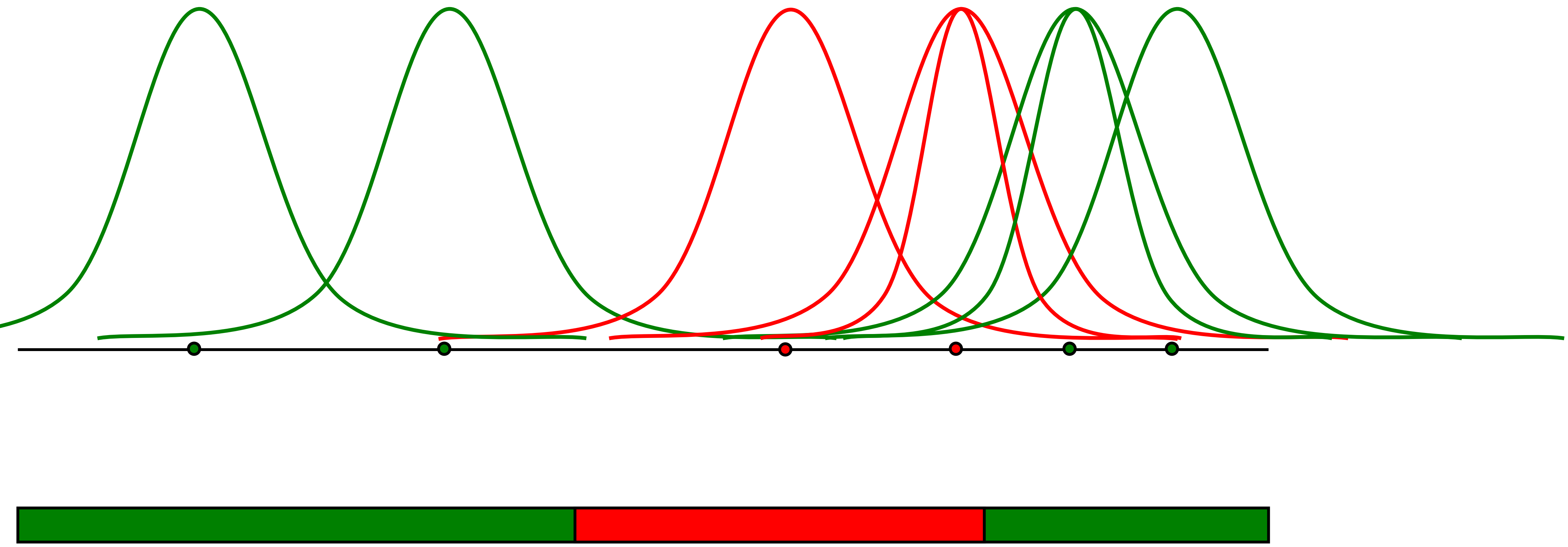
Comparison of Information Content



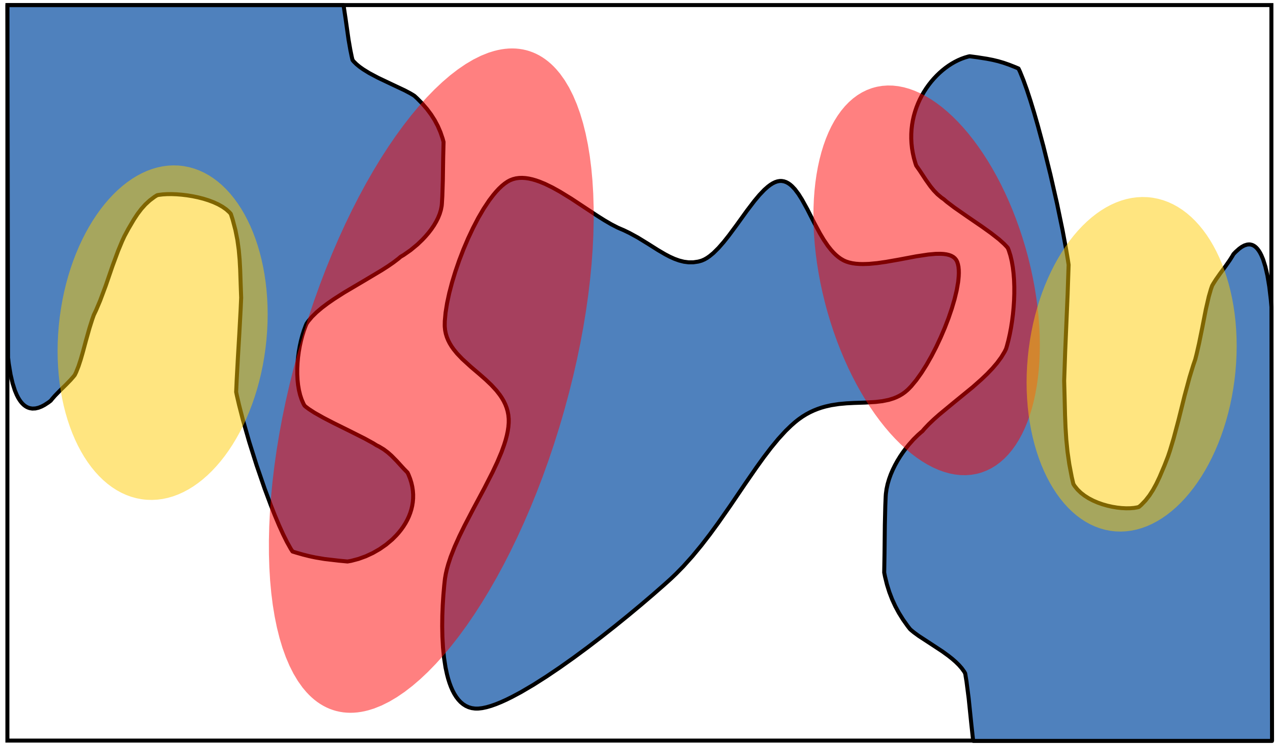
1D Non-Parametric Model



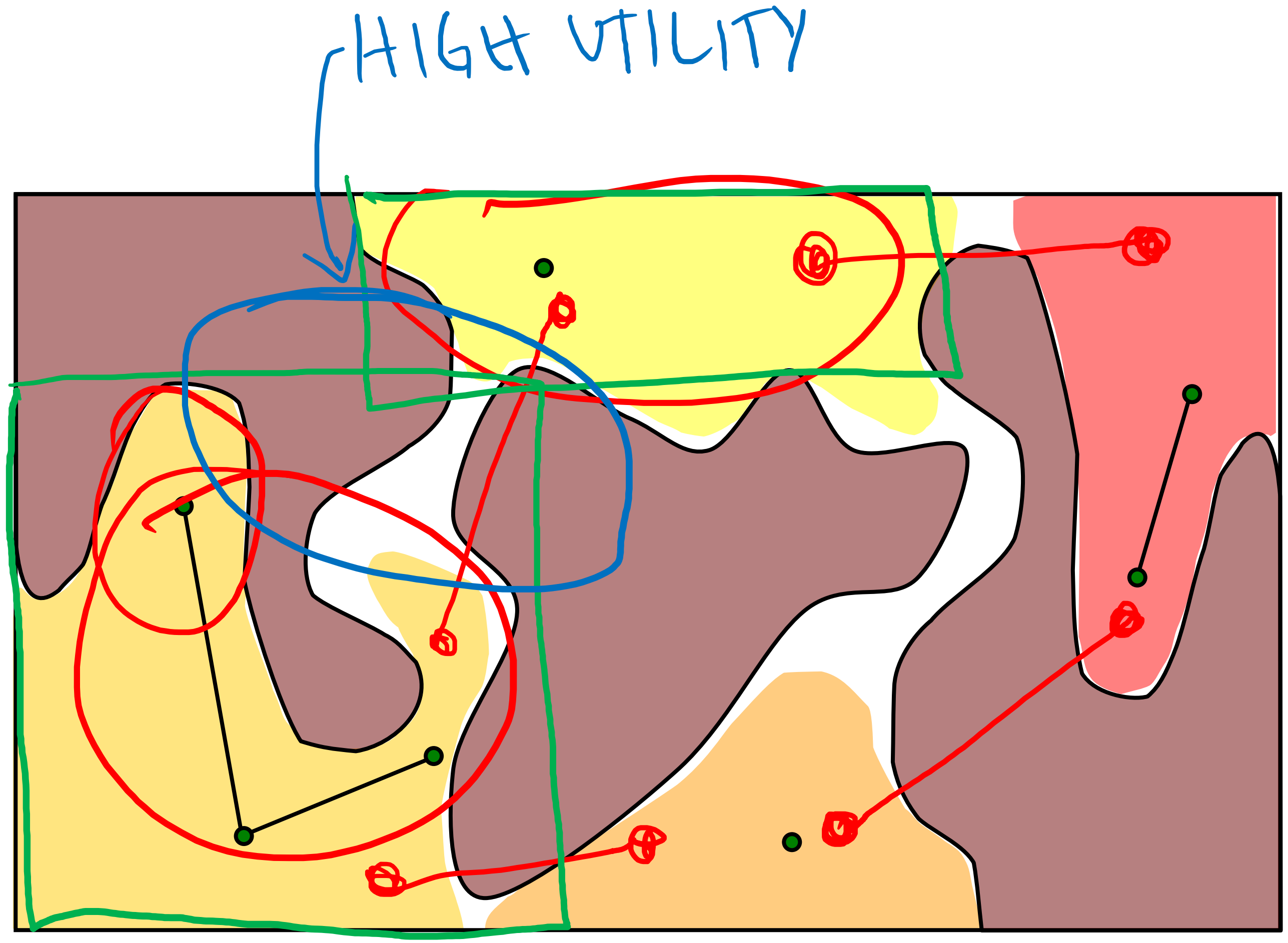
Sampling based on High Variance



High Model Variance



Estimating Utility



Expected Utility

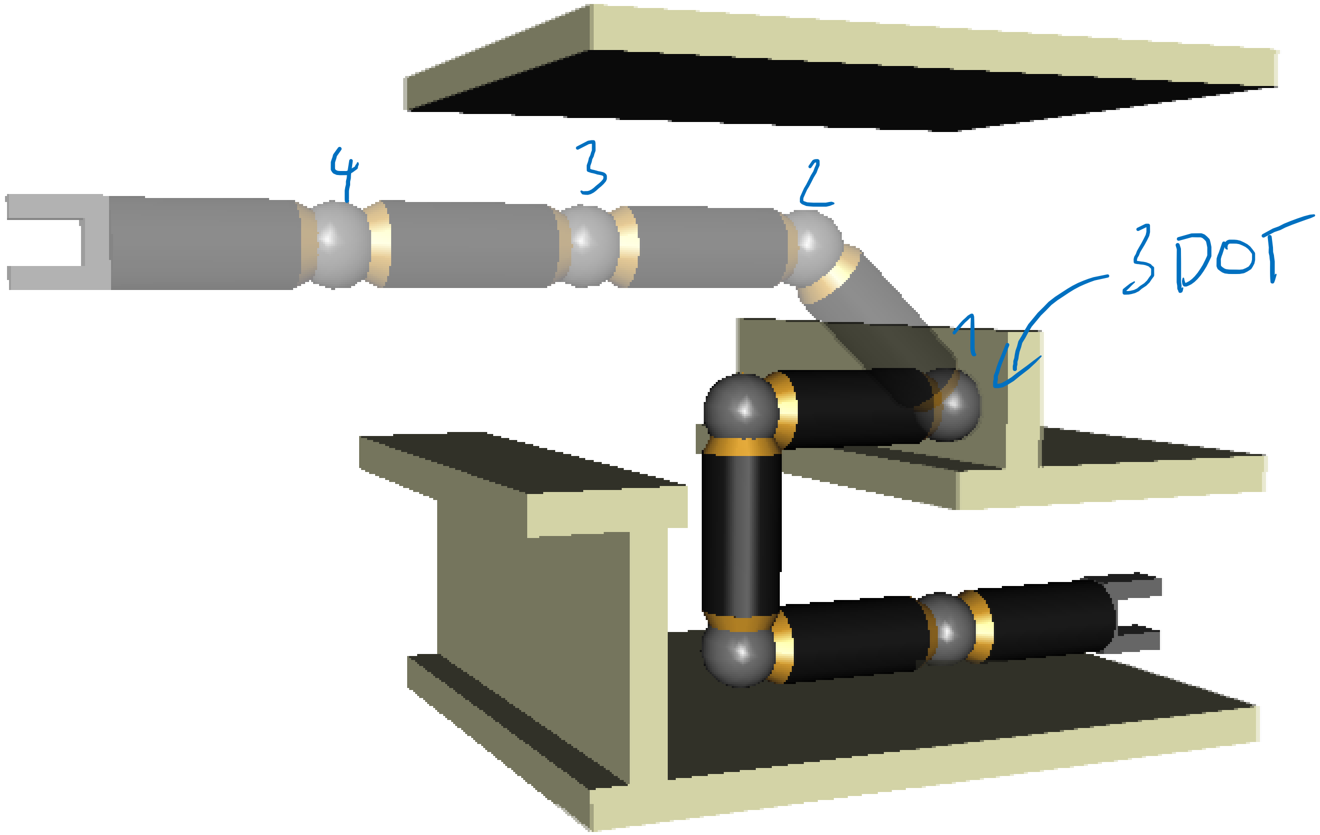
RANDOM !

NON-PARAMETRIC
MODEL OF C-SPACE

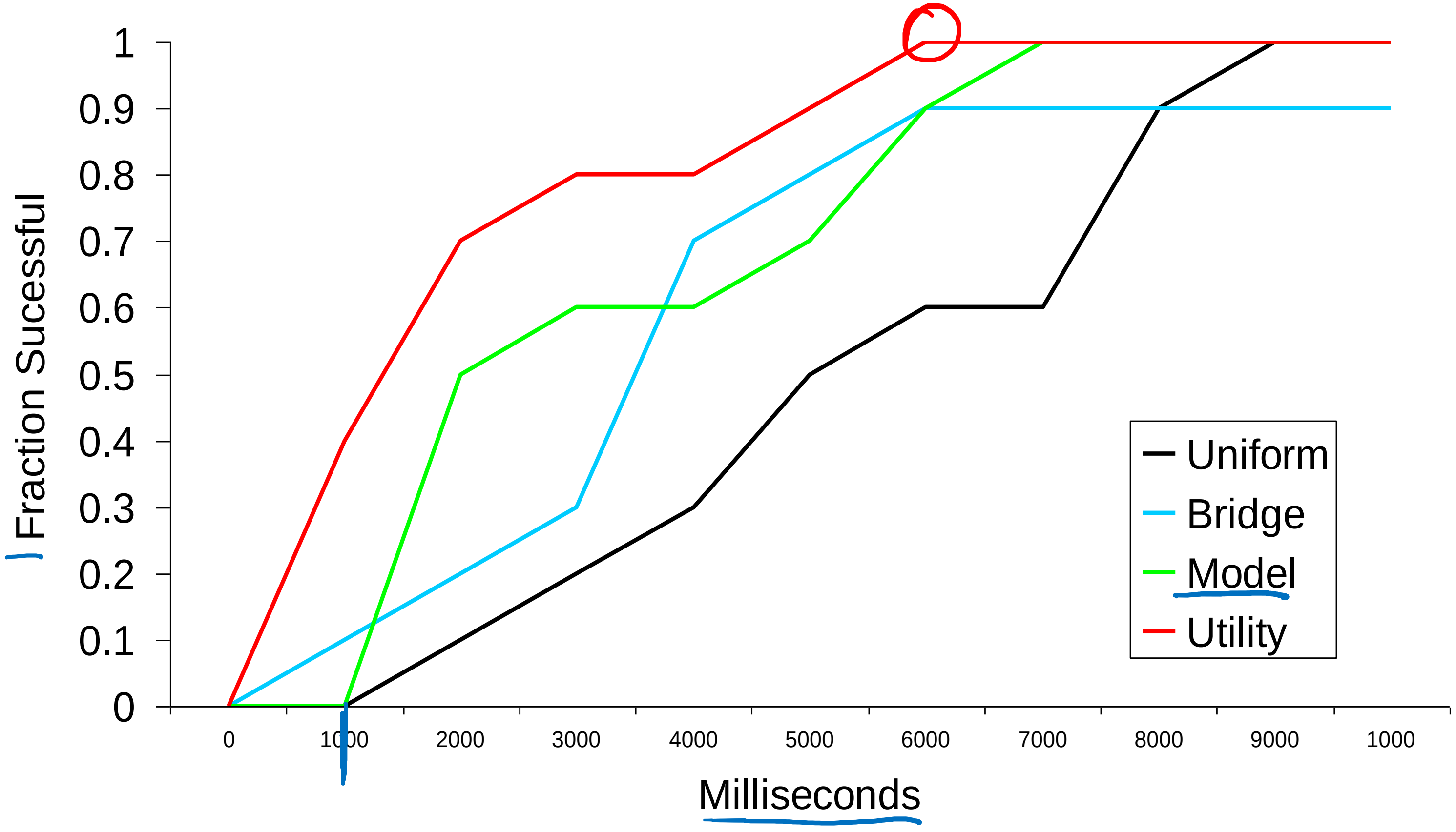
$$E[U(q \mid M)] = \sum_{i \in \{0,1\}} \overbrace{\underbrace{P(q = i \mid M)}_{\text{MODEL}}}^{\text{Instance}} \cdot \underbrace{U(q = i \mid M)}_{\text{Domain}}$$

q MAXIMIZES

Experimental Environment

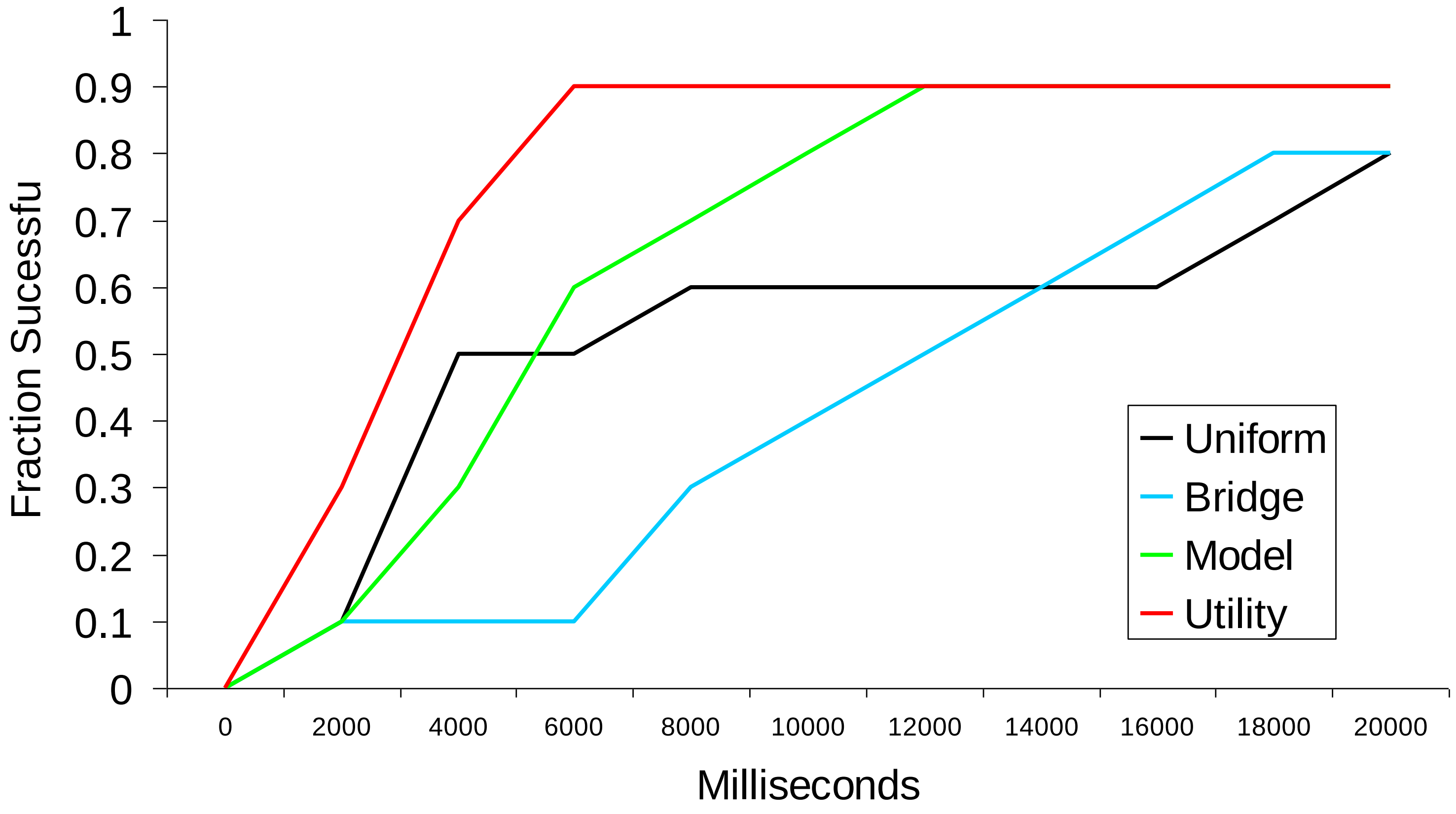


Motion Planning 9-DOF

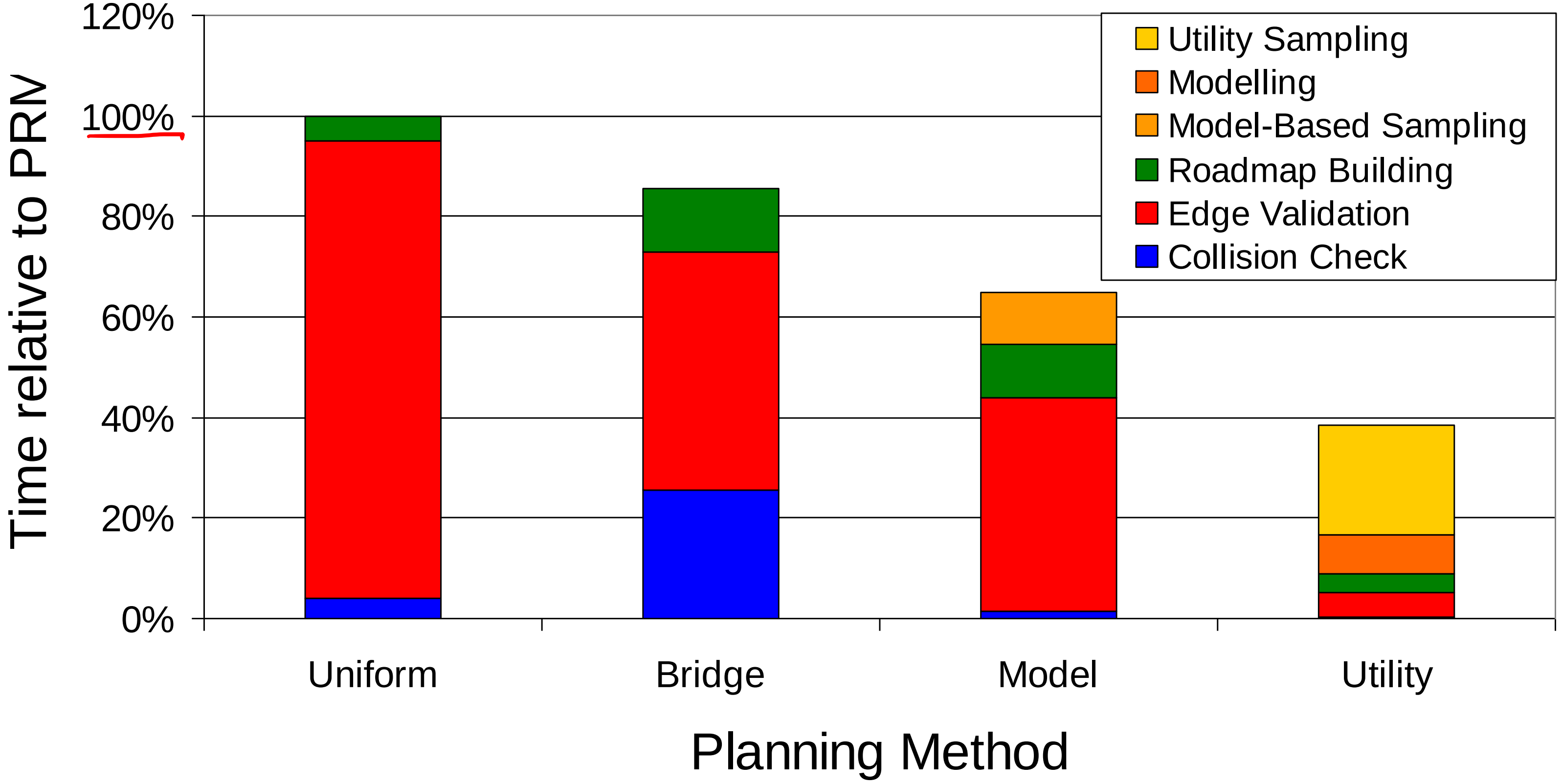


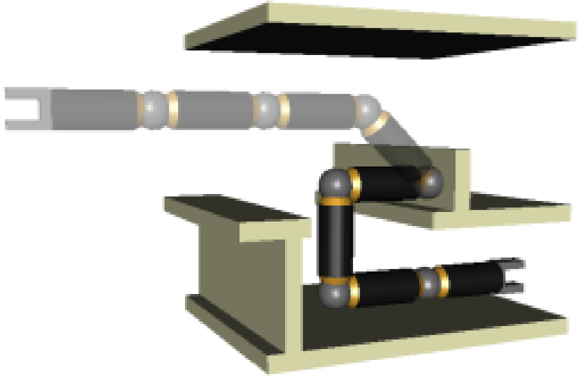
FASTER?

Motion Planning 12-DOF



Motion Planning 9 DOF





Motion Planning 12 DOF