A Particle Swarm Optimization Sampler for Probabilistic Roadmap Motion Planning

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CS 633 - Computational Geometry - Fall 2008

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Background Probabilistic Roadmap Motion Planning Particle Swarm Optimization

Implementation Fitness Function Fitness Function, Round 2

Summary Results Conclusion

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Improving PRMP

- ► Key Idea: Estimate C_{free}
- Probabilistic Motion Planning
 - Uninformed Sampling
 - Model Aware
- ► The Narrow Passage Problem
 - Uniform Sampling sucks
 - ► Gaussian Sampling/Bridge-Test sucks *less*
- Population Based Search to the rescue!

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Particle Swarm Optimization

Implementation

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Outline

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Why Particle Swarm Optimization

- Benefits of PSO
 - ► Simple to set up
 - Lots of parameters to tweak
- Drawbacks of PSO
 - Hard to adapt to non-metric problem domains
 - Lots of parameters to tweak

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What is Particle Swarm Optimization

- ► Key idea: A set of **particles** moving in a **space** according to their **fitness**
 - Particles: $X = \{\mathbf{x_i} \in \mathbb{R}^m, i = 1, ..., n\}$
 - Velocities: $V = \{\mathbf{v_i} \in \mathbb{R}^m, i = 1, ..., n\}$
 - Fitness function: $f : \mathbb{R}^m \to \mathbb{R}$
- ► Things that affect a particle's velocity:
 - Current fitness
 - Personal best $(\hat{x_i})$
 - ► Neighborhood best (n̂i)
 - Random noise

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Particle Swarm Optimization

What is Particle Swarm Optimization

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The Algorithm:

Initialize X, V, personal and neighborhood bests

while not done do

foreach \mathbf{x}_i \in X do

\begin{vmatrix} \mathbf{x}_i \leftarrow \mathbf{x}_i + \mathbf{v}_i \\ \text{Create two random vectors } \mathbf{r}_1, \mathbf{r}_2 \\ \mathbf{v}_i \leftarrow \omega \mathbf{v}_i + c_1 \mathbf{r}_1 \circ (\hat{\mathbf{x}}_i - \mathbf{x}_i) + c_2 \mathbf{r}_2 \circ (\hat{\mathbf{n}}_i - \mathbf{x}_i) \\ \text{Calculate } f(\mathbf{x}_i) \text{ and update } \hat{\mathbf{x}}_i \text{ and } \hat{\mathbf{n}}_i \\ \text{end} \end{vmatrix}
```

end

- \blacktriangleright Select the components of r_1 and r_2 uniformly from [0,1]
- ω is the **momentum** coefficient
- ▶ *c*₁ and *c*₂ are weights
- ▶ "○" is Hadamard matrix multiplication

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Fitness Function

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Fitness Function

Keeping Track of Obstacles

- Key idea: map the **boundary** between C_{free} and C_{forb}
- Keep a list of known collisions
- Try to estimate the expected probability of collision
- Define the probability p_{ci}(x_j) that x_j will collide with the obstacle c_i collided with.

Background	Implementation
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Fitness Function	

Fitness Function: Visualization

• One such function: $f(x) = w(\frac{1}{1+e^{-\sum_c pc_i(x_j)}} - 0.5)$



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Summary

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Fitness Function, Round 2

Finding Narrow Passages

- Key idea: borrow techniques from the gaussian and bridge-test samplers, and optimize
- Use sub-samples to test if a configuration is in a narrow passage
- f(x) = average number of sub-samples that pass

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Results		

Results

What?! NONE?!

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Conclusion



- ▶ PSO can be used for PRMP (should it?)
- Parameter tweaking sucks
- Dynamic fitness functions are *bad*
- Could be applied to RRT?

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