# Rapidly-Exploring Random Trees (RRT)





(a) Technical Report 98-11

discussed. To date, we have successfully applied RRTs to holonomic, notholonomic, and binodynamic planning problems of up to tarire degrees of freedom.

1 Introduction

Over the past decade, several randomized approaches have been proposed and successfully applied to the gra-

(b) S. M. LaValle

Figure: Originally published on Oct. 1998 by S. M. LaValle.

## RRT Construction Algorithm

```
GENERATE_RRT(x_{init}, K, \Delta t)
       \mathcal{T}.\operatorname{init}(x_{init});
       for k = 1 to K do
  3
              x_{rand} \leftarrow \text{RANDOM\_STATE}();
              x_{near} \leftarrow \text{NEAREST\_NEIGHBOR}(x_{rand}, \mathcal{T});
              u \leftarrow \text{SELECT\_INPUT}(x_{rand}, x_{near});
  5
              x_{new} \leftarrow \text{NEW\_STATE}(x_{near}, u, \Delta t);
  6
              \mathcal{T}.add_vertex(x_{new});
              \mathcal{T}.add_edge(x_{near}, x_{new}, u);
        Return \mathcal{T}
```

Figure: Source [LaValle, 1998]

### **Properties**

- Relative simplicity;
- Bias toward unexplored space:
  - State selection related to Voronoi region size;
- Probabilistic completeness:
  - Usually insufficient alone; randomness leads to zigzags;
- Input selection:
  - Movement constraints;
  - Metric effects on performance.

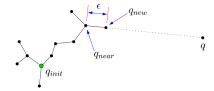


Figure: Source [Kuffner & LaValle, 2000]

#### **Variants**

- Nonholonomic constraints on tree growth:
  - Articulated-body;
  - Rigid-body.
  - Steering;
- Obstacles:
  - Selection of random free states;
  - Transition validity for new states.
- Bias toward goal:
  - Avoids "bad luck":
  - Needs to be slight.
- BiRRT, RRT\*, DO-RRT, BI<sup>2</sup>RRT\*, I-RRT-C ...

### References



S. M. Lavalle, Rapidly-Exploring Random Trees: A New Tool for Path Planning, 1998, [Online]. Available: http://msl.cs.uiuc.edu/~lavalle/papers/Lav98c.pdf



J. J. Kuffner and S. M. LaValle, "RRT-Connect: An Efficient Approach to Single-Query Path Planning," Proceedings IEEE International Conference on Robotics and Automation, pp 995–1001, 2000,