16782 HW 2

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Performance Comparison

Planner	Average Planning Time	Success Rate	Vertices Generated	Path Quality (cost)
RRT	0.01632449687	100%	89.59090909	11.08592216
RRT Connect	0.003267656472	100%	20.95454545	10.24297351
RRT Star	0.3935189818	100%	880.8181818	9.210821838
PRM	0.05129707642	100%	333.1363636	10.83494827

Table comparing the performance of the planners

The table above compares each planner based on the average values of: planning time, successrate, vertices generated, and path qualities. The values for each of the 20 runs and average calculation for each planner is present at the end of this report, in the appendix.

From the table above, we can clearly see that the planner which takes the least amount of time and expands the least number of nodes is RRT Connect, which is in line with the theory, since the start and goal trees expand bidirectionally toward each other. We can also see that the largest planning time and number of nodes expanded is RRT star, since we are running RRT over and over again. PRM is a close second with time and nodes, since it samples the entire workspace before running a search to find the best path.

With the right parameters, all four planners are able to make a plan for the 20 randomly generated start and end configurations. Looking at the quality of paths qualitatively, the paths by RRT Star produce the smoothest, least-jumpy motion. If we define the quality to be the cost of the path, all four planners have similar results, with RRT Star having the lowest cost. Which again, is in line with the theory, since RRT rewires the tree with every iteration, to optimize the path.

Questions

What planner do you think is the most suitable for the environment and why?

Given the simple nature of this environment, RRT connect is the most suitable for this environment. There are no rapidly moving obstacles in the scene which would require fast replanning, so it is acceptable for the planner to take longer to plan. Moreover, the motion with this planner is smoother, and hence is better for the robot, since it wont stress the joints.

What issues does the planner still have?

The planner takes much longer to plan as compared to the other RRT implementations. While significantly better than its counterparts, the resultant trajectory is still not smooth, and it jumps due to the random sampling of the space, giving unpredictable trajectories.

How do you think you can improve that planner?

I would improve this planner by biasing the tree expansion toward the goal to get smoother, predictable paths. Further, I would define a metric for path smoothness for the end effector, and stop rewiring after a certain quality is reached, thereby reducing the planning time and number of expanded nodes.

Appendix

RRT

mapName	problemIndex	numSteps	cost	timespent	success	nodes expanded
map1.txt	0	16	17.95935921	0.01292245393	TRUE	216
map2.txt	1	8	5.8786346	0.002794484142	TRUE	11
map2.txt	2	8	7.617559	0.003071880899	TRUE	19
map2.txt	3	8	7.089002229	0.002751521999	TRUE	17
map2.txt	4	10	10.82252471	0.002773358952	TRUE	21
map2.txt	5	9	8.707650614	0.002666769084	TRUE	25
map2.txt	6	7	5.723590614	0.002884139074	TRUE	14
map2.txt	7	24	28.63480241	0.02206990286	TRUE	227
map2.txt	8	11	11.98431286	0.007918386022	TRUE	118
map2.txt	9	13	13.60837983	0.003807016183	TRUE	43
map2.txt	10	7	6.930410307	0.003028769046	TRUE	18
map2.txt	11	6	5.035939514	0.003385273973	TRUE	13
map2.txt	12	8	7.301000614	0.008037427906	TRUE	85
map2.txt	13	12	12.36463631	0.005916024791	TRUE	74
map2.txt	14	17	18.83885451	0.005150350975	TRUE	68
map2.txt	15	13	13.25896502	0.003606829094	TRUE	23
map2.txt	16	5	4.244849	0.002477910835	TRUE	11
map2.txt	17	14	16.05320623	0.246310455	TRUE	772
map2.txt	18	13	12.80109461	0.002681300044	TRUE	34
map2.txt	19	11	11.55944203	0.009296764154	TRUE	121
map2.txt	20	7	5.432751922	0.002766273217	TRUE	13
map2.txt	21	11	12.04332139	0.002821638947	TRUE	28
	Average	10.81818182	11.08592216	0.01632449687		89.59090909

Result values for each run

RRT Connect

mapName	problemIndex	numSteps	cost	timespent	success	nodes expanded
map1.txt	0	20	18.37461311	0.002624379937	TRUE	45
map2.txt	1	7	4.750375	0.003378669033	TRUE	7
map2.txt	2	9	6.535644229	0.002503667027	TRUE	9
map2.txt	3	8	6.134457614	0.002687396016	TRUE	8
map2.txt	4	10	8.517575322	0.00310256402	TRUE	10
map2.txt	5	9	6.281293386	0.002550398931	TRUE	9
map2.txt	6	8	5.793608	0.003231415059	TRUE	8
map2.txt	7	15	12.94137021	0.002815912943	TRUE	26
map2.txt	8	13	11.43791241	0.003177551087	TRUE	23
map2.txt	9	20	17.30428801	0.003469118848	TRUE	37
map2.txt	10	10	7.439477693	0.002481361153	TRUE	16
map2.txt	11	9	6.867679714	0.002788340906	TRUE	11
map2.txt	12	18	14.85513461	0.00286150421	TRUE	32
map2.txt	13	13	11.24073769	0.002706727944	TRUE	33
map2.txt	14	12	10.53622123	0.002845723182	TRUE	17
map2.txt	15	12	10.23396331	0.002563792048	TRUE	14
map2.txt	16	5	3.724643	0.003824808169	TRUE	5
map2.txt	17	17	15.17022892	0.006146766944	TRUE	50
map2.txt	18	17	14.96007838	0.002860246925	TRUE	23
map2.txt	19	23	19.83687139	0.003692290979	TRUE	62
map2.txt	20	6	4.268826693	0.003057091963	TRUE	6
map2.txt	21	10	8.140417386	0.006518715061	TRUE	10
	Average	12.31818182	10.24297351	0.003267656472		20.95454545

Result values for each run

RRT Star

mapName	problemIndex	numSteps	cost	timespent	success	nodes expanded
map1.txt	0	7	11.70453671	0.534375716	TRUE	1179
map2.txt	1	9	4.319683	0.41678311	TRUE	1409
map2.txt	2	6	7.505138386	0.3904671969	TRUE	844
map2.txt	3	6	6.983487614	0.3852108889	TRUE	840
map2.txt	4	6	9.377688093	0.383349902	TRUE	840
map2.txt	5	5	6.049096614	0.3887665921	TRUE	848
map2.txt	6	5	4.886650614	0.3885298481	TRUE	848
map2.txt	7	5	5.026743814	0.3896458389	TRUE	843
map2.txt	8	12	21.98534707	0.3838095469	TRUE	837
map2.txt	9	7	11.35780661	0.3811490452	TRUE	838
map2.txt	10	7	7.950480922	0.396031636	TRUE	837
map2.txt	11	5	7.062922286	0.3940590119	TRUE	841
map2.txt	12	9	15.42230131	0.383562	TRUE	843
map2.txt	13	7	10.573727	0.376116157	TRUE	835
map2.txt	14	9	16.81644554	0.3812152171	TRUE	842
map2.txt	15	9	10.71270371	0.3680633558	TRUE	815
map2.txt	16	3	3.129575	0.3834417192	TRUE	850
map2.txt	17	6	10.75902631	0.3857191731	TRUE	844
map2.txt	18	6	10.89129392	0.4108564251	TRUE	841
map2.txt	19	7	9.590202614	0.3764493549	TRUE	832
map2.txt	20	4	3.873977307	0.3774513709	TRUE	830
map2.txt	21	5	6.659246	0.3823644931	TRUE	842
	Average	6.590909091	9.210821838	0.3935189818		880.8181818

Result values for each run

PRM

mapName	problemIndex	numSteps	cost	timespent	success	nodes expanded
map1.txt	0	7	12.783207	0.09506857512	TRUE	494
map2.txt	1	9	5.077185	0.1742350732	TRUE	675
map2.txt	2	6	12.601097	0.04099058104	TRUE	308
map2.txt	3	5	6.559161	0.04101128993	TRUE	308
map2.txt	4	7	13.3638174	0.04031573795	TRUE	308
map2.txt	5	5	8.670678	0.04056075402	TRUE	308
map2.txt	6	6	11.26793061	0.05411448609	TRUE	308
map2.txt	7	4	8.385886214	0.04808163713	TRUE	308
map2.txt	8	5	10.66253846	0.04225976393	TRUE	308
map2.txt	9	7	15.79770123	0.04242371395	TRUE	308
map2.txt	10	4	7.292078307	0.04189364193	TRUE	308
map2.txt	11	5	9.476295714	0.04150958802	TRUE	308
map2.txt	12	8	12.55882461	0.04153529904	TRUE	308
map2.txt	13	7	12.01878831	0.04277600907	TRUE	308
map2.txt	14	7	15.94706131	0.04299129499	TRUE	308
map2.txt	15	8	17.66198661	0.04275045288	TRUE	308
map2.txt	16	4	5.186617	0.04305803101	TRUE	308
map2.txt	17	8	14.216913	0.04305766406	TRUE	308
map2.txt	18	7	11.00311261	0.04306148086	TRUE	308
map2.txt	19	5	9.381103214	0.04228674388	TRUE	308
map2.txt	20	5	7.279551307	0.04155967804	TRUE	308
map2.txt	21	6	11.177328	0.04299418512	TRUE	308
	Average	6.136363636	10.83494827	0.05129707642		333.1363636

Result values for each run