# Week3: Bidirectional RRT

Zhaoliang

# Works in week 3

1. Debugged my RRT algorithm
2. Developed bidirectional RRT algorithm/RRT connect
3. Introduction of different Motion Planning algorithms

# Bugs

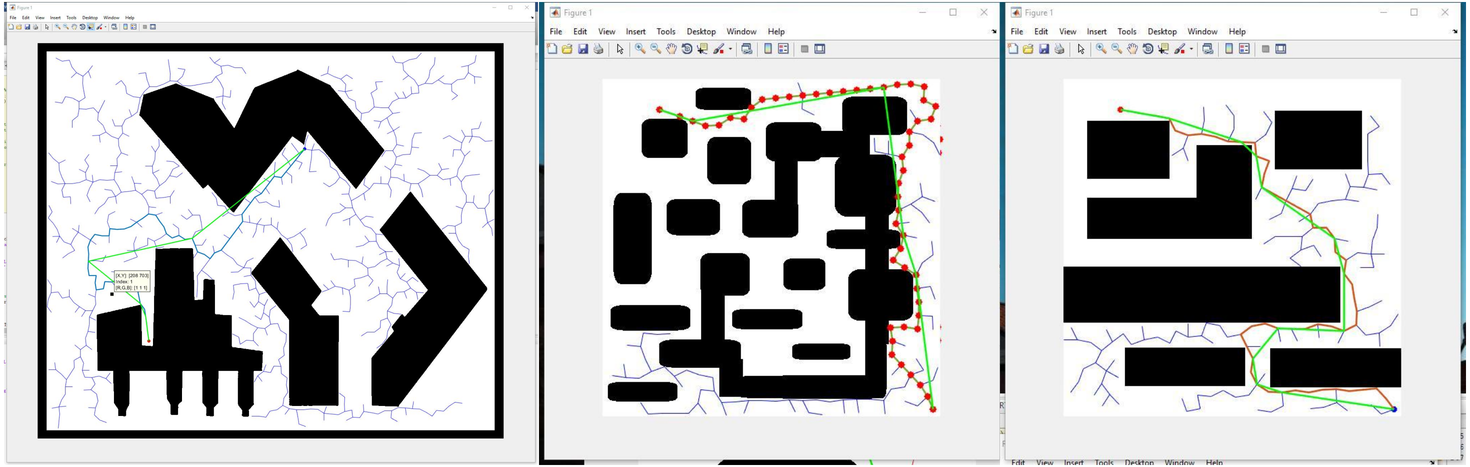
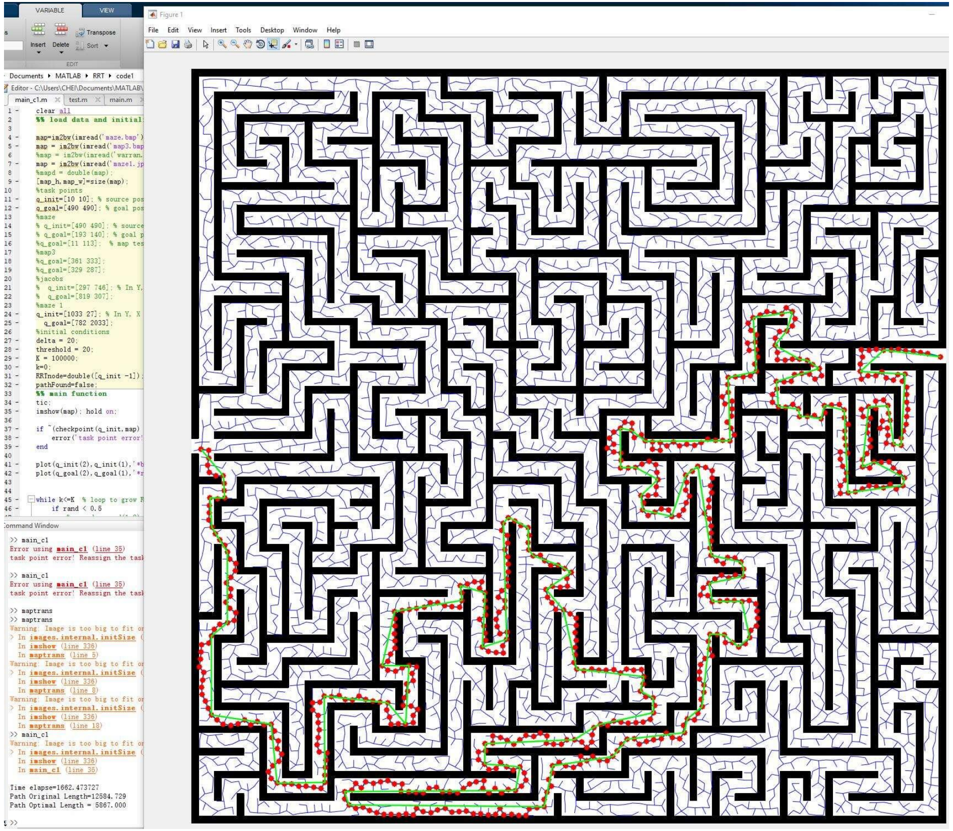


Figure 1
File Edit View Insert Tools Desktop Window Help
[X,Y]: [208 703]
Index: 1
[R,G,B]: [1 1 1]
Figure 1
File Edit View Insert Tools Desktop Window Help
Figure 1
File Edit View Insert Tools Desktop Window Help

Something wrong with my Path Optimization Function!

Turned out the collision detection conditions were not sufficient.

# Extreme Test



```
clear all
%% load data and initial

map=im2bw(imread('maze.bmp')
map = im2bw(imread('map3.bmp
%map = im2bw(imread('warran.
map = im2bw(imread('maze1.jp
%mapd = double(map);
[map_h,map_w]=size(map);
%task points
q_init=[10 10]; % source pos
q_goal=[490 490]; % goal pos
%maze
% q_init=[490 490]; % source
% q_goal=[193 140]; % goal p
%q_goal=[11 113];  % map tes
%map3
%q_goal=[361 333];
%q_goal=[329 287];
%jacobs
%  q_init=[297 746]; % In Y,
%  q_goal=[819 307];
%maze 1
q_init=[1033 27]; % In Y, X
  q_goal=[782 2033];
%initial conditions
delta = 20;
threshold = 20;
K = 100000;
k=0;
RRTnode=double([q_init -1]);
pathFound=false;
%% main function
tic;
imshow(map); hold on;

if ~(checkpoint(q_init,map)
    error('task point error!
end

plot(q_init(2),q_init(1),'*b
plot(q_goal(2),q_goal(1),'*r


while k<=K  % loop to grow R
    if rand < 0.5
```

```
>> main_c1
Error using main_c1 (line 35)
task point error! Reassign the task

>> main_c1
Error using main_c1 (line 35)
task point error! Reassign the task

>> maptrans
>> maptrans
Warning: Image is too big to fit or
> In images.internal.initSize (
  In imshow (line 336)
  In maptrans (line 5)
Warning: Image is too big to fit or
> In images.internal.initSize (
  In imshow (line 336)
  In maptrans (line 8)
Warning: Image is too big to fit or
> In images.internal.initSize (
  In imshow (line 336)
  In maptrans (line 18)
>> main_c1
Warning: Image is too big to fit or
> In images.internal.initSize (
  In imshow (line 336)
  In main_c1 (line 35)

Time elapse=1662.473727
Path Original Length=12584.729
Path Optimal Length = 5867.000

>>
```

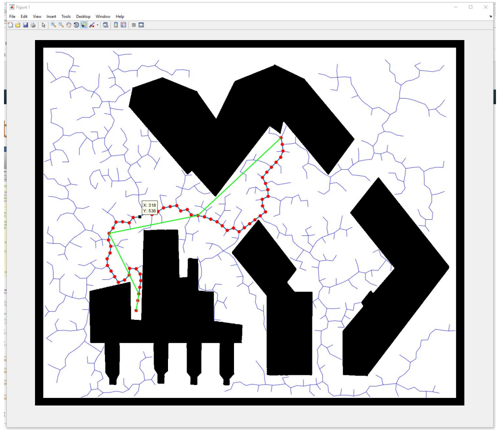
This map is so big (2024 * 2024) that it took 1662 s to finish processing.

Path optimization function works great!

Path length before optimized: 12564

Path length after optimized: 5867

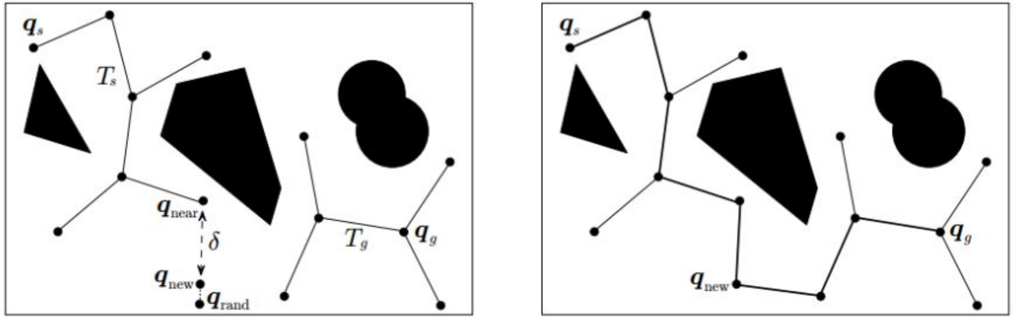
Previous:

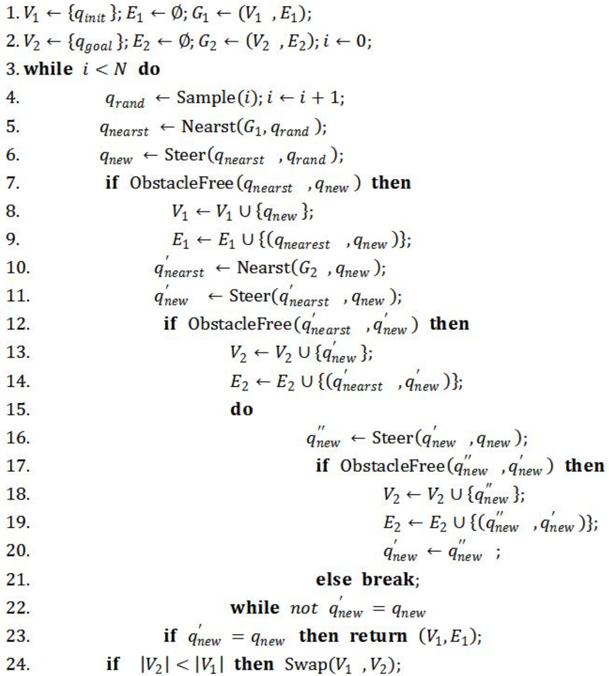


# Bidirectional RRT algorithm/RRT connect

Basic RRT only explores space from initial point.

Bidirectional RRT simultaneously  explores space from both initial and goal points.



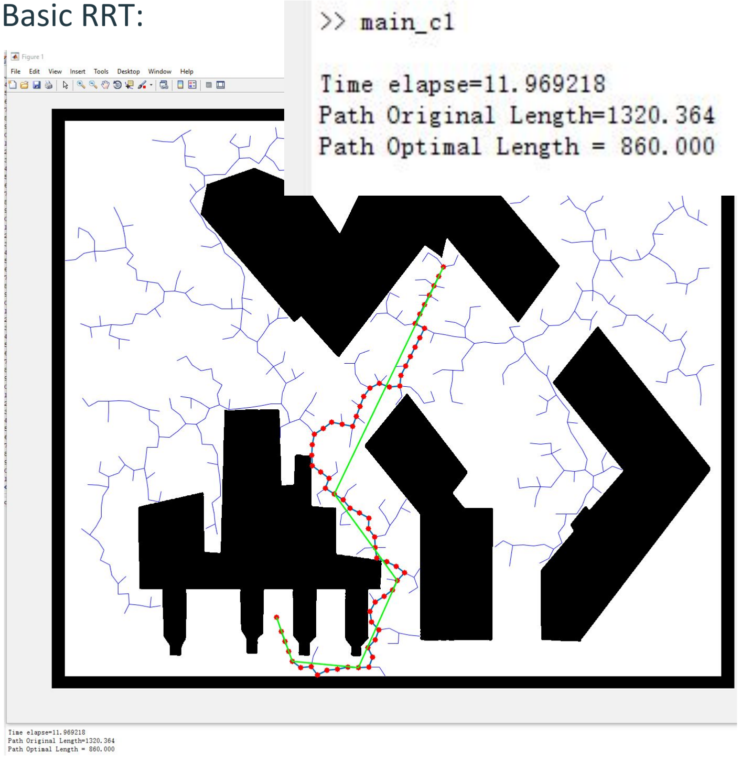


```
$V_1 \leftarrow \{q_{init}\}; E_1 \leftarrow \emptyset; G_1 \leftarrow (V_1, E_1);$
$V_2 \leftarrow \{q_{goal}\}; E_2 \leftarrow \emptyset; G_2 \leftarrow (V_2, E_2); i \leftarrow 0;$
while $i < N$ do
        $q_{rand} \leftarrow$ Sample$(i); i \leftarrow i + 1;$
        $q_{nearst} \leftarrow$ Nearst$(G_1, q_{rand});$
        $q_{new} \leftarrow$ Steer$(q_{nearst}, q_{rand});$
        if ObstacleFree$(q_{nearst}, q_{new})$ then
                $V_1 \leftarrow V_1 \cup \{q_{new}\};$
                $E_1 \leftarrow E_1 \cup \{(q_{nearest}, q_{new})\};$
            $q'_{nearst} \leftarrow$ Nearst$(G_2, q_{new});$
            $q'_{new} \leftarrow$ Steer$(q'_{nearst}, q_{new});$
            if ObstacleFree$(q'_{nearst}, q'_{new})$ then
                $V_2 \leftarrow V_2 \cup \{q'_{new}\};$
                $E_2 \leftarrow E_2 \cup \{(q'_{nearst}, q'_{new})\};$
                do
                    $q''_{new} \leftarrow$ Steer$(q'_{new}, q_{new});$
                    if ObstacleFree$(q''_{new}, q'_{new})$ then
                        $V_2 \leftarrow V_2 \cup \{q''_{new}\};$
                        $E_2 \leftarrow E_2 \cup \{(q''_{new}, q'_{new})\};$
                        $q'_{new} \leftarrow q''_{new}$ ;
                    else break;
                while not $q'_{new} = q_{new}$
            if $q'_{new} = q_{new}$ then return $(V_1, E_1);$
        if $|V_2| < |V_1|$ then Swap$(V_1, V_2);$
```

# Demo

# Comparison (RRT vs Bi-RRT)

Basic RRT:

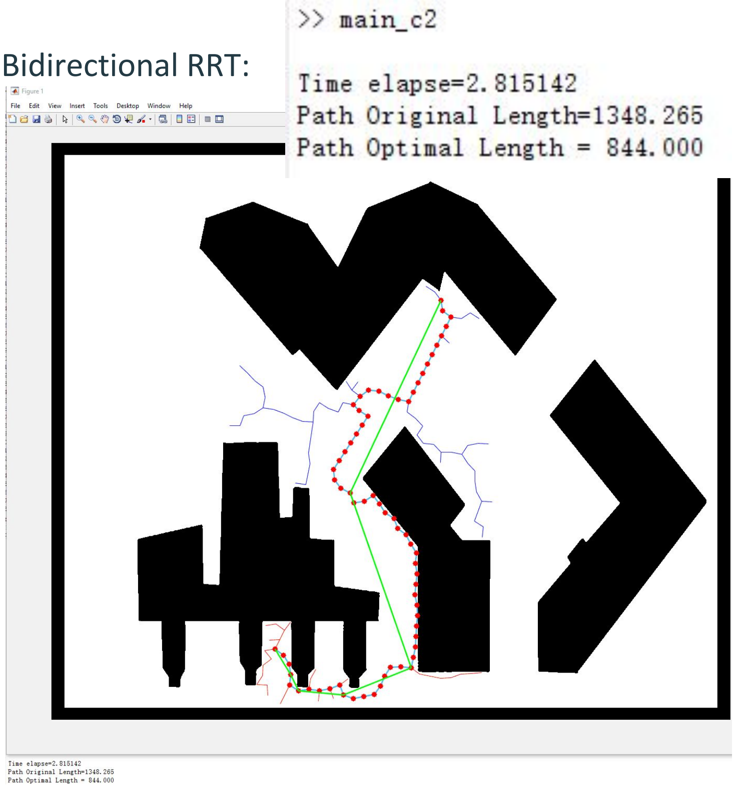


```
>> main_c1

Time elapse=11.969218
Path Original Length=1320.364
Path Optimal Length = 860.000
```

Time elapse=11.969218
Path Original Length=1320.364
Path Optimal Length = 860.000

Bidirectional RRT:

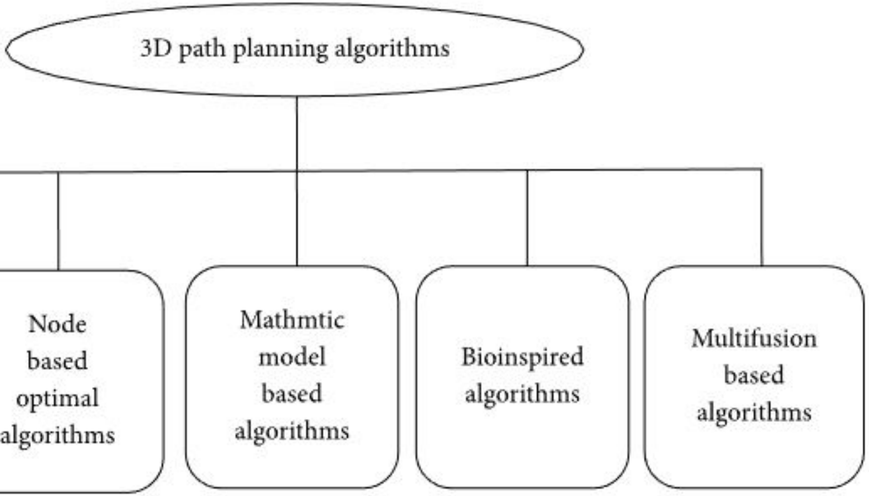


```
>> main_c2

Time elapse=2.815142
Path Original Length=1348.265
Path Optimal Length = 844.000
```

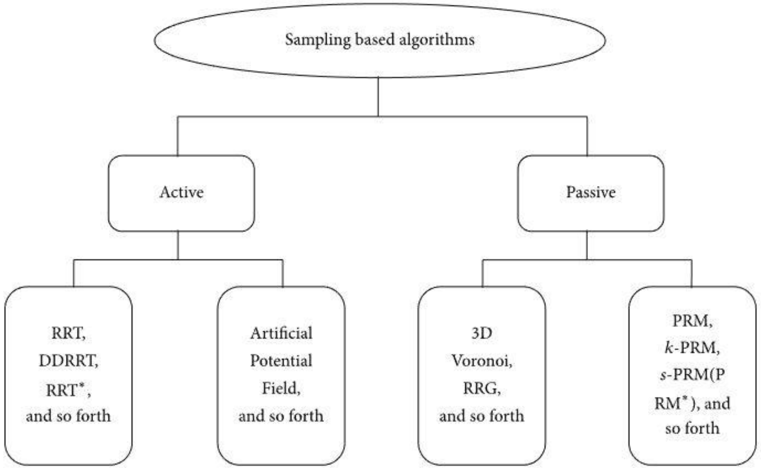
Time elapse=2.815142
Path Original Length=1348.265
Path Optimal Length = 844.000

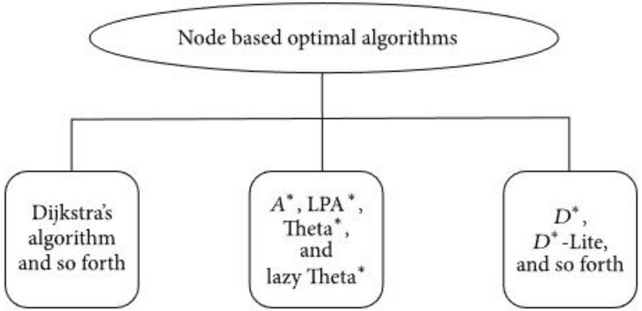
# Different PPAs


3D path planning algorithms
Sampling based algorithms
Node based optimal algorithms
Mathmtic model based algorithms
Bioinspired algorithms
Multifusion based algorithms

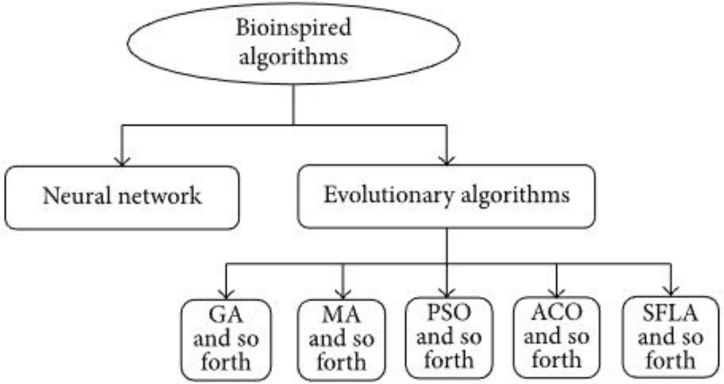
[1]Journal of Control Science and Engineering Volume 2016, Article ID 7426913, 22 pages

# Different PPAs


Sampling based algorithms
Active
Passive
RRT, DDRRT, RRT$^*$, and so forth
Artificial Potential Field, and so forth
3D Voronoi, RRG, and so forth
PRM, $k$-PRM, $s$-PRM(PRM$^*$), and so forth


Node based optimal algorithms
Dijkstra's algorithm and so forth
$A^*$, LPA$^*$, Theta$^*$, and lazy Theta$^*$
$D^*$, $D^*$-Lite, and so forth

# Different PPAs



Bioinspired algorithms

Neural network

Evolutionary algorithms

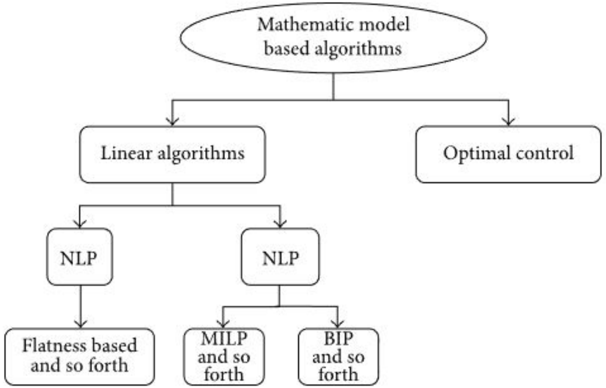
GA and so forth

MA and so forth

PSO and so forth

ACO and so forth

SFLA and so forth



Mathematic model based algorithms

Linear algorithms

Optimal control

NLP

NLP

Flatness based and so forth

MILP and so forth

BIP and so forth

GA is Genetic Algorithm
MA is Memetic Algorithm
PSO is particle swarm optimization
ACO is Ant Colony Optimization
SFLA is Shuffled Frog Leaping Algorithm

# Next week

1. Implement RRT algorithm and its variants in 3D maps
2. Dig more in other PPAs, try to analyze them and make comparison of different PPAs

Q&A? Any Suggestions?