

Question-1.1 RRT

RRT

RRR Robot

Samples = 6000

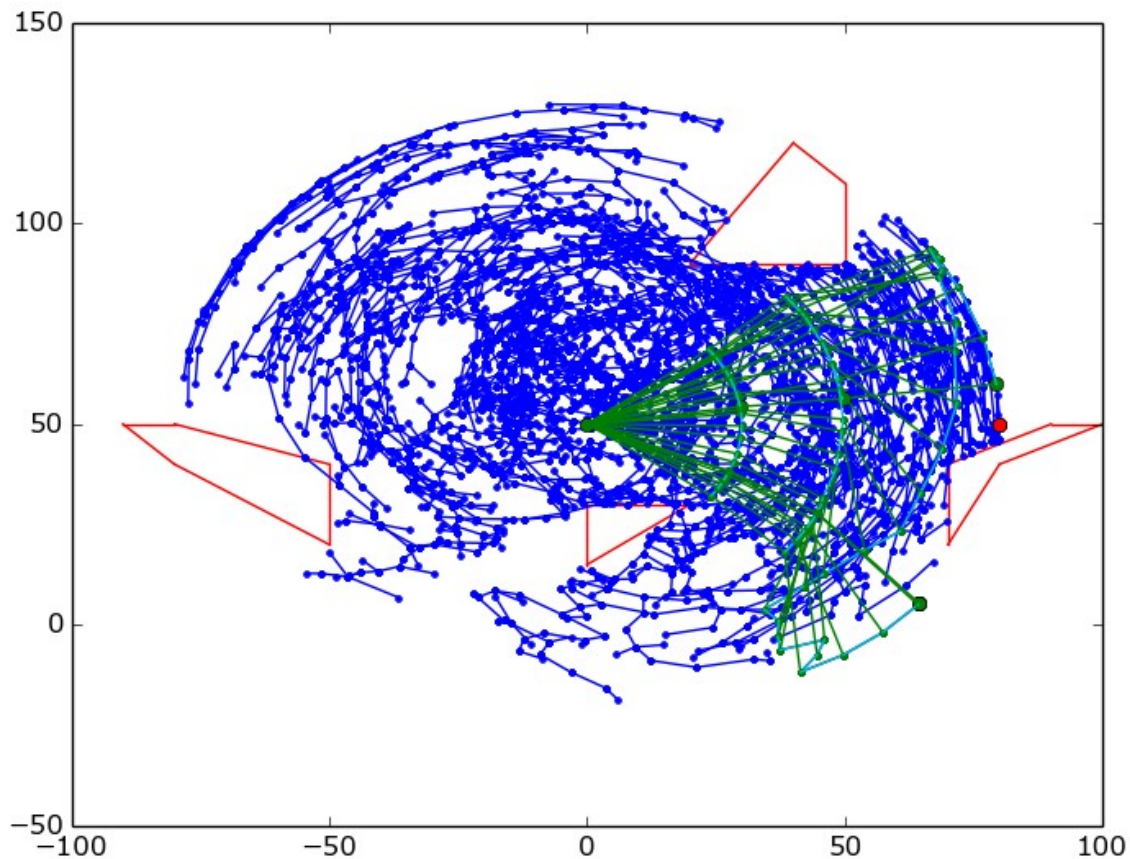
step_size = 0.15

Probability = 0.05 towards the goal

Run_time = 161.292327881 seconds

Start: 0 0 0

Goal: -0.4 -0.15 -0.3



plan: [array([0.14384122, -0.03974196, 0.01517496]), array([0.22330685, 0.00284973, 0.13505474]), array([0.34007406, 0.09461611, 0.11397511]), array([0.40648926, 0.21042123, 0.04557777]), array([0.47935364, 0.14138776, -0.06589045]), array([0.58193519, 0.06154778, -0.14074098]), array([0.61652782, 0.10941811, -0.2786242]), array([0.60048717, 0.10953931, -0.427764]), array([0.66600618, 0.0524801 , -0.55004035]), array([0.58621089, -0.00769683, -0.66189494]), array([0.57809058, -0.05134605, -0.80517371]), array([0.45454523, -0.09773832, -0.87647801]), array([0.38219985, -0.19916017, -0.96002294]), array([0.26449549, -0.23391401, -1.04626593]), array([0.11762331, -0.23397839, -1.0767382]), array([0.0886275 , -0.30891056, -1.20340474]), array([-0.01478393, -0.34795089, -1.30480459]), array([-0.1146604 , -0.27656016, -1.39099075]), array([-0.24665429, -0.34407924, -1.36821392]), array([-0.31991198, -0.24243783,

-1.28573764]), array([-0.40783944, -0.2222335, -1.16590215]), array([-0.48091239, -0.20719479, -1.03577075]), array([-0.43498963, -0.15857038, -0.90150695]), array([-0.52019326, -0.167988, -0.77841492]), array([-0.63824654, -0.14121668, -0.68983321]), array([-0.56003988, -0.14409989, -0.56186679]), array([-0.48183321, -0.14698309, -0.43390038]), array([-0.40362654, -0.1498663, -0.30593396]), array([-0.4, -0.15, -0.3])]

RRR Robot

Samples = 7000

step_size = 0.15

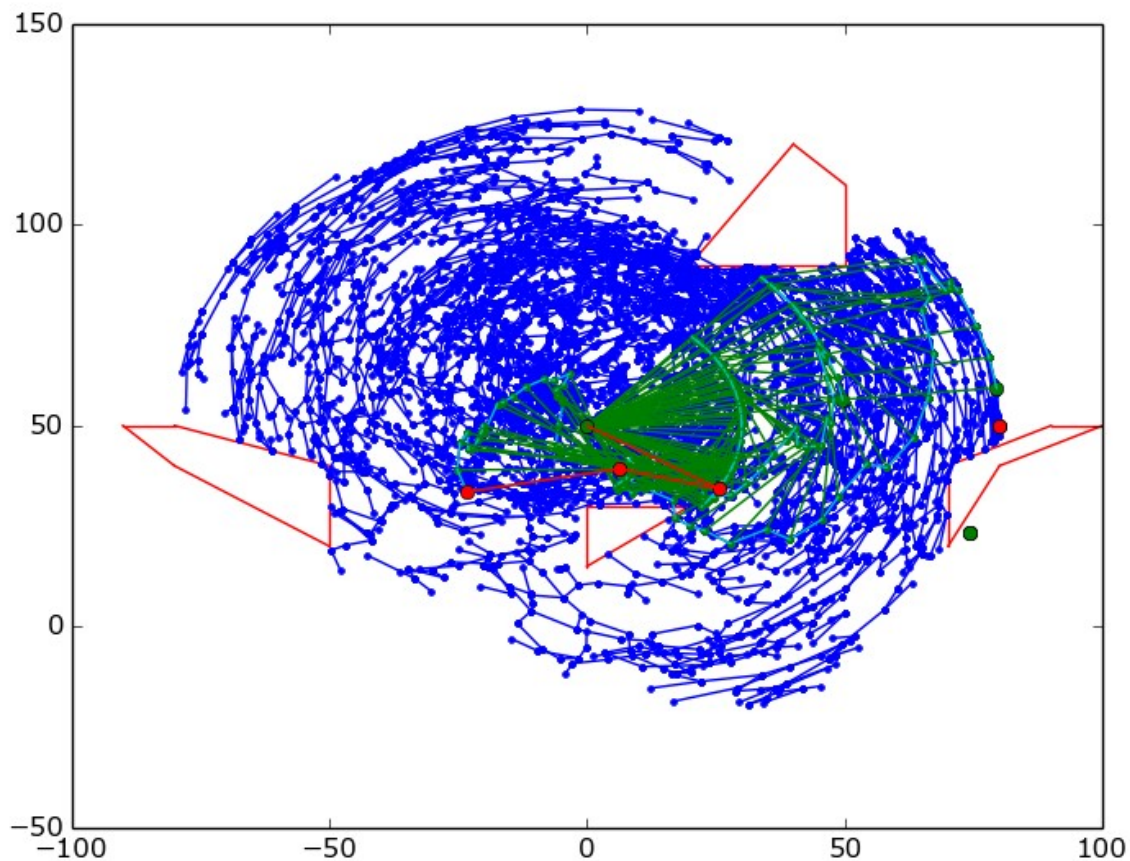
Probability = 0.05 towards the goal

Run_time = 252.97706604 seconds

Start: 0 0 0

Goal: -0.4 -0.15 0.4

Since the randomly selected goal is on the back of the obstacle as you can see from the figure RRR robot hasn't reached the goal.



plan: [array([0.09905284, 0.07785122, -0.08141083]), array([0.18278106, 0.15612312, -0.17817391]), array([0.27473442, 0.22921619, -0.27145833]), array([0.41854329, 0.2205878 , -0.31322627]), array([0.45743966, 0.28774797, -0.44158742]), array([0.53020542, 0.19218159, -0.5314329]), array([0.61713727, 0.0856754 , -0.59142695]), array([0.71310851, 0.16315099, -0.6767912]), array([0.80880914, 0.04880321, -0.69309989]), array([0.76343464, -0.02571404, -0.81511766]), array([0.82415498, -0.11420677, -0.91991306]), array([0.69391679, -0.11611899, -0.99430632]), array([0.61547198, -0.18642575, -1.10109289]), array([0.55616425, -0.31437922, -1.15218597]), array([0.51587403, -0.40703221, -1.26305581]), array([0.59960084, -0.49942358, -1.34644439]), array([0.48472801, -0.57775408, -1.4027344]), array([0.35112405, -0.53925179, -1.45901545]), array([0.27799821, -0.66985027, -1.44918447]), array([0.3386565 , -0.75858035, -1.55381498]), array([0.228023 , -0.85935875, -1.56401028]), array([0.26428396, -0.96769604, -1.661212]), array([0.30820461, -1.10729086, -1.62828385]), array([0.36630405, -1.24373067, -1.60573096]), array([0.48444826, -1.28597543, -1.68793392]), array([0.43890829, -1.40017255, -1.77387068]), array([0.38472355, -1.5366167 , -1.80464419]), array([0.29137471, -1.59688729, -1.90540852]), array([0.18393068, -1.68790567, -1.8537226]), array([0.09079087, -1.75849393, -1.75968924]), array([0.04772624, -1.88469187, -1.6909905]), array([0.01425343, -1.9711985 , -1.57310847]), array([0.11252433, -2.06250057, -1.50597605]), array([0.14907365, -2.16869756, -1.60540616]), array([0.08432997, -2.29246632, -1.66008293]), array([-0.04973265, -2.30734872, -1.59446487]), array([-0.12043928, -2.39150098, -1.49239152]), array([-0.23262416, -2.44998207, -1.41180296]), array([-0.37933438, -2.47726284, -1.39657563]), array([-0.45548337, -2.58222047, -1.3211752]), array([-0.53186983, -2.56745312, -1.1929292]), array([-0.55370614, -2.62552914, -1.05636291]), array([-0.51573773, -2.64378018, -0.91240007]), array([-0.40834115, -2.67043687, -0.81113114]), array([-0.3526136 , -2.72626614, -0.68354771]), array([-0.33756386, -2.7932586 , -0.55018536]), array([-0.314472 , -2.74323865, -0.41066916]), array([-0.36866326, -2.81914278, -0.2931878]), array([-0.26799847, -2.88569909, -0.20409875]), array([-0.30990083, -2.9087682 , -0.06192981]), array([-0.4254104 , -2.86165844, 0.02136611]), array([-0.51676534, -2.88652336, 0.13771046]), array([-0.65879029, -2.92354983, 0.16866129]), array([-0.73699031, -2.90746803, 0.29565]), array([-0.69745434, -2.87695211, 0.43709146]), array([-0.551805 , -2.84208132, 0.44547576])]

RRR Robot

Samples = 7000

step_size = 0.15

Probability = 0.05 towards the goal

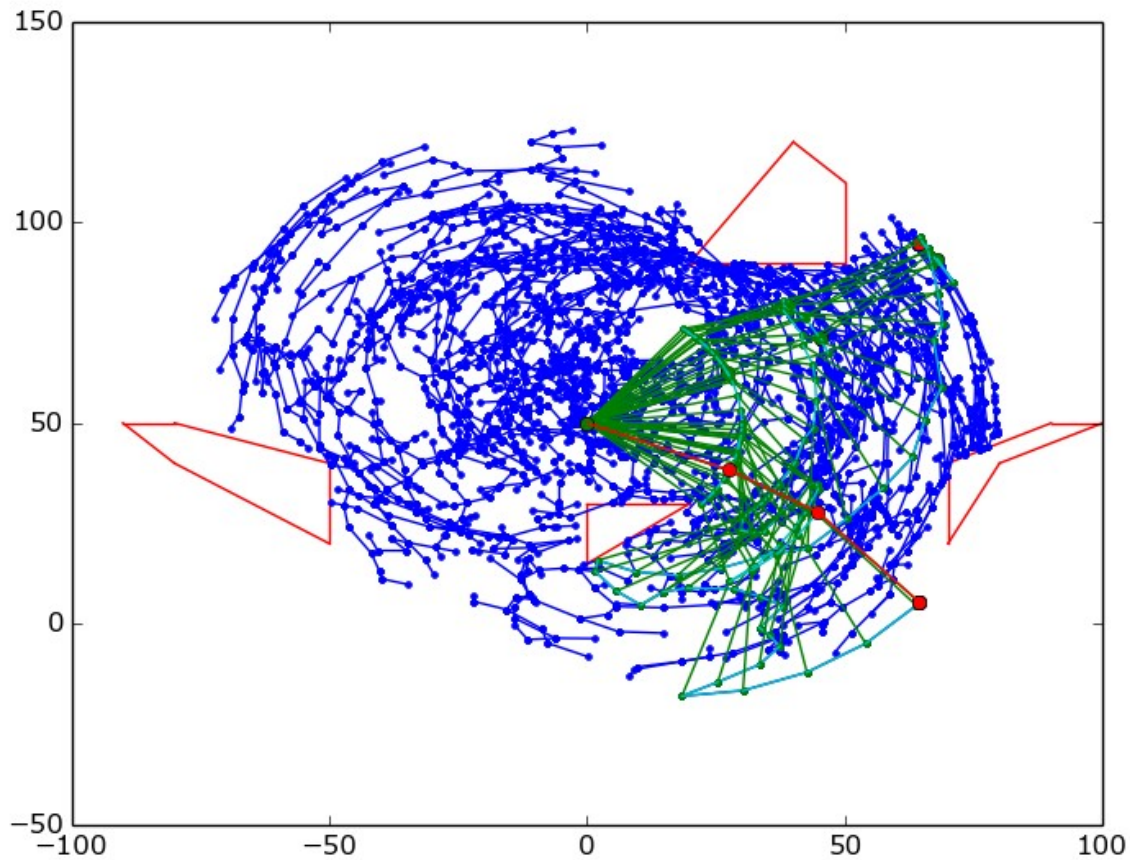
Run_time = 84.7751209736

Start: 0.4 0.15 0.3

Goal: -0.4 -0.15 -0.3

plan: [array([0.43625643, 0.00809042, 0.26764043]), array([0.40630079, -0.11951014, 0.34058396]), array([0.52753526, -0.18185787, 0.40315364]), array([0.63748134, -0.20615117, 0.30404917]), array([0.69479274, -0.33140188, 0.24465503]), array([0.7846731 , -0.35774309, 0.12748993]), array([0.80124196, -0.35131384, -0.02145348]), array([0.85132007, -0.43653381, -0.13427963]), array([0.87702741, -0.5633601 , -0.21013622]), array([0.85091007, -0.59332849, -0.35477294]), array([0.90163721, -0.67646947, -0.46885332]), array([0.75965148, -0.69194858, -0.51468397]), array([0.75300535, -0.81184339, -0.6045787]), array([0.63869497, -0.80872591, -0.701653]), array([0.58197431, -0.87315188, -0.82466544]), array([0.49463019, -0.94286436,

-0.9247213]), array([0.3713716 , -1.02180804, -0.95751178]), array([0.35346789, -1.15562114, -1.02288388]), array([0.23015312, -1.21143817, -1.08752075]), array([0.11080374, -1.30199919, -1.0948983]), array([-0.00973044, -1.36047221, -1.16236992]), array([-0.12362431, -1.42658037, -1.2341884]), array([-0.22545016, -1.3175536 , -1.24983004]), array([-0.25175666, -1.17630309, -1.20674568]), array([-0.26842266, -1.02745792, -1.19853847]), array([-0.13132931, -1.03892408, -1.2583209]), array([-0.09285148, -0.91751193, -1.33755818]), array([-0.0098041 , -0.83036882, -1.24806399]), array([-0.0534725 , -0.70041411, -1.18719655]), array([-0.10541137, -0.61702408, -1.07384552]), array([-0.24727899, -0.59820202, -1.02890881]), array([-0.26740725, -0.62534274, -0.88276424]), array([-0.33406738, -0.58503298, -0.75457863]), array([-0.45783726, -0.56973306, -0.6712304]), array([-0.60628241, -0.55169691, -0.65945175]), array([-0.73935966, -0.55440061, -0.59029155]), array([-0.66328673, -0.47940281, -0.48499084]), array([-0.57752305, -0.37210231, -0.42473146]), array([-0.49175937, -0.26480181, -0.36447208]), array([-0.40599568, -0.15750131, -0.30421269]), array([-0.4 , -0.15, -0.3])]



RRR Robot

Samples = 7000

step_size = 0.15

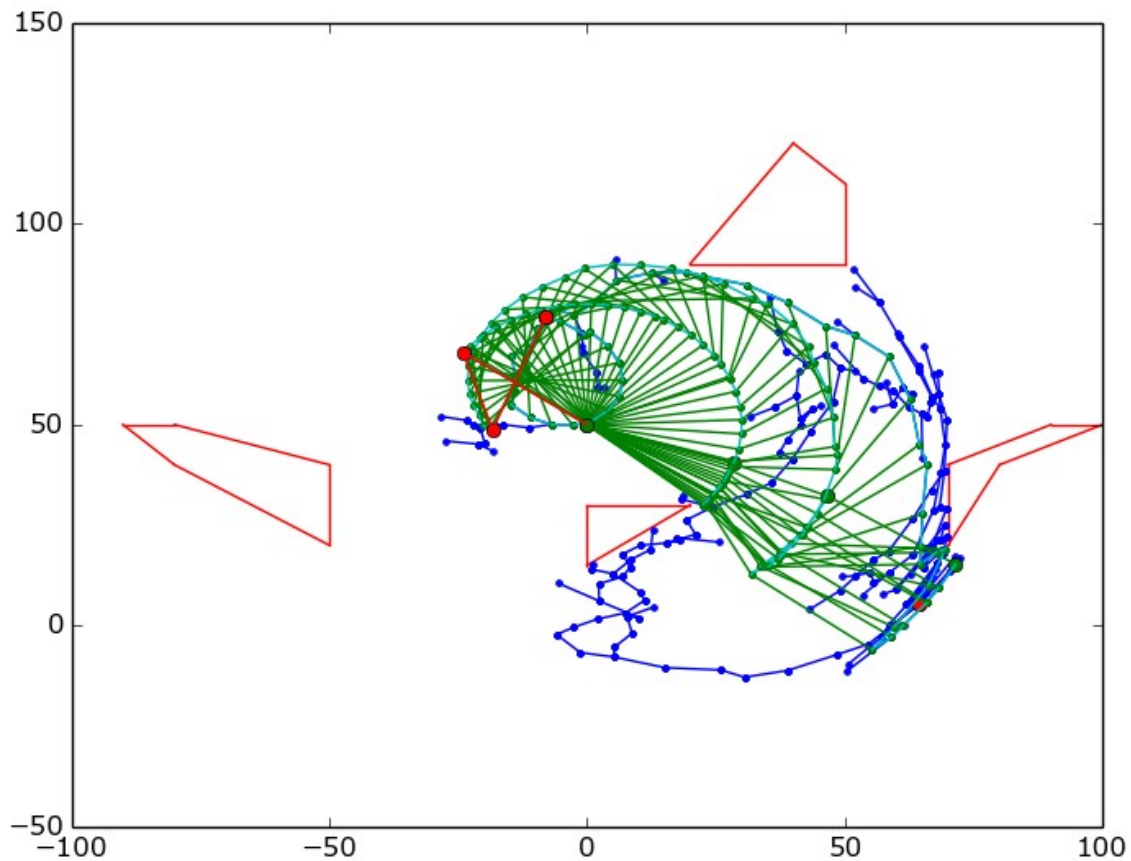
Probability = 0.05 towards the goal

Start: -0.4 -0.15 -0.3

Goal: 2.5 2.5 2.5

Run_time = 1.00547790527

plan: [array([-0.32889986, -0.08896647, -0.18286897]), array([-0.38511634, -0.19072069, -0.08807558]), array([-0.4254937, -0.27891004, 0.02634604]), array([-0.45773843, -0.31731617, 0.16771522]), array([-0.54520898, -0.38455318, 0.26934243]), array([-0.65990842, -0.30959722, 0.33038046]), array([-0.70024, -0.40939037, 0.43485387]), array([-0.62698714, -0.45775468, 0.55648821]), array([-0.54477249, -0.40362504, 0.66967272]), array([-0.51210245, -0.32774935, 0.79487474]), array([-0.61081784, -0.24233527, 0.86876457]), array([-0.68136859, -0.28950945, 0.99244637]), array([-0.72573122, -0.15720609, 1.04747162]), array([-0.71760687, -0.03566018, 1.1349964]), array([-0.6058347, 0.05242276, 1.18241345]), array([-0.62101949, 0.20159723, 1.17836408]), array([-0.48516637, 0.25510427, 1.21272869]), array([-0.3551602, 0.31688857, 1.25493173]), array([-0.30842261, 0.38405324, 1.3806477]), array([-0.3224806, 0.52672059, 1.42478838]), array([-0.2051319, 0.60876253, 1.46949185]), array([-0.07671419, 0.67557475, 1.5087986]), array([0.04008538, 0.7582739, 1.55372865]), array([0.15106122, 0.69379301, 1.63135969]), array([0.27848588, 0.71460588, 1.70771269]), array([0.39113414, 0.80513942, 1.7478879]), array([0.40897699, 0.93667703, 1.81774126]), array([0.52521006, 1.023577, 1.85566577]), array([0.60788026, 1.07003358, 1.73944433]), array([0.72183337, 1.15615346, 1.78524887]), array([0.83578648, 1.24227333, 1.83105342]), array([0.94485963, 1.30622639, 1.75034993]), array([1.0559974, 1.39153916, 1.80392351]), array([1.11769019, 1.516042, 1.74741648]), array([1.21520467, 1.60922921, 1.68178822]), array([1.32442183, 1.68495135, 1.7513423]), array([1.43363898, 1.76067349, 1.82089639]), array([1.54285613, 1.83639563, 1.89045047]), array([1.65207329, 1.91211777, 1.96000455]), array([1.76129044, 1.98783991, 2.02955864]), array([1.8705076, 2.06356205, 2.09911272]), array([1.97972475, 2.13928419, 2.16866681]), array([2.08894191, 2.21500633, 2.23822089]), array([2.19815906, 2.29072847, 2.30777498]), array([2.30737622, 2.36645061, 2.37732906]), array([2.42772774, 2.41241924, 2.300502]), array([2.47495426, 2.46964914, 2.43086455]), array([2.5, 2.5, 2.5])]



Box Robot

Samples = 1000

step_size = 2

Probability = 0.05 towards the goal

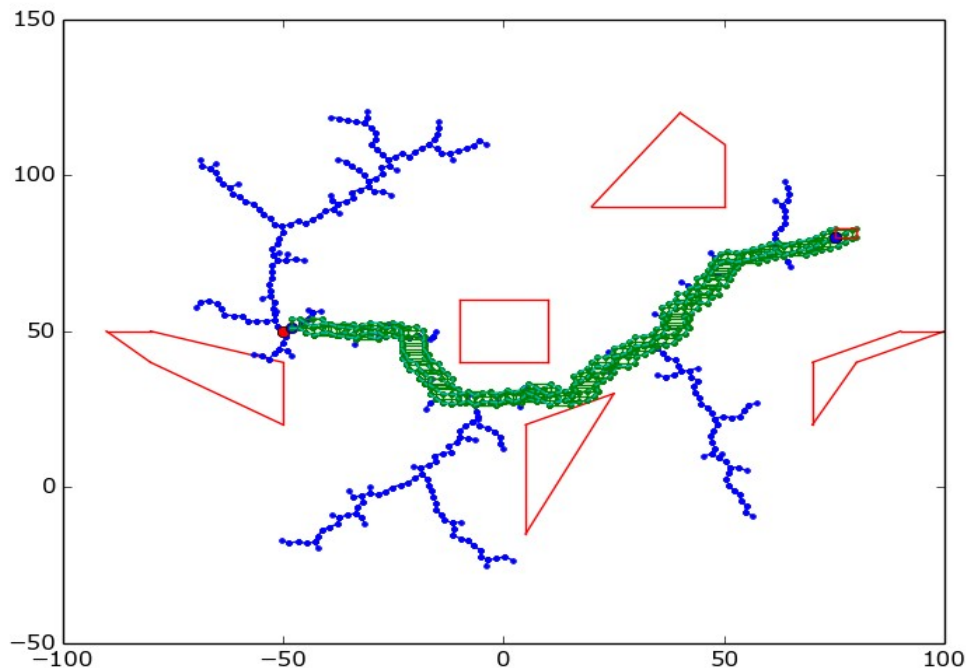
Start: -50 50

Goal: 75 80

Run_time = 2.54233407974 seconds

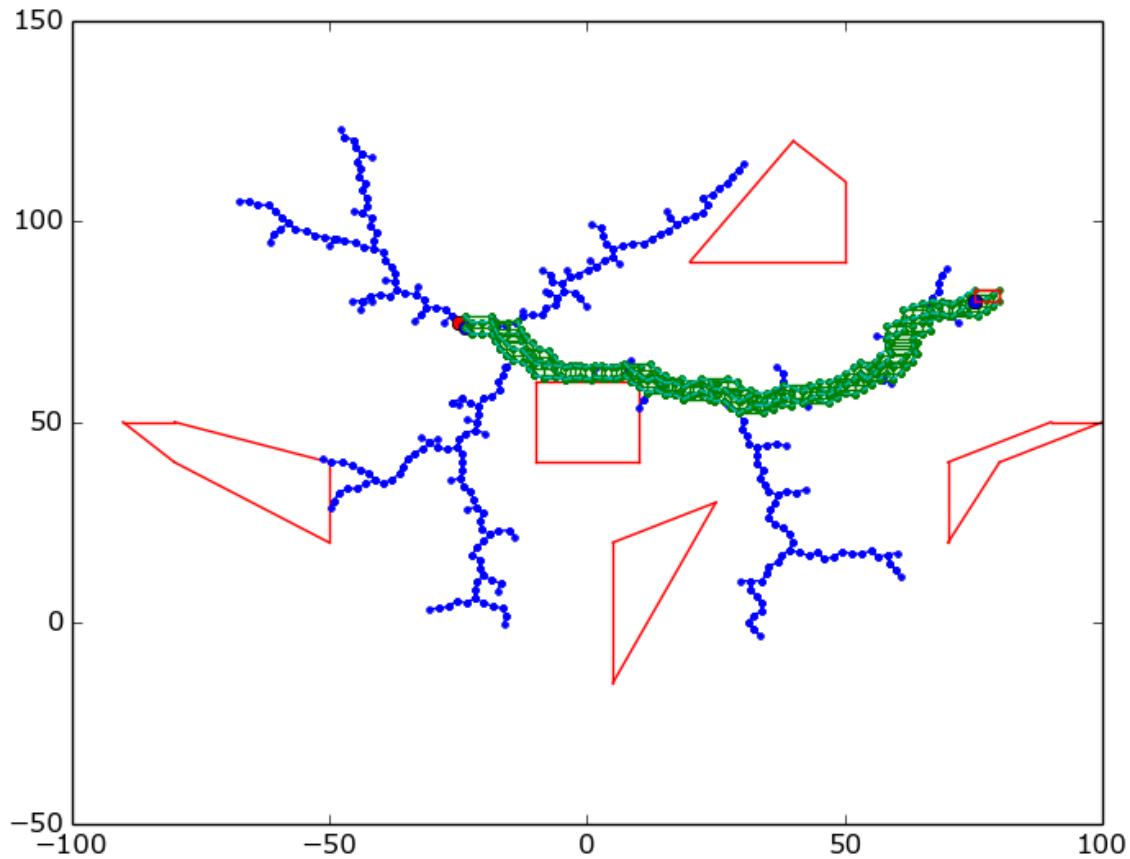
plan: [array([-48.23171229, 50.93442955]), array([-46.23179599, 50.95272661]), array([-44.85899648, 49.49827774]), array([-43.04382556, 48.65854296]), array([-41.24352021, 49.52969202]), array([-39.26282096, 49.25250894]), array([-37.40800506, 48.50440601]), array([-35.43069713, 48.20398408]), array([-33.51183653, 47.64009223]), array([-32.10933708, 49.06592367]), array([-30.2153999, 49.70857594]), array([-28.22194201, 49.54694165]), array([-26.79271287, 48.1479048]), array([-24.8187917, 48.46982902]), array([-23.23704689, 47.24586686]), array([-23.02219986, 45.25744016]), array([-23.00027278, 43.25756036]), array([-23.02950902, 41.25777406]), array([-22.10265186, 39.48550552]), array([-21.4620125, 37.5908865]), array([-19.65437964, 36.73504572]), array([-19.03552882, 34.83319829]), array([-17.76558746, 33.28812582]), array([-16.50144472, 31.73830546]), array([-16.75266524, 29.75414613]), array([-15.30038982, 28.37904755]), array([-13.86015743, 26.99134057]), array([-

11.87181965, 26.77567208]], array([-9.87706482, 26.92042415]), array([-8.00909125,
27.63503924]), array([-6.56516408, 26.25117713]), array([-4.84515674, 27.27175284]), array([
-2.84543007, 27.23868859]), array([-0.85034419, 27.0985733]), array([0.79008648,
28.2426831]), array([2.61090458, 27.41526457]), array([4.22903445, 28.59070309]),
array([5.54624556, 30.0956798]), array([7.2613989 , 29.06696749]), array([8.74320038,
27.72373839]), array([10.24688342, 26.40505067]), array([12.03581473, 27.29932398]),
array([13.99123555, 27.71923995]), array([15.50990208, 29.0206438]), array([16.37635018,
30.82321632]), array([15.87873896, 32.7603232]), array([17.44121542, 34.00878918]),
array([19.00369188, 35.25725516]), array([20.01886242, 36.98045822]), array([20.99925912,
38.72368004]), array([22.99662032, 38.62097549]), array([24.63104061, 39.77365512]),
array([24.92605601, 41.75177693]), array([26.81543039, 42.4077224]), array([28.39230306,
43.63795514]), array([29.6828378 , 45.16586877]), array([31.66246031, 45.45064014]),
array([33.53507982, 46.15299061]), array([34.61544815, 47.83608427]), array([36.17989806,
49.08207643]), array([36.96752339, 50.92045788]), array([36.03410209, 52.68927801]),
array([35.79238533, 54.67461753]), array([37.47238991, 55.75978323]), array([38.86993439,
57.19047168]), array([39.28840093, 59.14620319]), array([41.2865713, 59.0606744]),
array([42.09604791, 60.88953952]), array([43.82551304, 61.89400473]), array([43.60216898,
63.88149496]), array([45.38141136, 64.79489332]), array([46.31034031, 66.56607682]),
array([46.90555284, 68.47545422]), array([47.9068563 , 70.20675182]), array([48.95310893,
71.91126215]), array([50.75125149, 72.78686669]), array([52.63652372, 72.11922261]),
array([54.52282751, 72.78394664]), array([56.40913129, 73.44867068]), array([58.29543507,
74.11339472]), array([60.11078085, 74.95275144]), array([62.00491045, 75.59483635]),
array([63.45672807, 74.21925443]), array([65.24501759, 75.11481045]), array([67.03330711,
76.01036648]), array([69.02106485, 76.23131702]), array([70.71299848, 77.29778811]),
array([72.40493212, 78.3642592]), array([73.93436028, 79.6529987]), array([75., 80.])]



Box Robot
Samples = 1000
step_size = 2
Probability = 0.05 towards the goal
Start: -25 75
Goal: 75 80

Run_time = 2.54233407974 seconds



plan: [array([-23.70454013, 73.47625995]), array([-22.4598386, 71.910783]), array([-20.45994332, 71.89031605]), array([-18.47054172, 72.09594015]), array([-17.83754959, 70.1987525]), array([-16.9961414 , 68.38435666]), array([-15.75021716, 66.81985265]), array([-14.47430561, 65.27970665]), array([-12.51534001, 64.87665112]), array([-11.33860107, 63.2594667]), array([-10.14919293, 61.65157731]), array([-8.24887065, 61.02805889]), array([-6.25422742, 61.17434083]), array([-4.33183394, 60.62261325]), array([-2.38895213, 61.09717649]), array([-0.42345866, 60.72726382]), array([1.51428015, 61.22240856]), array([3.495632 , 60.94992947]), array([5.49202396, 60.82984967]), array([7.3286642 , 61.62152675]), array([8.50739655, 60.0057947]), array([10.065985 , 58.75247828]), array([11.53928221, 57.39992686]), array([13.42337152, 58.07090188]), array([15.01174587, 56.85555547]), array([17.01009461, 56.77430082]), array([18.69056195, 55.68985187]), array([20.374002 , 56.76968037]), array([22.06766681, 57.83340003]), array([23.94845902, 57.1532378]),

array([24.63626929, 55.27522901]), array([26.63503656, 55.20501932]), array([27.95668046, 53.70393391]), array([29.27696351, 52.20165143]), array([30.98590927, 53.24064345]), array([32.69485502, 54.27963546]), array([34.6890225 , 54.12700487]), array([36.3721616 , 55.20730241]), array([38.10673311, 56.20292366]), array([40.00552115, 55.57474855]), array([41.75942368, 54.61358992]), array([43.34889709, 55.82749859]), array([44.93837051, 57.04140726]), array([46.93525495, 56.92981643]), array([48.5997467 , 58.03862985]), array([50.13730119, 59.31766316]), array([51.67485568, 60.59669647]), array([52.95323611, 62.13479382]), array([54.34472267, 60.69821276]), array([55.81461413, 62.05446462]), array([56.72650791, 63.83447859]), array([58.22448032, 65.15964977]), array([58.92316926, 67.0336385]), array([58.25615858, 68.91913492]), array([58.09947368, 70.91298794]), array([59.86099297, 71.86011507]), array([61.53213413, 72.9588813]), array([61.31492596, 74.94705147]), array([63.07795241, 75.89137014]), array([64.96881668, 76.54300832]), array([66.85968094, 77.1946465]), array([68.84248379, 76.93293507]), array([70.73603736, 76.28915337]), array([72.2447134, 77.6021258]), array([73.75338944, 78.91509823]), array([75., 80.])]

Box Robot

Samples = 1000

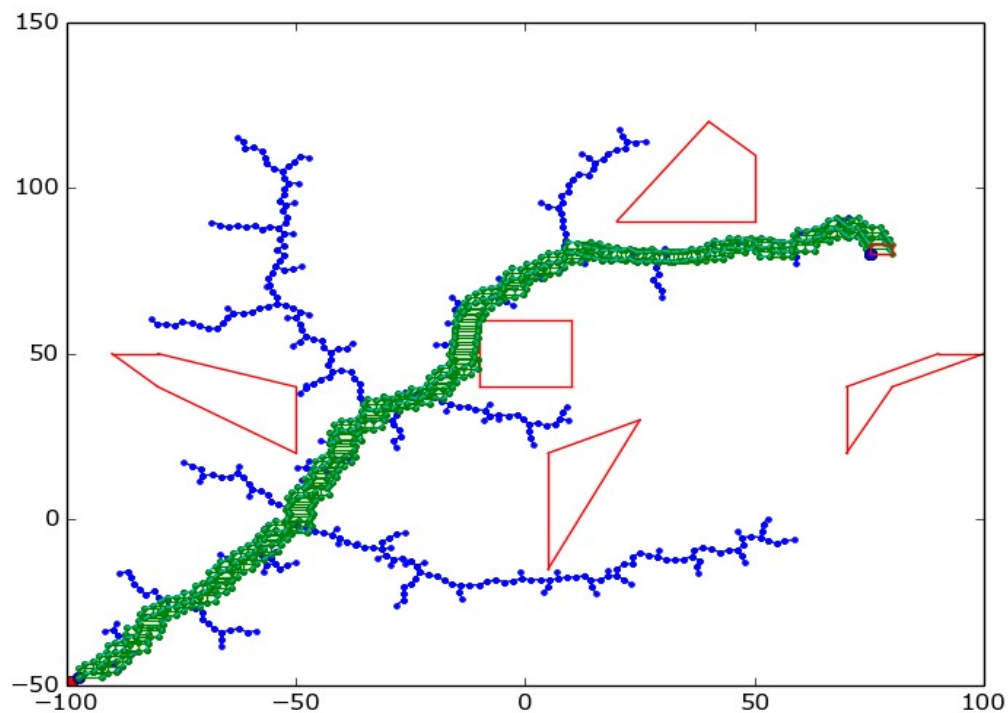
step_size = 2

Probability = 0.05 towards the goal

Start: -99 -49

Goal: 75 80

Run_time = 3.81539511681 seconds



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array([ 61.25534238, 83.974008 ]), array([ 62.96142572, 85.0176936 ]), array([ 64.89911541,
85.51303053]), array([ 65.91036085, 87.23853992]), array([ 67.68492611, 88.16099215]),
array([ 69.01984641, 86.6717011 ]), array([ 70.3547667 , 85.18241006]), array([ 72.35393415,
85.2401119 ]), array([ 73.25544353, 83.45481617]), array([ 74.15695292, 81.66952045]), array([ 75.,
80.])]
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Box Robot

Samples = 1000

step_size = 2

Probability = 0.05 towards the goal

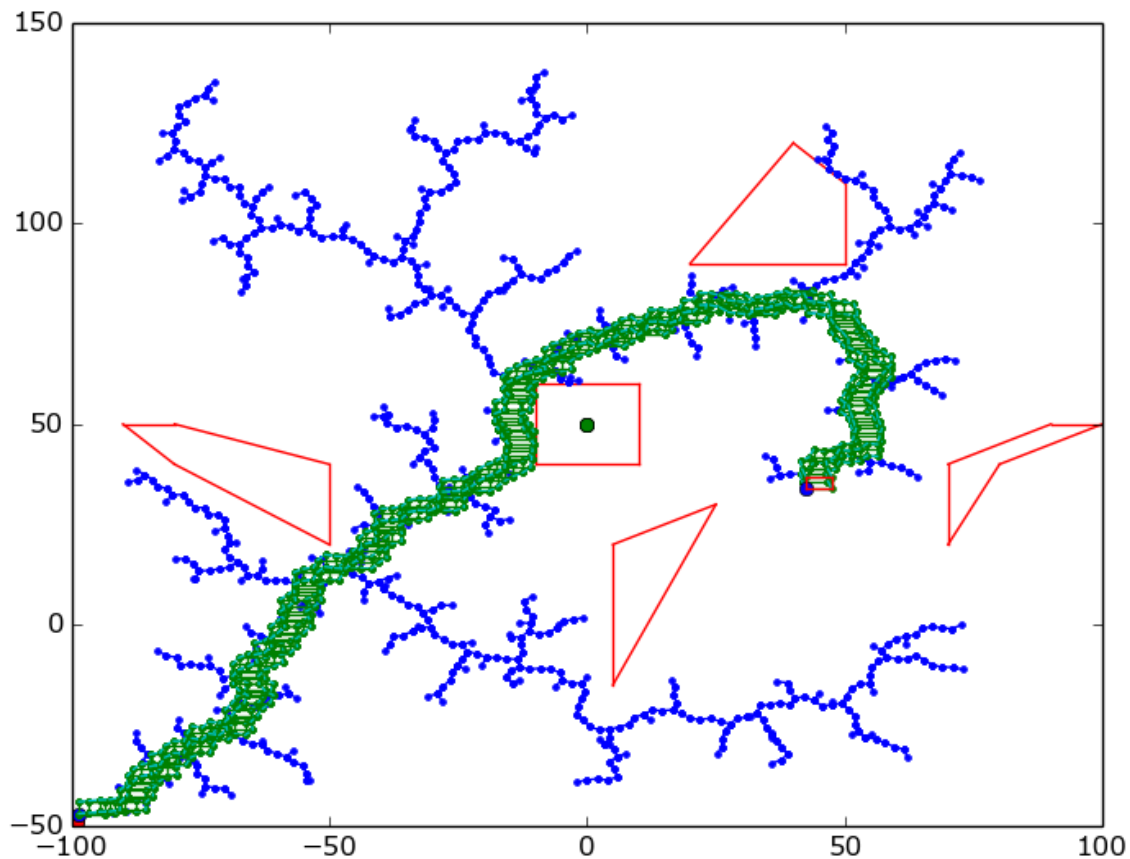
Start: -99 -49

Goal: 0 50

Run_time = 9.95082688332 seconds

Knowingly I created a goal inside a obstacle. And the goal is not reached.

I print last nodes path. Hence green path appears although robot is not reaching the goal



plan: [array([-98.53311488, -47.05525881]), array([-96.5464356 , -46.82481264]), array([-94.56226219, -46.5737034]), array([-92.56343258, -46.50529125]), array([-90.6080384 , -46.08525129]), array([-90.51776223, -44.08728977]), array([-89.18607114, -42.59511055]), array([-89.13119959, -40.59586341]), array([-87.96444415, -38.97146145]), array([-86.42821278, -37.69083926]), array([-84.47746129, -37.24973993]), array([-84.70997591, -35.26330167]), array([-82.76953424, -34.77885754]), array([-81.8260623 , -33.01537782]), array([-80.14677853, -31.929097]), array([-78.14678251, -31.9330886]), array([-77.51136012, -30.03671354]), array([-76.60600964, -28.25336262]), array([-74.63211293, -28.57543677]), array([-73.27075573, -27.11027242]), array([-71.29627178, -27.42872669]), array([-69.82965 , -26.06893975]), array([-70.19104901, -24.10186304]), array([-68.88886978, -22.58386131]), array([-67.87926583, -20.85739096]), array([-66.47878788, -19.42957391]), array([-65.81709269, -17.54220551]), array([-67.44933552, -16.38644457]), array([-68.61228666, -14.75931685]), array([-68.73032311, -12.76280303]), array([-67.52590999, -11.1661224]), array([-65.72472201, -10.29679976]), array([-63.95430525, -9.36641033]), array([-64.45283093, -7.42953859]), array([-62.52633924, -6.89229586]), array([-61.207011 , -5.38917477]), array([-61.38666657, -3.39726015]), array([-59.96375866, -1.99179471]), array([-58.63228522, -0.49942128]), array([-58.85199038, 1.4884745]), array([-59.4625342 , 3.39300496]), array([-57.88843811, 4.62678837]), array([-56.53586606, 6.10006664]), array([-56.77283708, 8.0859782]), array([-56.82232022, 10.08536596]), array([-55.02123908, 10.95490995]), array([-53.05138064, 11.30082572]), array([-52.25440414, 13.13517259]), array([-50.78722087, 14.49435369]), array([-48.81841556, 14.14249341]), array([-46.82128082, 14.03547551]), array([-45.43364565, 15.47577709]), array([-43.84123097, 16.68582481]), array([-44.15178767, 18.66156632]), array([-42.88915384, 20.21261623]), array([-40.97845925, 20.80358676]), array([-40.91697592, 22.80264149]), array([-41.39136518, 24.74556578]), array([-39.80245028, 25.96020542]), array([-37.80399224, 26.03872583]), array([-35.87034937, 26.54963214]), array([-34.6171378, 28.1083049]), array([-32.66796501, 28.55632885]), array([-30.67164496, 28.43505953]), array([-28.87255236, 29.30871039]), array([-28.82888535, 31.30823363]), array([-27.99115256, 33.12432938]), array([-26.00097918, 33.32234433]), array([-24.00109611, 33.34397041]), array([-22.35799067, 34.48423553]), array([-20.95403464, 35.90863276]), array([-19.29440765, 37.0247144]), array([-17.50304488, 37.91410713]), array([-15.98429737, 39.21541647]), array([-15.76359868, 41.2032022]), array([-15.60945009, 43.1972529]), array([-15.35709106, 45.18126775]), array([-16.34992264, 46.91743752]), array([-17.20348782, 48.72614603]), array([-17.86319478, 50.61421031]), array([-17.90131785, 52.61384693]), array([-16.10724478, 53.49775972]), array([-16.03719113, 55.49653247]), array([-15.142807 , 57.28540838]), array([-16.47534534, 58.77683106]), array([-15.3675404 , 60.44199418]), array([-13.6281745 , 61.42921566]), array([-11.92987559, 62.48552093]), array([-10.02370368, 63.0909205]), array([-8.10486833, 63.65489826]), array([-8.24361269, 65.65007995]), array([-6.75130726, 66.98162962]), array([-4.8791371 , 67.68517697]), array([-3.20712483, 68.78261717]), array([-1.57080501, 69.93259866]), array([0.37799776, 70.38222939]), array([2.07420726, 69.32257221]), array([3.59471182, 70.62182811]), array([5.3212944 , 71.63124011]), array([6.68234937, 73.09668522]), array([8.57952922, 73.72970071]), array([9.97544566, 72.29742376]), array([11.45728274, 73.64061357]), array([12.14802794, 75.51754486]), array([14.14802529, 75.52080337]), array([16.12419463, 75.21298081]), array([17.99685559, 75.91522074]), array([18.71252988, 77.78278876]), array([20.68856798, 78.0914527]), array([21.91144791, 79.67403435]), array([23.91143322, 79.66636815]), array([25.81486501, 79.05240771]), array([27.407221 , 77.84228276]), array([29.39047527, 77.58401454]), array([31.36822117, 77.28648949]), array([32.81904229, 78.66312237]), array([34.80446135, 78.90418496]), array([36.66247386, 79.64431299]), array([38.59104418, 80.1740455]), array([40.18297667, 78.96336349]), array([42.10390716, 79.52016333]), array([42.86389935, 77.67018715]), array([44.84740638,

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array([47.28186218, 73.05375248]), array([48.29994551, 71.33226872]), array([49.59373448,
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Question-1.2 Probability

Box Robot

Samples = 2500

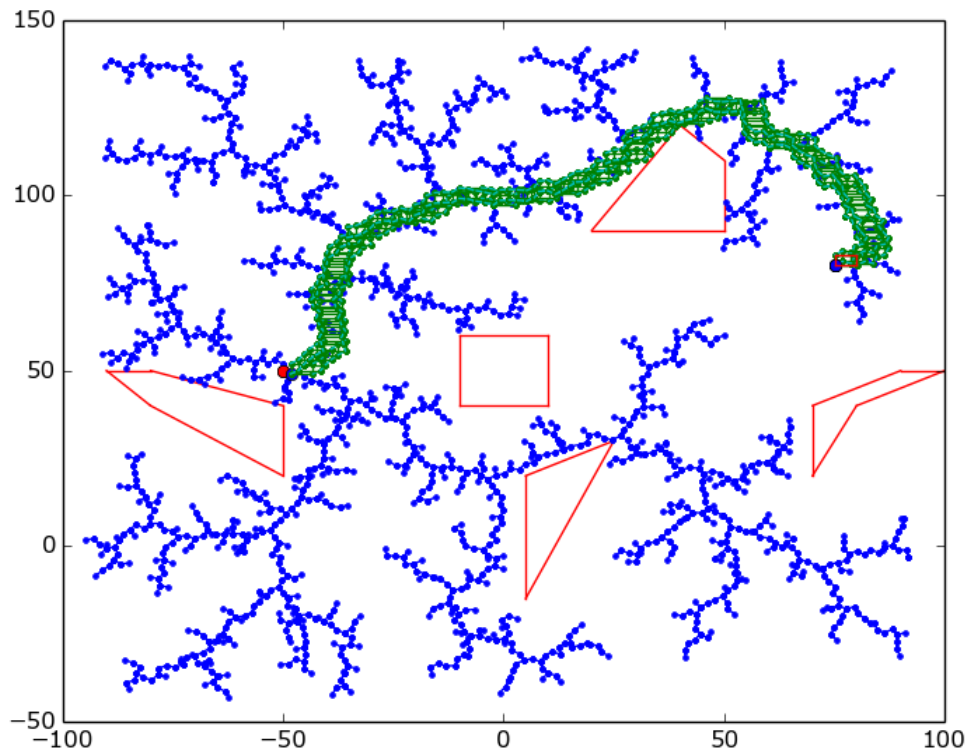
step_size = 2

Start: -50 50

Goal: 75 80

Probability = 0 towards the goal

Run_time = 32.9347159863 seconds

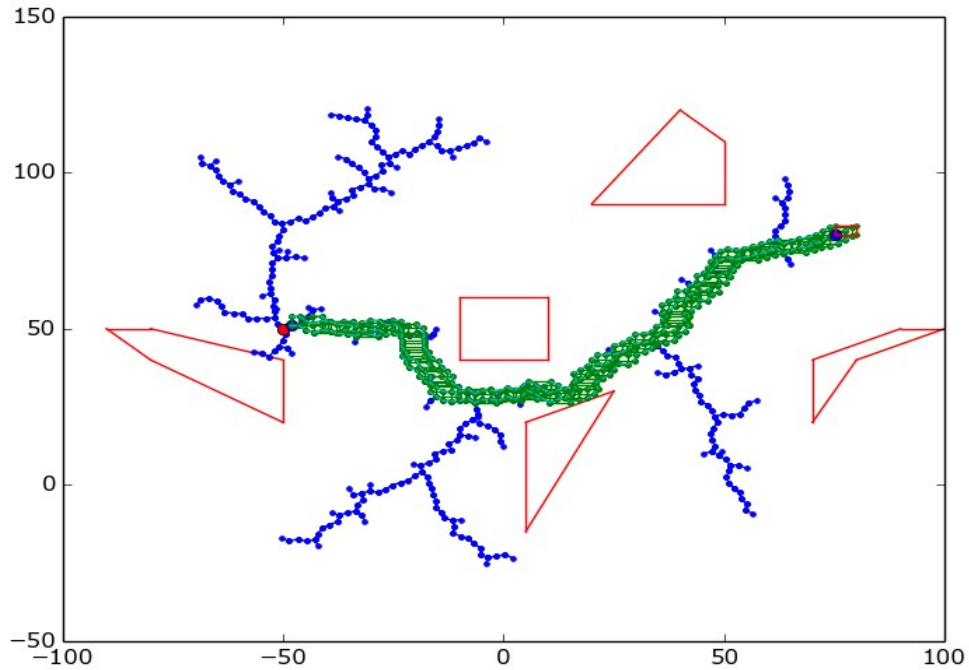


plan: [array([-48.22238036, 49.08344754]), array([-46.469741, 50.04690758]), array([-45.34143138, 51.69824565]), array([-44.01751018, 53.19732291]), array([-42.49082948, 54.48931596]), array([-40.85418343, 55.63883313]), array([-41.28690038, 57.59146111]), array([-41.73374251, 59.54090517]), array([-40.90689677, 61.36198345]), array([-41.77046105, 63.1659393]), array([-42.49476531, 65.03017731]), array([-41.72217305, 66.87492694]), array([-43.08014331, 68.34323099]), array([-43.60679091, 70.27264601]), array([-42.31146454, 71.79649954]), array([-41.79374501, 73.72832937]), array([-40.03526645, 74.68109017]), array([-40.81940488, 76.52096162]), array([-40.6161514, 78.51060682]), array([-40.09148654, 80.44056194]), array([-39.47141734, 82.34201249]), array([-37.9082906, 83.58966421]), array([-36.90824381, 85.321688]), array([-35.02513417, 85.9954076]), array([-35.44541661, 87.95074968]), array([-33.49223757, 88.38097245]), array([-31.70889329, 89.286336]), array([-30.22859805, 90.63122485]), array([-28.86156821, 92.09109793]), array([-26.96953233, 92.73932646]), array([-24.9899585, 92.45421686]), array([-23.20606015, 93.3584882]), array([-21.31089691, 92.71946058]), array([-20.11331419, 94.32127069]), array([-18.29212609, 95.14787453]), array([-17.46955119, 96.97088593]), array([-15.6207014, 97.73361423]), array([-13.62935603, 97.9194733]), array([-11.62936102, 97.92394324]), array([-10.02479459, 99.1178304]), array([-8.03469971, 98.91902798]), array([-6.1253559, 98.32370774]), array([-4.17845424, 97.86591529]), array([-2.27004484, 97.26760637]), array([-0.73850037, 98.55383012]), array([1.25683709, 98.69031613]), array([3.25400319, 98.58388518]), array([5.24494768, 98.39377982]), array([6.99094426, 99.36922635]), array([8.01711398, 101.08590212]), array([10.00577782, 101.29854293]), array([11.74493075, 100.3109463]), array([13.41957314, 101.40436883]), array([14.979914, 102.65550288]), array([16.60616772, 103.81967591]), array([18.60133078, 103.95868797]), array([20.23496746, 105.1124779]), array([21.2829415, 106.8159304]), array([23.26630285, 107.073375]), array([23.19824906, 109.07221684]), array([24.97809099, 109.98444636]), array([26.96378915, 110.22319904]), array([28.27067695, 111.73714893]), array([27.02779308, 113.30406937]), array([28.00575953, 115.04865575]), array([29.68761855, 116.1309451]), array([31.63229581, 116.59809643]), array([33.09832299, 117.95852441]), array([33.94990787, 119.76816615]), array([35.86066518, 120.35893385]), array([37.67662918, 121.1969522]), array([39.59094158, 120.61780795]), array([41.41779902, 121.43180542]), array([43.33474458, 122.00217349]), array([44.21056157, 123.80021258]), array([45.93010386, 124.82157165]), array([47.68162862, 123.8560868]), array([49.67360581, 123.67712626]), array([51.66983087, 123.79994933]), array([53.64914636, 124.08684686]), array([54.03640754, 122.12469784]), array([54.565823, 120.19604047]), array([54.40917293, 118.20218471]), array([55.51979434, 116.53889878]), array([56.94812746, 115.13894717]), array([58.93347256, 115.38061805]), array([60.09984206, 113.75593894]), array([61.95843808, 114.49460045]), array([63.92878196, 114.15146053]), array([65.66966737, 113.16692105]), array([65.53809445, 111.1712536]), array([66.90932408, 109.71532458]), array([68.54008873, 108.55747889]), array([70.363866, 107.73660344]), array([70.52485345, 105.74309321]), array([71.2392916, 103.87505195]), array([72.61297152, 102.42143458]), array([74.5690792, 102.83813922]), array([75.65618783, 101.15939123]), array([76.7799581, 99.50496069]), array([77.13240469, 97.53626026]), array([78.3033782, 95.91489632]), array([77.3052876, 94.18174453]), array([78.93744127, 93.02585769]), array([79.46313894, 91.09618363]), array([81.06587716, 89.8998433]), array([80.00509769, 88.20433544]), array([81.06822925, 86.51030141]), array([82.27252843, 84.91353484]), array([81.41550716, 83.10646136]), array([79.52422273, 82.45604366]), array([78.79813772, 80.5924985]), array([76.87656465, 81.14707669]), array([75.15351731, 80.13164188]), array([75., 80.])]

Box Robot
Samples = 1000
step_size = 2
Probability = 0.05 towards the goal
Start: -50 50
Goal: 75 80

Run_time = 2.54233407974 seconds

plan: [array([-48.23171229, 50.93442955]), array([-46.23179599, 50.95272661]), array([-44.85899648, 49.49827774]), array([-43.04382556, 48.65854296]), array([-41.24352021, 49.52969202]), array([-39.26282096, 49.25250894]), array([-37.40800506, 48.50440601]), array([-35.43069713, 48.20398408]), array([-33.51183653, 47.64009223]), array([-32.10933708, 49.06592367]), array([-30.2153999, 49.70857594]), array([-28.22194201, 49.54694165]), array([-26.79271287, 48.1479048]), array([-24.8187917, 48.46982902]), array([-23.23704689, 47.24586686]), array([-23.02219986, 45.25744016]), array([-23.00027278, 43.25756036]), array([-23.02950902, 41.25777406]), array([-22.10265186, 39.48550552]), array([-21.4620125, 37.5908865]), array([-19.65437964, 36.73504572]), array([-19.03552882, 34.83319829]), array([-17.76558746, 33.28812582]), array([-16.50144472, 31.73830546]), array([-16.75266524, 29.75414613]), array([-15.30038982, 28.37904755]), array([-13.86015743, 26.99134057]), array([-11.87181965, 26.77567208]), array([-9.87706482, 26.92042415]), array([-8.00909125, 27.63503924]), array([-6.56516408, 26.25117713]), array([-4.84515674, 27.27175284]), array([-2.84543007, 27.23868859]), array([-0.85034419, 27.0985733]), array([0.79008648, 28.2426831]), array([2.61090458, 27.41526457]), array([4.22903445, 28.59070309]), array([5.54624556, 30.0956798]), array([7.2613989, 29.06696749]), array([8.74320038, 27.72373839]), array([10.24688342, 26.40505067]), array([12.03581473, 27.29932398]), array([13.99123555, 27.71923995]), array([15.50990208, 29.0206438]), array([16.37635018, 30.82321632]), array([15.87873896, 32.7603232]), array([17.44121542, 34.00878918]), array([19.00369188, 35.25725516]), array([20.01886242, 36.98045822]), array([20.99925912, 38.72368004]), array([22.99662032, 38.62097549]), array([24.63104061, 39.77365512]), array([24.92605601, 41.75177693]), array([26.81543039, 42.4077224]), array([28.39230306, 43.63795514]), array([29.6828378, 45.16586877]), array([31.66246031, 45.45064014]), array([33.53507982, 46.15299061]), array([34.61544815, 47.83608427]), array([36.17989806, 49.08207643]), array([36.96752339, 50.92045788]), array([36.03410209, 52.68927801]), array([35.79238533, 54.67461753]), array([37.47238991, 55.75978323]), array([38.86993439, 57.19047168]), array([39.28840093, 59.14620319]), array([41.2865713, 59.0606744]), array([42.09604791, 60.88953952]), array([43.82551304, 61.89400473]), array([43.60216898, 63.88149496]), array([45.38141136, 64.79489332]), array([46.31034031, 66.56607682]), array([46.90555284, 68.47545422]), array([47.9068563, 70.20675182]), array([48.95310893, 71.91126215]), array([50.75125149, 72.78686669]), array([52.63652372, 72.11922261]), array([54.52282751, 72.78394664]), array([56.40913129, 73.44867068]), array([58.29543507, 74.11339472]), array([60.11078085, 74.95275144]), array([62.00491045, 75.59483635]), array([63.45672807, 74.21925443]), array([65.24501759, 75.11481045]), array([67.03330711, 76.01036648]), array([69.02106485, 76.23131702]), array([70.71299848, 77.29778811]), array([72.40493212, 78.3642592]), array([73.93436028, 79.6529987]), array([75., 80.])]



Box Robot

Samples = 500

step_size = 2

Start: -50 50

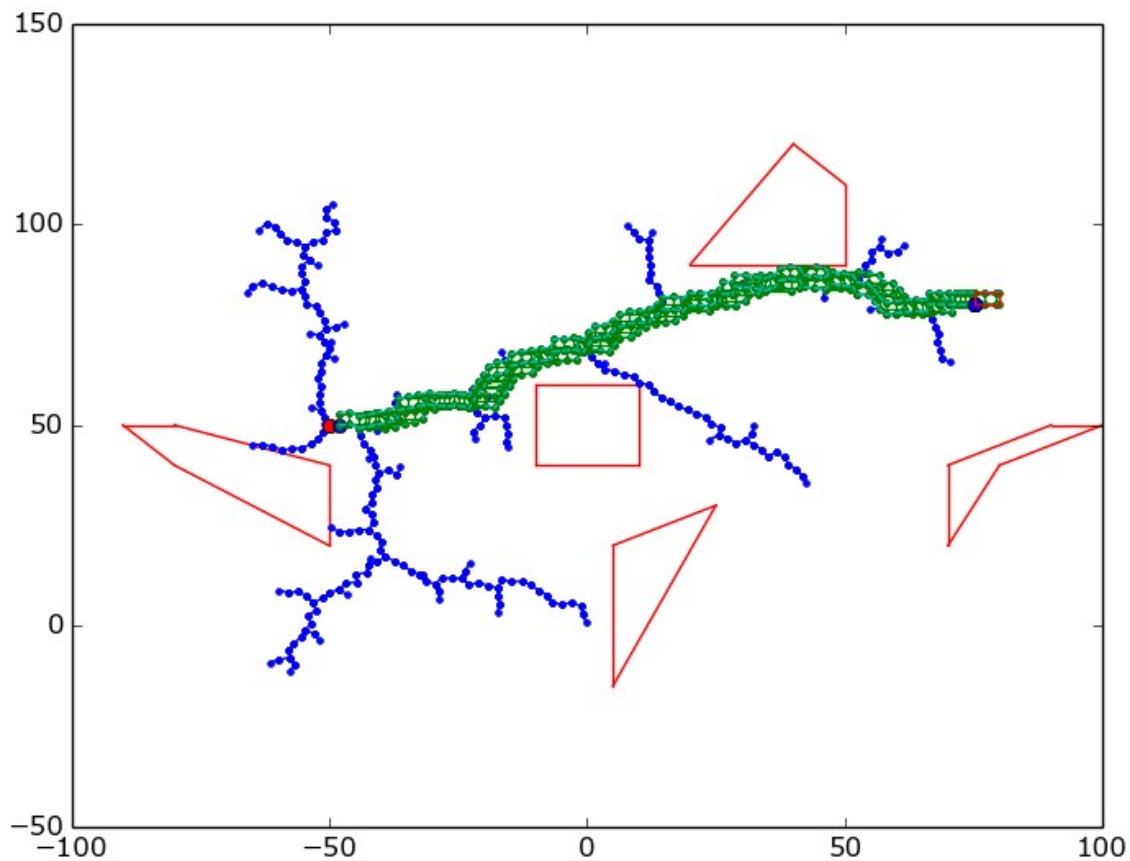
Goal: 75 80

Probability = 0.1 towards the goal

Run_time = 1.89111495018 seconds

plan: [array([-48.00057158, 49.95218789]), array([-46.02734226, 50.27832597]), array([-44.31222078, 49.24956055]), array([-42.34820025, 49.62721562]), array([-40.43492509, 50.20977736]), array([-38.49837273, 50.70954227]), array([-36.764342, 51.70610507]), array([-36.58903996, 53.69840755]), array([-34.62907658, 54.09658285]), array([-32.72452279, 54.70705384]), array([-30.77747106, 55.16420763]), array([-28.81245977, 54.79174205]), array([-26.81405303, 54.71192654]), array([-24.81806367, 54.83852218]), array([-22.89507492, 54.28887296]), array([-22.01438871, 56.08453211]), array([-20.97668719, 57.79426179]), array([-20.02743134, 59.55463485]), array([-19.27005064, 61.40568171]), array([-17.6766046, 62.61437097]), array([-15.71089391, 62.98312764]), array([-14.72864325, 64.72530549]), array([-12.83341612, 65.36414359]), array([-10.86061718, 65.69287499]), array([-8.88781824, 66.02160639]), array([-6.91501929, 66.35033779]), array([-6.63018297, 68.32995096]), array([-4.63982413, 68.52609295]), array([-2.66026336, 68.81129318]), array([-0.72988065, 68.28820373]), array([0.29522341, 70.00551608]), array([1.30131492, 71.73403564]), array([3.29673687, 71.86928076]), array([4.81241711, 73.17416137]), array([6.31529508,

74.49376654]], array([8.13673568, 75.31981384]), array([10.13185412, 75.4594649]),
array([12.09720584, 75.83013001]), array([13.47265591, 77.28207254]), array([14.61815964,
78.92153014]), array([16.6178407, 78.9572461]), array([18.53447013, 78.38581665]),
array([19.91074144, 79.83698076]), array([21.91073269, 79.8428991]), array([23.91073243,
79.84188865]), array([25.68986543, 80.75550004]), array([26.24810961, 82.67601128]),
array([28.24510344, 82.56639547]), array([28.55607037, 84.54207246]), array([30.5465742 ,
84.34740735]), array([32.52583195, 84.06011178]), array([34.44139408, 83.48511462]),
array([36.30248193, 84.21747519]), array([37.24985376, 85.97886289]), array([39.18480079,
86.48480753]), array([41.15280166, 86.12847538]), array([42.16560937, 84.40388252]),
array([44.14785923, 84.13801507]), array([46.13010909, 83.87214763]), array([47.65811075,
85.16257814]), array([49.62338518, 84.79150346]), array([51.58865961, 84.42042878]),
array([52.4085099 , 82.59619045]), array([54.39543291, 82.36785533]), array([55.66230646,
80.82026642]), array([56.60603774, 79.05692548]), array([57.92752758, 77.55570444]),
array([59.90733927, 77.83915753]), array([61.88715097, 78.12261061]), array([63.86696266,
78.40606369]), array([65.84275145, 78.09580787]), array([66.20984164, 80.06183045]),
array([68.20979216, 80.04776269]), array([70.20974268, 80.03369493]), array([72.20969321,
80.01962717]), array([74.20964373, 80.00555941]), array([75., 80.])]



Box Robot

Samples = 250

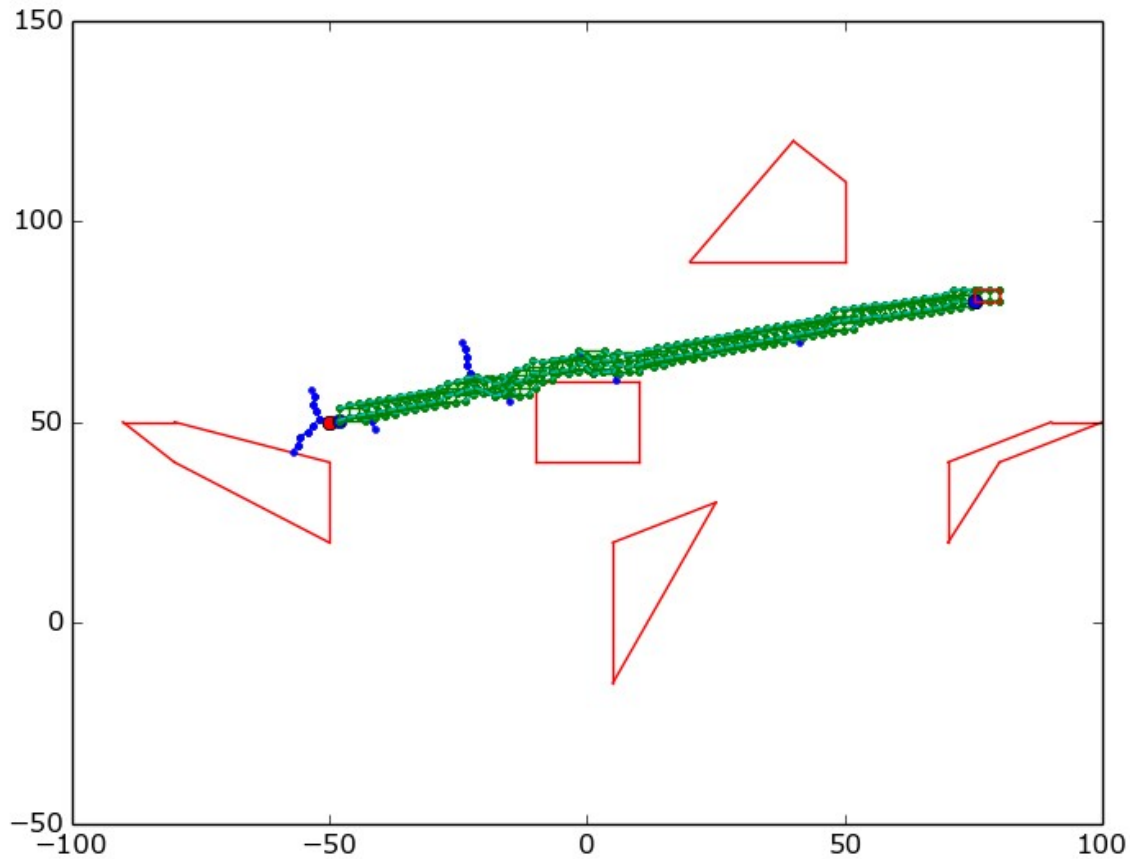
step_size = 2

Start: -50 50

Goal: 75 80

Probability = 0.5 towards the goal

Run_time = 0.342051029205 seconds



plan: [array([-48.0552254, 50.4667459]), array([-46.19591418, 51.20360533]), array([-44.25008572, 51.66593812]), array([-42.30425726, 52.1282709]), array([-40.3584288 , 52.59060368]), array([-38.41260034, 53.05293646]), array([-36.46677188, 53.51526925]), array([-34.52094342, 53.97760203]), array([-32.56183301, 54.37995311]), array([-30.61626169, 54.84336682]), array([-28.67069038, 55.30678053]), array([-27.17529358, 56.63485748]), array([-25.2256213 , 57.08070274]), array([-23.45095291, 58.00295657]), array([-21.49907992, 58.43906647]), array([-19.63434474, 57.71604317]), array([-18.04909768, 56.49662045]), array([-16.11000068, 56.98641921]), array([-15.03392122, 58.67225817]), array([-13.68603751, 60.14982695]), array([-11.7343282 , 60.58666874]), array([-10.7386314 , 62.32119689]), array([-8.76095244, 62.02322716]), array([-6.80548163, 62.44291025]), array([-4.85001081, 62.86259333]), array([-2.89454 , 63.28227641]), array([-1.58805889, 64.79657728]), array([-0.07115427, 63.4931202]),

```
array([ 1.24182803, 61.98445275]), array([ 3.18471246, 62.45900526]), array([ 5.18459349,
62.48082012]), array([ 5.88712035, 64.35337346]), array([ 7.76497977, 63.66515548]),
array([ 9.70844515, 64.13732318]), array([ 11.50148506, 65.02332988]), array([ 13.44807414,
65.48244963]), array([ 15.39466322, 65.94156939]), array([ 17.3412523 , 66.40068914]),
array([ 19.28784139, 66.85980889]), array([ 21.23443047, 67.31892865]), array([ 23.18101955,
67.7780484 ]), array([ 25.12760863, 68.23716816]), array([ 27.07419771, 68.69628791]),
array([ 29.02078679, 69.15540766]), array([ 30.96737587, 69.61452742]), array([ 32.91396496,
70.07364717]), array([ 34.86055404, 70.53276692]), array([ 36.80714312, 70.99188668]),
array([ 38.7537322 , 71.45100643]), array([ 40.70032128, 71.91012618]), array([ 42.64691036,
72.36924594]), array([ 44.59349944, 72.82836569]), array([ 46.54008853, 73.28748544]),
array([ 47.76330535, 74.86980671]), array([ 49.72874434, 75.24000882]), array([ 51.69418332,
75.61021094]), array([ 53.6596223 , 75.98041305]), array([ 55.62506128, 76.35061516]),
array([ 57.62418599, 76.40977934]), array([ 59.58281356, 76.81447435]), array([ 61.54144113,
77.21916935]), array([ 63.5000687 , 77.62386436]), array([ 65.45869627, 78.02855937]),
array([ 67.41732383, 78.43325437]), array([ 69.3759514 , 78.83794938]), array([ 70.99640457,
80.01018294]), array([ 72.9963981 , 80.00509606]), array([ 74.99639163, 80.00000918]), array([ 75.,
80.])]
```

Comments:

The more the probability towards the goal the less the explored area implies less of nodes which resulted in less time to reach goal. And also random samples required are becoming less. Being greedy is not always will fetch faster solution. Since in this environment less number of obstacles and initial and goal is in very open area resulted in reduced time for execution.

1.3 RRT CONNECT

Box Robot

Samples = 250

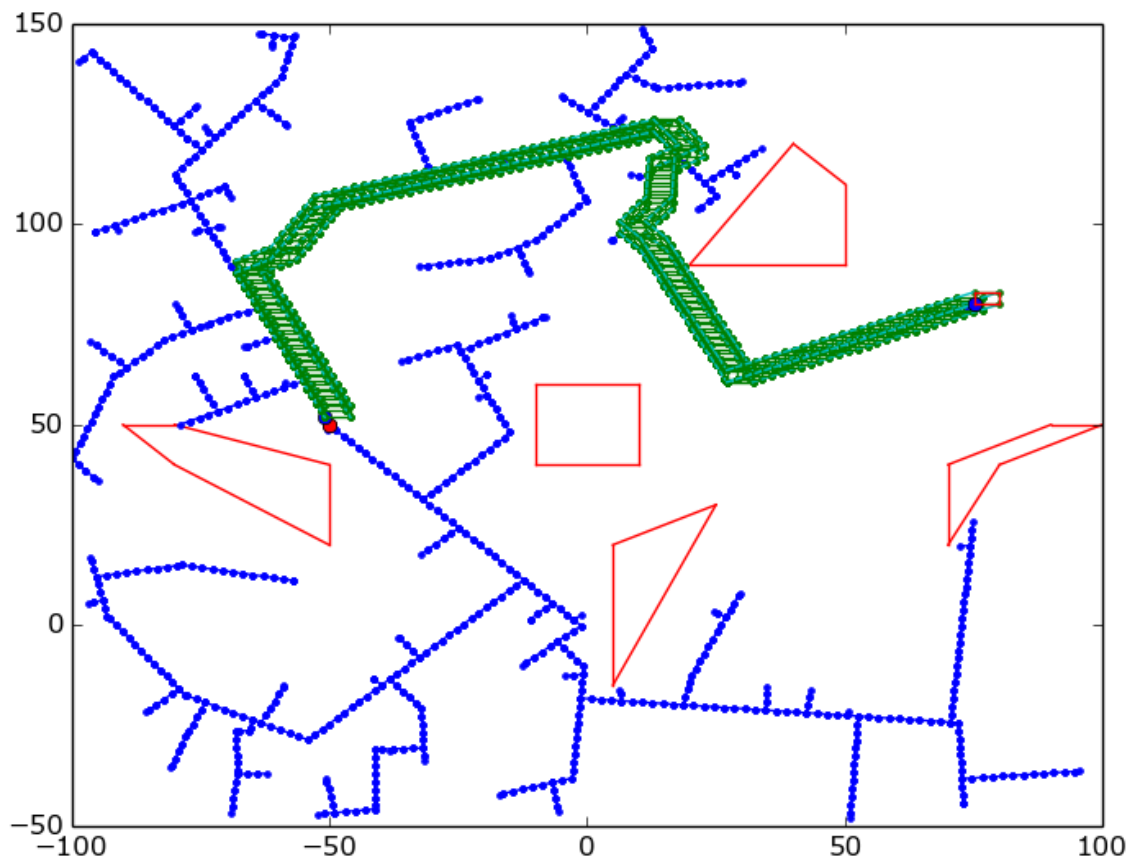
step_size = 2

Start: -50 50

Goal: 75 80

Probability = 0.05 towards the goal

Run_time = 3.6233549118 seconds



plan: [array([-50.8665396 , 51.80252854]), array([-51.7330792 , 53.60505707]), array([-

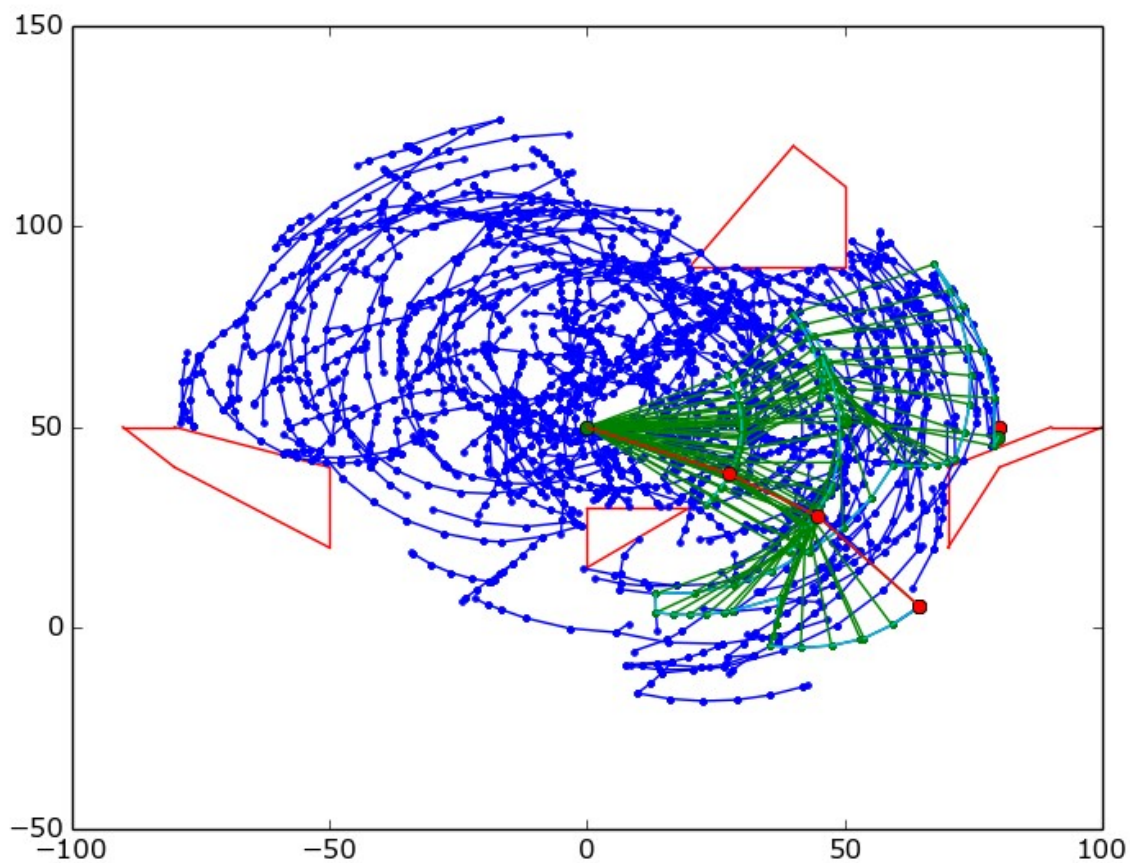
52.59961879, 55.40758561]), array([-53.46615839, 57.21011415]), array([-54.33269799, 59.01264268]), array([-55.19923759, 60.81517122]), array([-56.06577719, 62.61769976]), array([-56.93231678, 64.42022829]), array([-57.79885638, 66.22275683]), array([-58.66539598, 68.02528537]), array([-59.53193558, 69.8278139]), array([-60.39847518, 71.63034244]), array([-61.26501477, 73.43287098]), array([-62.13155437, 75.23539951]), array([-62.99809397, 77.03792805]), array([-63.86463357, 78.84045658]), array([-64.73117317, 80.64298512]), array([-65.59771276, 82.44551366]), array([-66.46425236, 84.24804219]), array([-67.33079196, 86.05057073]), array([-68.19733156, 87.85309927]), array([-66.39968466, 88.72972098]), array([-64.60203776, 89.60634269]), array([-62.80439086, 90.4829644]), array([-61.3734047 , 91.18078416]), array([-60.26695391, 92.84684738]), array([-59.16050312, 94.5129106]), array([-58.05405233, 96.17897382]), array([-56.94760154, 97.84503704]), array([-55.84115075, 99.51110026]), array([-54.73469996, 101.17716348]), array([-53.62824917, 102.8432267]), array([-52.80223602, 104.08701463]), array([-50.88051288, 104.64107256]), array([-48.95878975, 105.1951305]), array([-47.03706661, 105.74918843]), array([-45.11534347, 106.30324636]), array([-43.19362034, 106.85730429]), array([-41.2718972 , 107.41136222]), array([-39.35017407, 107.96542015]), array([-37.42845093, 108.51947808]), array([-35.5067278 , 109.07353602]), array([-33.58500466, 109.62759395]), array([-31.66328153, 110.18165188]), array([-29.74155839, 110.73570981]), array([-27.81983526, 111.28976774]), array([-25.89811212, 111.84382567]), array([-23.97638899, 112.3978836]), array([-22.05466585, 112.95194153]), array([-20.13294272, 113.50599947]), array([-18.21121958, 114.0600574]), array([-16.28949645, 114.61411533]), array([-14.36777331, 115.16817326]), array([-12.44605017, 115.72223119]), array([-10.52432704, 116.27628912]), array([-8.6026039 , 116.83034705]), array([-6.68088077, 117.38440499]), array([-4.75915763, 117.93846292]), array([-2.8374345 , 118.49252085]), array([-0.91571136, 119.04657878]), array([1.00601177, 119.60063671]), array([2.92773491, 120.15469464]), array([4.84945804, 120.70875257]), array([6.77118118, 121.26281051]), array([8.69290431, 121.81686844]), array([10.61462745, 122.37092637]), array([12.53635058, 122.9249843]), array([12.92566202, 123.03722788]), array([14.14154985, 121.44926793]), array([15.35743767, 119.86130799]), array([16.5733255 , 118.27334804]), array([17.78921332, 116.68538809]), array([16.04271771, 115.71083534]), array([14.29622209, 114.73628259]), array([12.54972647, 113.76172984]), array([11.94743031, 113.42564576]), array([11.84716301, 111.42816072]), array([11.7468957 , 109.43067569]), array([11.64662839, 107.43319065]), array([11.54636109, 105.43570561]), array([11.46298928, 103.77480593]), array([10.17279069, 102.24660842]), array([8.88259211, 100.71841092]), array([7.59239352, 99.19021341]), array([6.30219494, 97.66201591]), array([7.70581846, 96.23729102]), array([9.10944197, 94.81256612]), array([10.38829306, 93.51448943]), array([11.29388967, 91.73126348]), array([12.19948629, 89.94803754]), array([13.1050829 , 88.16481159]), array([14.01067952, 86.38158565]), array([14.91627613, 84.5983597]), array([15.82187275, 82.81513376]), array([16.72746936, 81.03190781]), array([17.63306598, 79.24868187]), array([18.53866259, 77.46545592]), array([19.44425921, 75.68222998]), array([20.34985582, 73.89900403]), array([21.25545244, 72.11577809]), array([22.16104905, 70.33255214]), array([23.06664567, 68.5493262]), array([23.97224228, 66.76610025]), array([24.87783889, 64.98287431]), array([25.78343551, 63.19964836]), array([26.68903212, 61.41642242]), array([27.11506515, 60.57751341]), array([28.96841328, 61.32924523]), array([30.82176141, 62.08097705]), array([32.67510953, 62.83270887]), array([34.52845766, 63.58444068]), array([36.38180578, 64.3361725]), array([38.23515391, 65.08790432]), array([40.08850203, 65.83963614]), array([41.94185016, 66.59136795]), array([43.79519828, 67.34309977]), array([45.64854641, 68.09483159]), array([47.50189454, 68.84656341]), array([49.35524266, 69.59829522]), array([51.20859079, 70.35002704]), array([53.06193891, 71.10175886]), array([54.91528704, 71.85349068]), array([56.76863516, 72.6052225]), array([58.62198329, 73.35695431]), array([60.47533141,

```
74.10868613]), array([ 62.32867954, 74.86041795]), array([ 64.18202766, 75.61214977]),
array([ 66.03537579, 76.36388158]), array([ 67.88872392, 77.1156134 ]), array([ 69.74207204,
77.86734522]), array([ 71.59542017, 78.61907704]), array([ 75., 80.])]
```

```
RRT_connect
RRR Robot
Samples = 3000
step_size = 0.15
Probability = 0.05 towards the goal
Run_time = 23.9294390678 seconds
```

```
Start: 0 0 0
Goal: -0.4 -0.15 -0.3
```

Few time run_time is around 110 seconds may because of randomness of sample generation.



```
plan: [array([ 0.03146586, -0.01042882, -0.14629128]), array([ 0.06293171, -0.02085763,
-0.29258257]), array([ 0.15924196, 0.0883338 , -0.32865982]), array([ 0.2555522 , 0.19752523,
```

-0.36473708]], array([0.35186244, 0.30671666, -0.40081434]), array([0.44817268, 0.4159081 ,
-0.4368916]), array([0.35980375, 0.47416271, -0.5431805]), array([0.27143481, 0.53241733,
-0.6494694]), array([0.18306588, 0.59067195, -0.75575831]), array([0.09469695, 0.64892657,
-0.86204721]), array([0.00632801, 0.70718119, -0.96833611]), array([-0.08204092, 0.76543581,
-1.07462502]), array([-0.17040985, 0.82369042, -1.18091392]), array([-0.09974566, 0.74902759,
-1.29014776]), array([-0.02908146, 0.67436475, -1.39938161]), array([0.04158273, 0.59970192,
-1.50861545]), array([0.11224693, 0.52503908, -1.61784929]), array([0.18291112, 0.45037624,
-1.72708313]), array([0.05985169, 0.43371897, -1.81121941]), array([-0.06320773, 0.4170617 ,
-1.89535568]), array([-0.18626716, 0.40040443, -1.97949196]), array([-0.19126659, 0.39972771,
-1.98291009]), array([-0.29887769, 0.29889912, -2.01035907]), array([-0.4064888 , 0.19807053,
-2.03780805]), array([-0.5140999 , 0.09724195, -2.06525703]), array([-0.62171101, -0.00358664,
-2.092706]), array([-0.69349165, 0.0618228 , -1.97838564]), array([-0.60966152, -0.01760041,
-1.88265444]), array([-0.52583139, -0.09702361, -1.78692323]), array([-0.44200126, -0.17644682,
-1.69119203]), array([-0.35817113, -0.25587003, -1.59546082]), array([-0.32023859, -0.29180847,
-1.55214312]), array([-0.19564206, -0.2412242 , -1.48568309]), array([-0.23824644, -0.29582905,
-1.35262981]), array([-0.28085083, -0.3504339 , -1.21957652]), array([-0.32345521, -0.40503875,
-1.08652324]), array([-0.36121172, -0.45343021, -0.96860985]), array([-0.38841814, -0.36106594,
-0.85359398]), array([-0.41562456, -0.26870166, -0.73857811]), array([-0.44283097, -0.17633739,
-0.62356223]), array([-0.44598476, -0.16563046, -0.61022952]), array([-0.4240181 , -0.15816388,
-0.46203466]), array([-0.4 , -0.15, -0.3])]

Comments:

since we are extending towards random config until collision is reached results in lesser number of random samples needed. Execution time is becoming less when compared to RRT

Question – 1.4 : RRT Bi-Connect

RRT_Bi-Connect

Box Robot

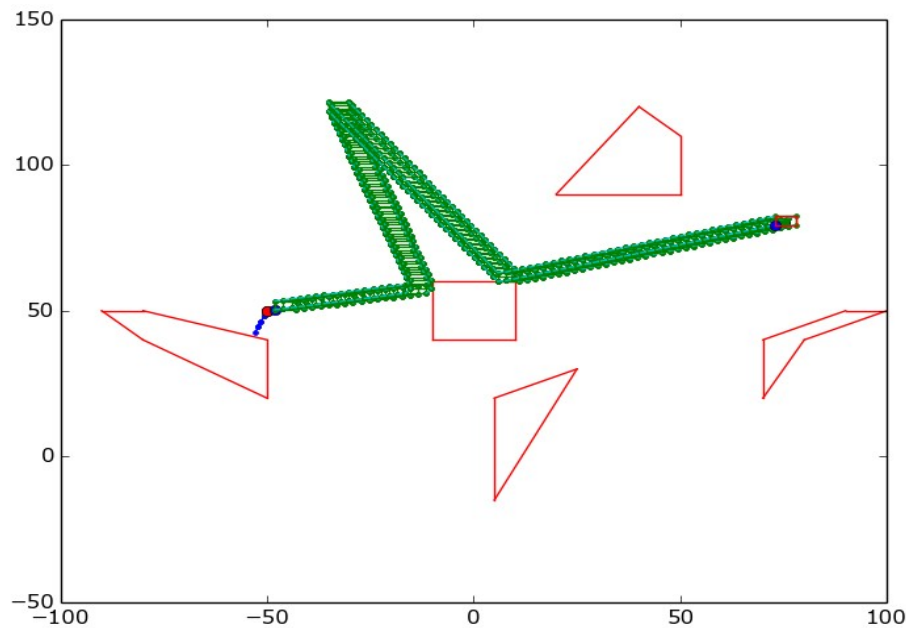
Samples = 10

```
step_size = 2
```

Probability = 0.05 towards the goal

Start: -25 75

Goal: 75 80

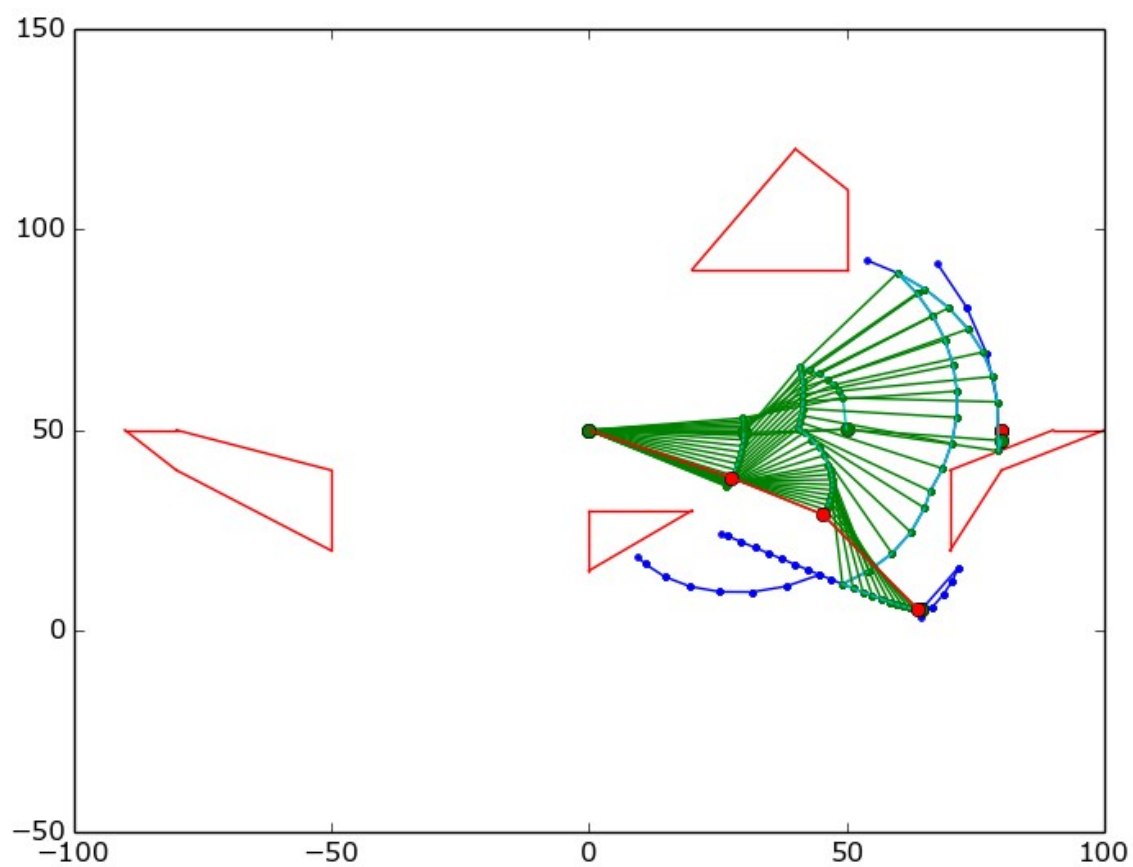


Run_time = 0.307993888855 seconds

```
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array([-24.03022631, 102.64110637]), array([-22.88141944, 101.00396166]), array([-21.73261257,
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array([4.68994538, 61.71248878]), array([5.83875225, 60.07534407]), array([7.82398166,
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array([13.58192609, 62.00499522]), array([15.5012409 , 62.56733912]), array([17.42055571,
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array([23.17850014, 64.81671471]), array([25.09781495, 65.37905861]), array([27.01712976,
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68.75312201]), array([38.53301862, 69.31546591]), array([40.45233343, 69.87780981]),
array([42.37164824, 70.44015371]), array([44.29096304, 71.00249761]), array([46.21027785,
71.56484151]), array([48.12959266, 72.12718541]), array([50.04890747, 72.68952931]),
array([51.96822228, 73.25187321]), array([53.88753709, 73.81421711]), array([55.8068519 ,
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array([61.56479633, 76.0635927]), array([63.48411114, 76.6259366]), array([65.40342595,
77.1882805]), array([67.32274076, 77.7506244]), array([69.24205557, 78.3129683]),
array([71.16137038, 78.8753122]), array([73.08068519, 79.4376561])]

RRT Bi-Connect
RRR Robot
Samples = 20
step_size = 0.15
Start: 0 0 0
Goal: -0.4 -0.15 -0.3

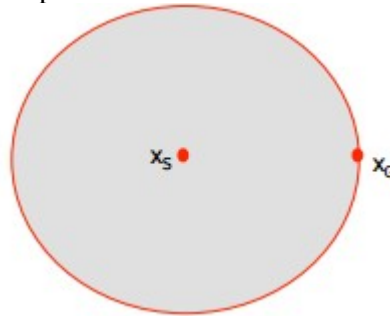


Run_time = 0.120750904083 seconds

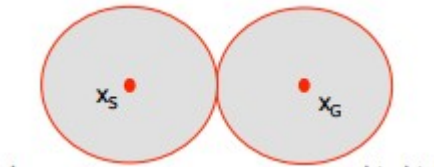

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-0.25815126]), array([ 0.05668781, 0.44445893, -0.22770313]), array([ 0.03478269, 0.5896935 ,
-0.19725501]), array([ 0.01287758, 0.73492806, -0.16680689]), array([-0.00902754, 0.88016262,
-0.13635876]), array([-0.03093266, 1.02539718, -0.10591064]), array([-0.08153571, 1.05404213,
-0.24418138]), array([-0.13213876, 1.08268709, -0.38245212]), array([-0.1827418 , 1.11133205,
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-0.79726435]), array([-0.33455095, 1.19726692, -0.93553509]), array([-0.38515399, 1.22591187,
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-1.34334439]), array([-0.47988139, 1.19998799, -1.39528363]), array([-0.47382252, 1.07347776,
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-1.63637713]), array([-0.45564588, 0.69394709, -1.71674163]), array([-0.45058717, 0.61722462,
-1.58794694]), array([-0.44552845, 0.54050216, -1.45915224]), array([-0.44046973, 0.4637797 ,
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-1.07276816]), array([-0.42529358, 0.23361231, -0.94397347]), array([-0.42023487, 0.15688985,
-0.81517878]), array([-0.41517615, 0.08016739, -0.68638408]), array([-0.41011743, 0.00344492,
-0.55758939]), array([-0.40505872, -0.07327754, -0.42879469])]
```

Comments:

For a Unidirectional RRT : Volume swept



For a Bi-directional RRT: Volume Swept



Hence reducing the number of samples and time consuming for execution.