# Proposed Modified Directed RRT Algorithm of the Basic RRT

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**Abstract:** Due to the development of intelligent systems and the increasing use of path planning algorithms, problems in motion planning appear and finding algorithms to solve such issues efficiently have become the new challenges for researchers. This paper presents Directed (Rapidly Exploration Randomly Tree) algorithm as a modification of the traditional RRT searching algorithm. The fundamental idea is to enhance and utilize RRT algorithm in term of solving path planning problems. This work accomplished by taking the searching directions of the basic RRT algorithm into consideration. The experiment result of the enhanced algorithm simulation shows promising result and encourage researcher to search further in this field.

**Keywords**: Artificial intelligent, Motion planning, Robot, RRT Algorithm.

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# 1. Introduction

A Rapidly-exploring Random Tree (RRT), is a popular algorithm in matters of solving path planning motions problems. RRT for many types of problems was successfully capable of finding feasible solutions. It's a probabilistic algorithm; finds a path that is near to optimal [1].

It also has been used to solve path planning problems in many different fields such as traffic growth in the airspace Air Traffic (AT) industry and specially in air traffic systems. Due to the rapid of AT and the importance of safety in aviation rules, introducing new AT systems have become a necessity [2].

Currently, Air Traffic Control operators (ATCO) have many responsibilities and their performance is limited by their capacity specially in heavily loaded traffic. An additional reason that complicates AT controlling issue is the frequency of abnormal situations where the ATCO may unable to control and observe such situation [3], therefor for such matters finding a new technique is highly requested [4] .

AT is extremely busy and rapidly growing daily. In fact, the aviation industry is planning for increase in flights and growth though worldwide [5],[6]. Current AT systems currently developed algorithms that employed as the solution to control and manage the crowded airspace by enabling the route generation outside of the ATCO [7] .

The main purpose of AT is to reduce flight paths in term of time , length , and best suitable path for flying aircrafts. It will make the decisions of choosing the best path based on these AT systems algorithms more secure and reliable [3].

The basic idea of this paper is to find an algorithm that work with such circumstances perfectly and for such goals. Representing and developing a basic RRT algorithm that helps to serve widely and solve this kind of problem.

This paper organized as following, second section review some of the previous works related with the RRT algorithm field, third section explain the different in proposed enhancements and then view a comparison of the proposal over a traditional algorithm. It provides some promising results for future researcher in a direction under this work.

## 2. Related work

'LaValle' 1998 was the first one who introduce the basic RRT algorithm and use it in path planning. In this paper, the author efficiently covered the whole space of RRT algorithm and how it's probabilistic worked [1].

'Karaman' and 'Frazzoli' in 2011 enhanced the RRT algorithm, by introducing a RRT* that changed the length of the generated path and reduced it by allowing algorithm rewiring of the connections path of the tree . RRT* is asymptotically optimal, but its convergence is slow especially in large environments [8].

'Gammell et al' in 2014 proposed Informed RRT* that works by sampling new generated nodes inside the ellipsoid, it successfully employed and enhanced the basic performance of a RRT by adopting the work of 'Karaman and Frazzoli' and developed it. This method increased the convergence rate of RRT* especially in large environments [9].

RRT is powerful algorithm when it used in air traffic management and controlling, such as the work that done by Frazzoli that adapted RRTs for matters of real time rout planning for an autonomous helicopter controlling with considering the moving obstacles and avoid them [10].

RRT can be adopted in other field not only AT Bruce. For example, RRT can be used with a robot soccer team [11]. In this paper an enhancement was applied to the basic RRT in attempt to project a new RRT method without manipulated its basic traditional aspects.

## 3. Traditional Rapidly Exploring Random Tree

RRT is a structural algorithm for historical data and path generation method that is designed for efficiently searching paths in a high-dimensional spaces [12]. It is a rapidly searching algorithm that have benefits over conventional road map motion planners algorithm due to it feasibility feature in generating solutions [5]. RRT construct by the expansion generation technique in which the tree is sampled to random point in W while satisfying constraints existing in workspace such as existing of obstacles or highly dynamical constraints in which it prove it ability in finding a feasible path as it shown in Fig.1 [13].

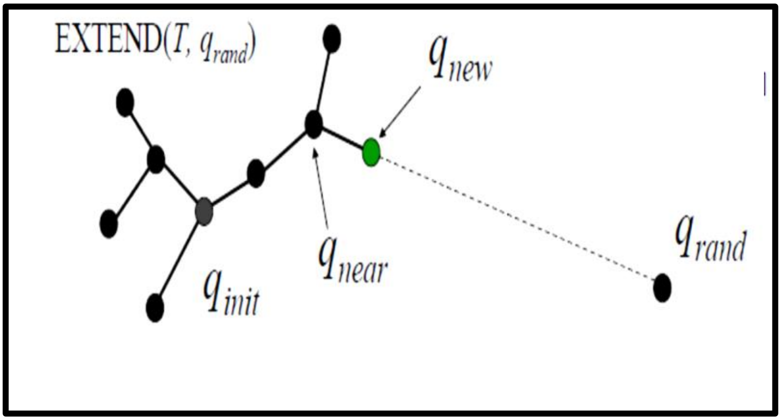



**Figure 1. Basic RRT expansion tree.**

Algorithm 1, start with a root tree Ʈ containing only the began node $R_{root}$, then it rapidly insert random point to tree Ʈ by an expansion technique and continue till it reach to a specific count node called $M_{nodes}$ , in which either the problem solved, or it have been reached to a set of goal points .

**Algorithm 1: traditional RRT method**

**Input:** workspace W , a root tree node $n_{root}$, number of generating iterations $M_{nodes}$ nodes, a step random size $n_R$, array of nodes distance *A.*

**Output:** generating path of tree Ʈ with having $M_{nodes}$ rooted at $n_{root}$,

Step 1: Ʈ =$n_{root}$,

Step 2: While number of nodes (Ʈ) < $M_{nodes}$ do // till stopping condition reached

Step 3: $n_{rand}$ = random CFG() // picking points randomly from the configuration space graph (CFG)

Step 4: $n_{near}$=nearest neighbor ($n_{rand}$, Ʈ, *A*) // choosing the nearest neighbors points to the picked random point

Step 5: $n_{new}$=expand($n_{near}$, $n_{rand}$, $\alpha_n$) // picking the most nearest point from q nearest

Step 6: If is valid ($n_{new}$) then // if the new point is accepted

1. $T$. Add node($n_{new}$) // add it to the path

2. $T$. add edge(: $n_{near}$, $n_{new}$)

Step 7: return $T$

Basically as it shown in figure1, RRT generate new nodes by using a randomly sampling generation model, then determine the nearest neighbor of the sampling random points in tree Ţ, and operate an expansion technique over that neighbor and applying verification check If new picked node valid, then add to Ţ with the edge that connecting it with the nearest neighbor. RRTs have been shown to have computational steps and randomization approaches thus it known to be a probabilistically complete [4].

For better understanding of RRT, consider the special case where the W is a square work space environment. Fig.2 shows the generation of an RRT for the case of W =(100*100) and (X,Y) initial position =(50,50) [1].

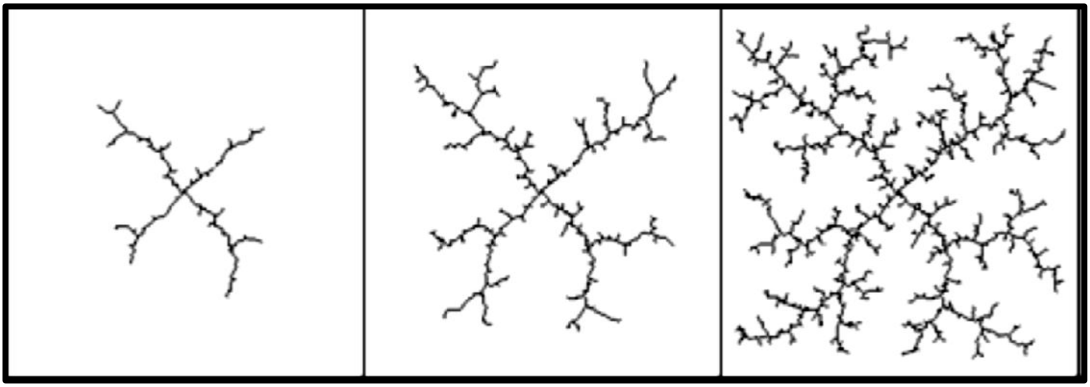


**Figure 2. Example of Construction of an RRT in a Squared Configuration Space**

## 4. Proposed Directed Rapidly Exploring Random Tree

The traditional RRT are able to covering the whole space efficiently and quickly. It proved it ability to be an useful solution method for many type of planning problems and effectively find a feasible path and thus to be a probabilistically complete .This paper combine the principles of the traditional RRT aspect and kept it basic concept and introduced a new methodology of a modified RRT path planning algorithm that called Directed RRT.

Directed RRT algorithm change the basic RRT expansion directions by make it expand only toward the goal than expand on the whole entire work space, via using a heuristic function, that calculate the heuristic value firstly for the current point and the goal point, secondly for each produced new RRT random point and the goal point. If the value of the new random point is less than the current, reject and search for new random point, otherwise accept and add the new random generated point to path. This is done by :

1- Calculating Euclidean distance between the current point and the goal point by using equation 1 :

$$D\ current = \sqrt{(x_{goal} - x_{currentl})^2 + (y_{goal} - y_{urrent})^2} \quad (1)$$

2- Calculating Euclidean distance between each new random generated point and the goal point by using equation 2 :

$$D\ new = \sqrt{(x_{goal} - x_{new})^2 + (y_{goal} - y_{new})^2} \quad (2)$$

3- For each Directed RRT iteration update $D\ current$ , and $D\ new$ then check if $D\ new$ is less than $D\ current$, if yes reject, and search for new random generated point otherwise accept and add to path. The directed RRT algorithm is shown in algorithm 2.

**Algorithm 2: Modified Directed RRT algorithm**

**Input:** an workspace W , a root tree node $n_{root}$, number of generating iterations $M_{nodes}$ nodes, a step random size $n_R$, array of nodes distance *A.*

**Output:** generating path of tree $T$ with having $M_{nodes}$ rooted at $n_{root}$,

Step 1: $T = n_{root}$,

Step 2: $D -_{current}$ =distance($n_{root}$ , $n_{goal}$) // calculating distance from start point to the current

Step 3: While number of nodes ($T$) < $M_{nodes}$ do // till terminal condition is reached

Step 4: $n_{rand}$ = random CFG( ) // picking points randomly from the configuration space graph (CFG)

Step 5: $n_{near}$=nearest neighbor ($n_{rand}$, $T$, $A$) // choosing the nearest neighbors points to the picked random point

Step 6: $n_{new}$=expand($n_{near}$, $n_{rand}$, $\alpha_n$) // picking the most nearest point from q nearest
Step 7: $D -_{new}$ =distance($n_{new}$, $n_{goal}$) // calculating distance from the new random point to the goal point
Step 8: If ($D -_{new} \geq D -_{current}$ ) then // if the new distance is less than the current distance then add to path
1. $T$. add node($n_{new}$)
2. $T$. add edge($n_{near}$, $n_{new}$)
Step 9: Otherwise return to step 4
Step 10: Update $D -_{current} = D -_{new}$
Step 11: return $T$

## 5. Simulation

The proposal modification Directed RRT algorithm was simulated using MATLAB programming language in a tow dimension work space and run on a laptop with inter® Pentium® CPU P6200 @ 2.13GHz 2.13GHz,4.00GB memory and windows 7 ultimate.

The execution of the proposal is a simulation to the free flying air traffic environment of 2D work space (X,Y) with coordination (0,0),(100,100) and initial state at (50,50) which it represent the plane take off point (source), goal state at (100,100) which it represent the plane landing point (destination) . The task of the basic and modified RRT is to find the nearest optimal generation rout from the source (start position) to the destination (goal position), the best free flying air traffic route from takeoff point till landing .

Figure(3- a, c ,e) display the original RRT path planning execution, Figure(3- b, d, f) display the Directed RRT path planning execution.

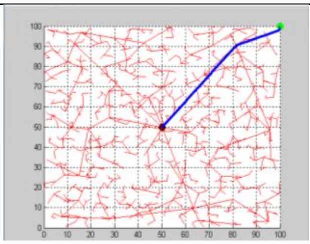
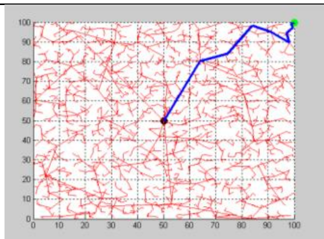


Fig.3.a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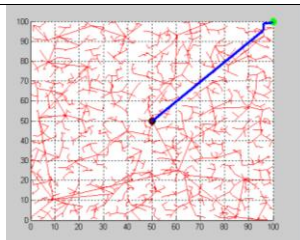
Fig.3.c

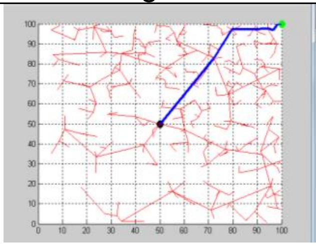
Fig.3.d

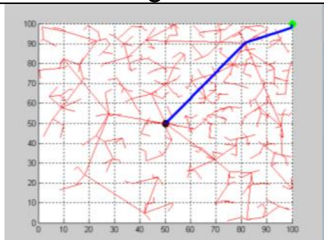
Fig.3.e

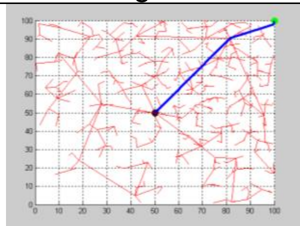
Fig.3.f

**Figure 3. Path Planning Using Proposal Directed and Original RRT Algorithm**

where Fig.3.a shows the found path and view the first try of how the basic RRT algorithm searching technique works to find the flight route for single plane from the start to the goal, and how the search expanding in the entire environment till it reach to it desired goal, Fig.3.b show different path and view the second execution try and Fig.3.c view the last execution try.

while Fig.3.d show the found path and view the first try of how the modified Directed RRT algorithm searching technique works to find the flight route for single plane form source to destination, and how it's clear that the search expanding only in the goal directions , Fig.3.e view the second modified technique execution try and Fig.3.f view the last execution try.

## 6. Experimental Results

Table 1 clears the different of the execution between the modified RRT path planning and the basic RRT path planning with taking in to consideration two execution measuring units time(seconds) and length (units) .In the three experiment of the both original and modified RRT algorithm it has been shown huge different in time and length where Directed RRT been used, where the path is shorter and the time is much less than using the original RRT algorithm, also after the second and third try it was notable that the expanding technique is directed only to the goal not on the entire work space therefor it take less storage space. It appears that the resulted searched path is pretty much enhanced and it shows an promising improve in the proposed Directed RRT over original RRT execution behaves in term of finding the best or more suitable flight routs while keeping it basic aspect.

**Table 1. Simulation result**

| Original RRT | | | Directed RRT | | |
|---|---|---|---|---|---|
| **Fig No.** | **Execution Time(second)** | **Path length (length units)** | **Fig No.** | **Execution Time(second)** | **Path length (length units)** |
| **3.a** | 4.000905 | 177.5630 | **3.d** | 2.202132 | 101.9544 |
| **3.b** | 12.991486 | 156.7758 | **3.e** | 0.228359 | 123.4794 |
| **3.c** | 7.763487 | 175.2400 | **3.f** | 1.011019 | 163.0060 |

## 7. Conclusion

The basic RRT algorithm covers the whole space efficiently and quickly. It is probabilistic algorithm thus its probabilistic completeness However, it work like tree that expanded in the whole environment searching thus it take time and space while it search for the goal. In this paper, the modified directed RRT intended to reduce the number of expanding nodes. Thus, reduce the data structure memory storage also reduce the amount of searching time till it find a goal. The proposed algorithm shows a promising result by enhance and modify the basic RRT and increase its advantages in many fields that RRT been used for specially in air traffic management systems also opening new direction of more enhancement as a future work.

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# مقترح خوارزمية شجره الاكتشاف العشوائية السريعة الموجهة المعدلة على شجره الاكتشاف العشوائية الاساسية

**علياء كريم عبد الحسن*** **شيلان وعد عدوان***

**المستخلص:** بالنظر للتطور الحاصل في الانظمة الذكية وازدياد استعمال مختلف انواع خوارزميات تخطيط المسار، ظهرت مشاكل تخطيط حركه المسار بصورة متزايدة وكيفية ايجاد الخوارزميات المناسبة التي تحل هكذا مشاكل بفعالية اصبحت من اكبر التحديات للباحثين. هذا البحث يقدم (شجرة الاكتشاف العشوائية السريعة الموجهة) هي عبارة عن تعديل على الخوارزمية البحث التقليدية (شجرة الاكتشاف العشوائية السريعة)، الفكرة الاساسية هي تحسين وتوظيف اداء خوارزميه (شجرة الاكتشاف العشوائية السريعة) التقليدية في حل مشاكل تخطيط المسار. وتم تحقيق هذا عن طريق اخذ اتجاه بحث الخوارزمية الاساسية بنضر الاعتبار و توجيهه نحو احداثيات معينة. النتائج المختبرية لنظام المحاكي لهذا التطوير اظهرت نتائج واعدة واتجاهات لبحوث مستقبلية.

**الكلمات المفتاحية:** الذكاء الاصطناعي، تخطيط الحركة، روبوت، خوارزمية شجرة الاكتشاف العشوائية السريعة الموجهة.

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