Self learning Automated ATC using AI Technique and Entropy Approach

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Abstract: Artificial intelligence consists of a broad range of computer science techniques directed at problems such as pattern matching, language processing and solving highly complex, ill-defined problems. This paper describes how the concept of Entropy and calculation of its efficiency can be used along with the Artificial Intelligence concepts and explore how these techniques might be applied to Air Traffic Control(ATC).Entropy is calculated by assigning some points to the events described in the paper and calculating the total to evaluate and develop a plan based on its efficiency and feasibility.

Key Words-Evaluating parameters,Plan critic,Performance evaluator,Plan efficiency,Plan generator

I. INTRODUCTION

The automated ATC using artificial intelligence provide an enhanced support for controlling air traffic by producing a plan using evaluating parameters and assigning arbitrary values based on a criteria and evaluating them.

As ATC is one of the most stress-giving and challenging area, we need to relieve human and need to automate it with far more efficient system so that we can alleviate stress and reduce risks. Some possible control strategies have been identified, ranging from visual and electronic collision avoidance, through proposed enhancements of the current air traffic control system, to strategies in which aircraft follow predetermined,
deconflicted flight paths. A large number of possible artificial intelligence applications have been found into some functional areas, and ways in which they might be incorporated into the different control strategies. These strategies will come handy in improving the present technologies.

In this project we assume that we already have information about planes, about their arrival time, departure time and their current location. With this information we will be manipulating the information according to the different scenarios.

A. *Possible Scenarios-*

1) *Normal weather*

In this scenario we shall provide a station with respect to their flights arrival and departure. E.g., A flight is going to arrive at a terminal and in that terminal one is going to depart just before 5minutes or at same time, we shall make the first flight to hover so as to have at least a difference of 15minutes or a minimum time to prevent accident. This will be applicable for all flights which come under the range of take-off of the flight. These decisions can be taken easily as the delays due to any intermediary disturbance shall be known to the airport .The delay is decided by the plan generator and hence will provide further advantage for considering the route.

2) *Fog*

The controller will provide the basic route and possibilities to land or divert the flight so as to have the flight landed or to make the flight to hover and help in providing space for other flights having more priority. Here it checks priority parameter to be provided while the plan is generated.

3) *Bad Weather*

In this scenario there can be an environment of *cloud/ snow/rain/thunderbolt etc***.** In this case the flights at runway will be taken informed and the arriving plane will be diverted, as the flights are stranded. The system will provide paths for the diverted flights to safer place.

Here we will be exploring all the possible scenarios and problems that can occur in automating this system and will try to find optimal solution.

The first air traffic control (ATC) system components to be automated were radar data processing, flight data processing and display data processing, but more recently such safety enhancements as conflict alert, en route minimum safe altitude warning, conflict resolution and Mode C intruder have been made. All are algorithm-based and use standard software. A simulation system for control radar training, the Automated En Route Air Traffic Control System (AERA-2) and an automated system for detecting low-level wind shear along with Doppler Weather radars are the first such programs.

The primary responsibility of air traffic control (ATC) is the prevention of aircraft collisions. An important secondary responsibility is to expedite traffic. These and other duties are all currently performed by human air traffic controllers. Our project required the development of a working model of ATC planning and decision making. This report presents the model along with justifications for choosing its particular structure, and mentions some of the problems that result from using a fairly typical rule-based programming system in an ATC environment. Then we discuss better alternatives that might be taken. Finally, a simple example extracted from one of the training scenarios with slight modifications is given to illustrate the operation of the planner.

II. Navigating Aircraft

A pilot must file a flight plan as a prerequisite to entering the ATC system under Instrument Flight Rules (IFR). Under IFR, controllers are responsible for assuring safe separation between aircraft. This procedure consists of chronologically listing either the specific navigational fixes over which the aircraft will fly, or the segments of airways that will be used. Before a flight commences, the ATC system must approve the route and issue a clearance to the pilot. The pilot is expected to navigate the aircraft along the agreed-upon route. Controllers are not responsible for navigating aircraft.

III. Maintaining Aircraft Seperation

Safe distances between aircraft can be maintained either in a horizontal or vertical fashion. Horizontal separation standards may be specified in terms of distances or times; vertical separations are always in terms of altitudes. The horizontal separation standards that apply to a given situation are a function of a large number of variables. For a situation in which many aircraft must be held at the same point the controller separates the vehicles vertically. This procedure results in a holding stack of aircraft. Another delaying tactic which can be performed only when an aircraft is under radar surveillance is to vector the aircraft through path-stretching maneuvers such as S-turns.

Here we can categorise different planes into different categories such as-

Air bus,jumbo, super-sonic etc and can allot a priority score for them which will then be useful for our plan critic to analyse and consider a plan using these parameters to decide the route and separation among the aircrafts.

The flights categories are also considered for maneuvering and conflicts in path due to some delay or other reasons.The controllers must ensure minimum separation of planes from each other.

Figure 1 Sample Priority setting of different flights based on their speed agility and effect.

IV. Issuing Altitude Clearance

Controllers are much more responsible for determining aircraft altitudes. Although pilots indicate preferred cruise altitudes on their flight plans, they do not specify their vertical profiles as a function of their positions along the routes. Before they can change from one assigned altitude to another, pilots must wait for altitude clearances from controllers. To maintain the required minimum separations, controllers use a variety of methods. Under radar surveillance, aircraft may be vectored so that the vehicles remain horizontally separated. Under both radar and non radar conditions, controllers may assign altitudes, speeds and revised routes off light to aircraft or an aircraft might be delayed by holding it at a particular point. The goal is to arrange the aircraft in a sequence with exactly the minimum allowable separation, thus achieving the maximum landing rate possible. Sequencing may also be needed for en route aircraft in areas where heavily travelled airways merge. This goal is implied mostly, mainly only if the traffic is too high.

For example, suppose two aircraft are flying on courses that cross each other. The vehicles are flying level at the same altitude, and their speeds and distances from the crossing point are such that the separation standards discussed earlier are likely to be violated, then possible resolutions to the conflict might be to turn one aircraft so that it travels behind the other. Adjust the altitude of one or both aircraft so they are vertically separated at the crossing point or delay one of the aircraft by either decreasing its speed or by implementing a delaying turn or holding maneuver.

However, other considerations such as the following might invalidate some of the above options:

- There might be other aircraft in the vicinity and the proposed maneuvers might create conflicts with them. In some cases, it is desirable to resolve such secondary conflicts by maneuvering the secondary aircraft. It might be better in other instances to resolve the original conflict another way.
- Severe weather conditions might prohibit some of the proposed options. Also, an aircraft's proximity to the ground, mountains, or other physical obstructions might forbid certain maneuvers.
- If a maneuver forces an aircraft to cross or come close to a sector boundary, the controller is burdened with the additional work of having to coordinate the maneuver with the controller of the adjacent sector. This solution, however, might be acceptable if other options are even less desirable.
- Aircraft that are close to their maximum flying altitude will be unable to climb farther. Furthermore, aircraft without pressurized cabins or oxygen masks are forbidden to climb above 10,000 ft.
- Certain maneuvers, either by themselves or by the secondary conflicts they cause, might result in undue delays.
- Requiring a jet to fly long distances at low altitudes wastes fuel, as in the case of lightning at Ionosphere or Stratosphere.
- It is inefficient to force a climbing aircraft to descend or a descending aircraft to climb.
- If the descent of an arriving aircraft is delayed, the vehicle might not have enough time to reach the appropriate altitude required to approach the airport for landing purposes, as in the case of lightning in lower atmosphere.
- If planes from opposite direction meets and are allotted certain altitude and no altitude is possible for the delayed or affected plane then it must be taken to further distance perpendicular to the planes and must be allotted an altitude.

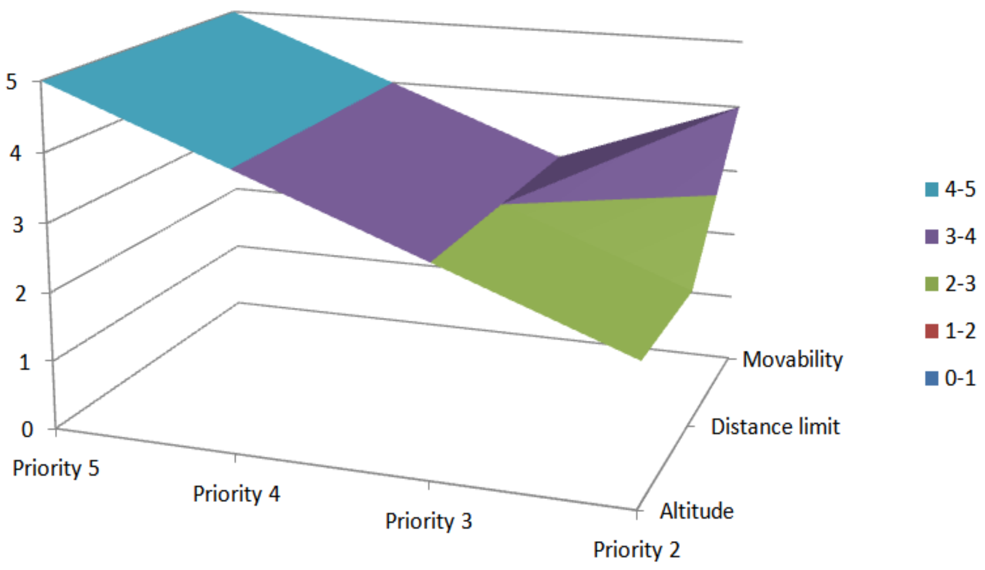

Figure 2 Characteristics of flights including Altitude limits for flights categorized based on different priority range

In this figure the attributes of flights is taken into consideration ,we can deduce that flights with higher priority has higher altitude limit and has higher distance limit ie it can travel large distance also it can travel upto wide range horizontally(movability) as it will be low congested zone. Here, but for the shorter distance flights having priority between 2-3 have similar movability as of the flights having priority between 3-4. So the plan critic has to take these parameters into consideration in order to provide with an efficient plan.

V. Plane Distributive Analysis

The aircrafts distribution and frequency analyzer can update itself from admin input or through experience in its knowledge Base and may help the system to be well prepared beforehand for an emergency transit in extra-ordinary conditions and it also will provide an advance plan for the aircrafts as to make it smoothly enter the airport and return from it. The weather forecasting mechanism can also be applied so as the system to get alert on the situation accordingly and provide a plan for the purpose .It will also be helpful to divert or to take in a plane to its destination. It will provide an automated solution for this purported purpose.

The plan is evaluated using many criteria mainly using Entropy.

In this it considers the change in plan from the original and cause that has caused the deviation from the original plan .As this is the condition hence the plan critic will make sure that the

Deviation from the original plan is restricted to certain level.This can be illustrated as follows-

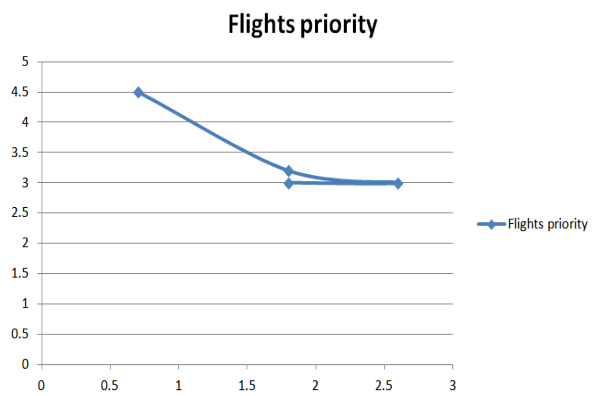

Figure 3 Decreasing Altitude from 3.2 to 3 for low priority flight for crossing of delayed high priority flight

The delay for the flight with higher priority may be due to some natural cause like volcanic eruption etc.The figure 5.1 shows that flight with lower priority will change its path in such a way that it causes minimum disturbance ie the total change in score evaluated due to change in its path must be < the score of delay of greater priority flight.It can horizontally too.

Note here rather than path the system considers the deviation in plan as path may differ according to the present scenario, but the plan must be made in such a way that it needs to be changed minimum.

This makes the plan critic to take actions and include the variance based on the region, as in some region the traffic is high but other problems are negligible and vice-versa or both could be high.The critic has to adjust the plan accordingly.

VI. SOFTWARE PROGRAMMING AND DESIGN PLAN

A plan generator produces plans that detail how the automated controller will handle the current traffic situation for the specified sector. Each of the sector plans contains a set of individual aircraft plans that specify the routes off light for the aircraft and the ATC clearances that are planned at particular points along these routes. Clearances might be altitude changes, speed changes, vectors, or holding commands. From the above information, it is possible to project within an approximate range the future horizontal positions and altitudes of the aircraft. Given a plan and projections of the future positions and altitudes of aircraft, it is possible to write plan critics. A plan critic is an independent software module that is responsible for looking for a particular type of undesirable feature or consequence of a plan.

Each plan critic produces a score that represents the module's evaluation of the plan from the module's particular point of view. In our system, the higher the score, the more severe are the problems with the given plan, similar to that of measure of randomness. The individual scores are then weighted and combined by a simple summation into an overall score for the plan. The resulting score is fed back to the plan generator, which uses the score to rank the given plan against other possible plans. It is this combining function that allows the system to make trade-offs among the various considerations represented by the individual critics . The individual scores are weighted to give the correct trade-offs among the various problems so that the system ranks plans in a desired order. The weight-adjusting process (which reflects learning) could perhaps be automated with techniques that neural network researchers are currently exploring. It might also be possible to determine the weights in an analytic way, e.g., by assigning to each type of problem an estimated cost in RUPEES but is impractical. The overall effect of the scoring process is the creation of a function that takes a plan as its argument and returns a number. Given that higher scores denote less acceptable plans, the plan generator's goal is to find a plan with as small a score as possible.

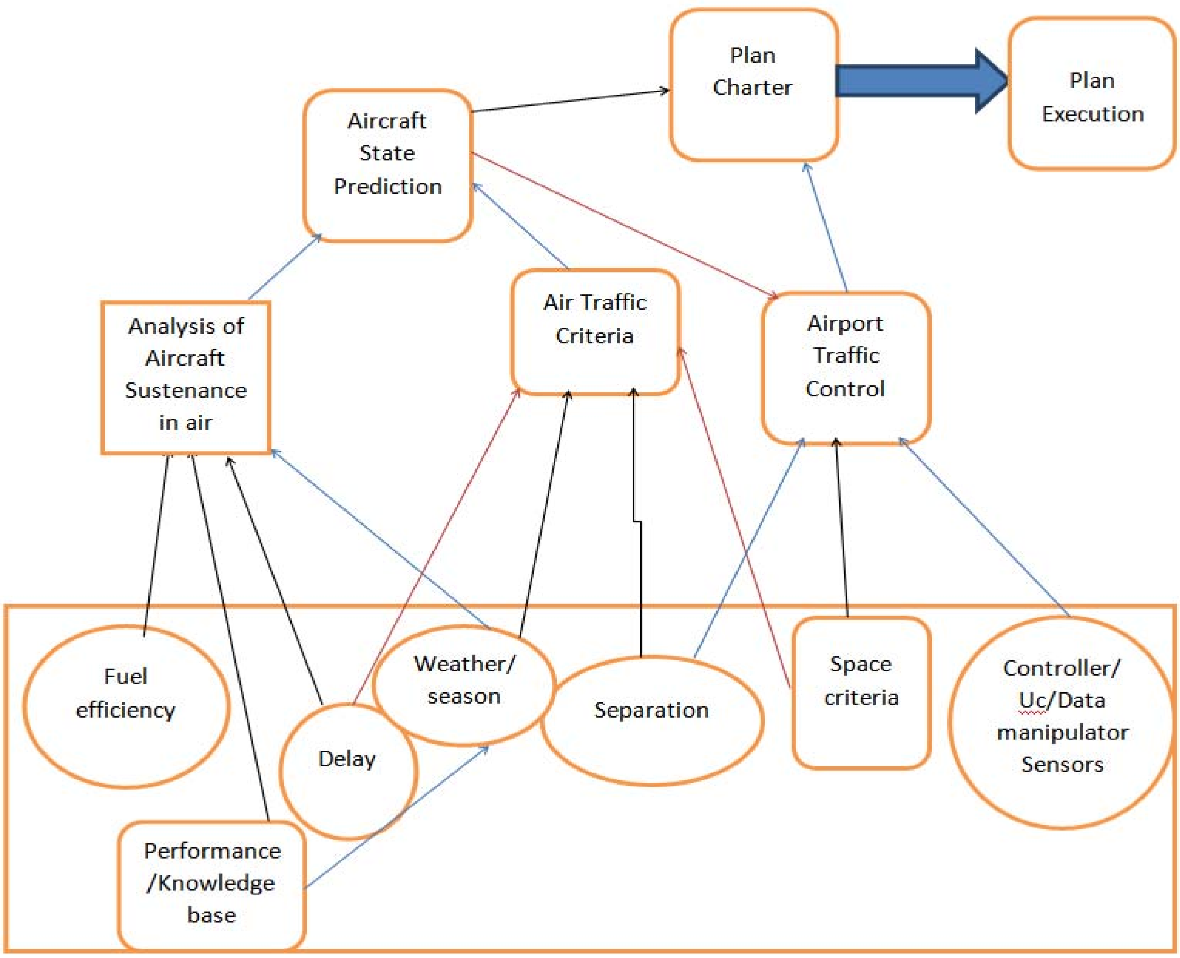

Figure4- Overview of software and design plan

VII. EVALUATION

The system performance is evaluated based on the parameters provided like that of priority scores ,plan scores and plan success/fail ratio for different categories .

It is calculated by checking the degree of overall plan deviation from the original overall plan.

(New plan score – original plan score) mod 360 and for separate plan deviations are similarly calculated and multiplied with priority scores ie if many flights having more priority scores deviates from plan then the plan critic tries to minimize it and if the deviation is above a threshold level then cause is noted and certain scores are given to them from which the causes are divided as per their probability in that region and is updated, from this the critic learns to include those factors and creates more efficient plan for future trips.

VIII. CONCLUSION

This paper is an attempt for providing an efficient automated ATC by self learning technique and plan critics .

Though it is very difficult to provide automated ATC as it is requires man –like decisions to be made but it manages to provide with some help to the ATC and shall help eventually in managing the consequences and the cause which cannot be evaluated by human so quickly.

This method will help develop an automated self learning system which by using knowledge base and entropy score technique could relieve manual intervention partially at least in major areas and over a period of time will help in managing and maintaining ATC itself, though not fully. It can be considered as cost effective and efficient.

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