Personal recommendation system for foraging

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Abstract. Airplane has been proved as the safest transportation. With the technology and economy developing, more and more people choose to travel by air; however, there were several significant aircraft accidents these years. So it is necessary for us to deal with the search and rescue work. This paper is aim at concluding the probability of location where the wreckage and pieces of forage may be and providing with the most effective strategy of searching for the lost plane. Focusing on trying to enhance the efficiency of search and rescue work, we separate the progress into two parts. On the one hand, we build a Monte Carlo Model to estimate the range of where the wreckage possibly comes into observation. One the other hand, we combine the result and Bayesian Statistics to draw up the optimized project of searching work. And we examine our model statistically.

1. Introduction

1.1 Our Work

The content of the paper mainly answers the following question:

What are the objective and subjective factors of effect on chance that airplanes break down?

How to describe the falling trajectory and analysis the whole process? How to work out the possible range we should search for the downed plane? How to make the strategy of searching and rescuing?

After the analysis done above, we make a comprehensive conclusion of the model and expand the model into general case. Through integrated into account, we recommend a generic model to assist planning and scheduling the search for a missing plane.

1.2 The Description of Problem

According to the problems, we separate the search process of an aircraft accident into four steps. The first step is from losing signals to crashing in water. Secondly, the wreckage sinks into the sea and some parts of the plane break up into smaller pieces and slowly move with the wave, and “searchers” are ready to search and rescue the lost plane. And then the third step is before reaching the sea area. The process of searching becomes the finally step.

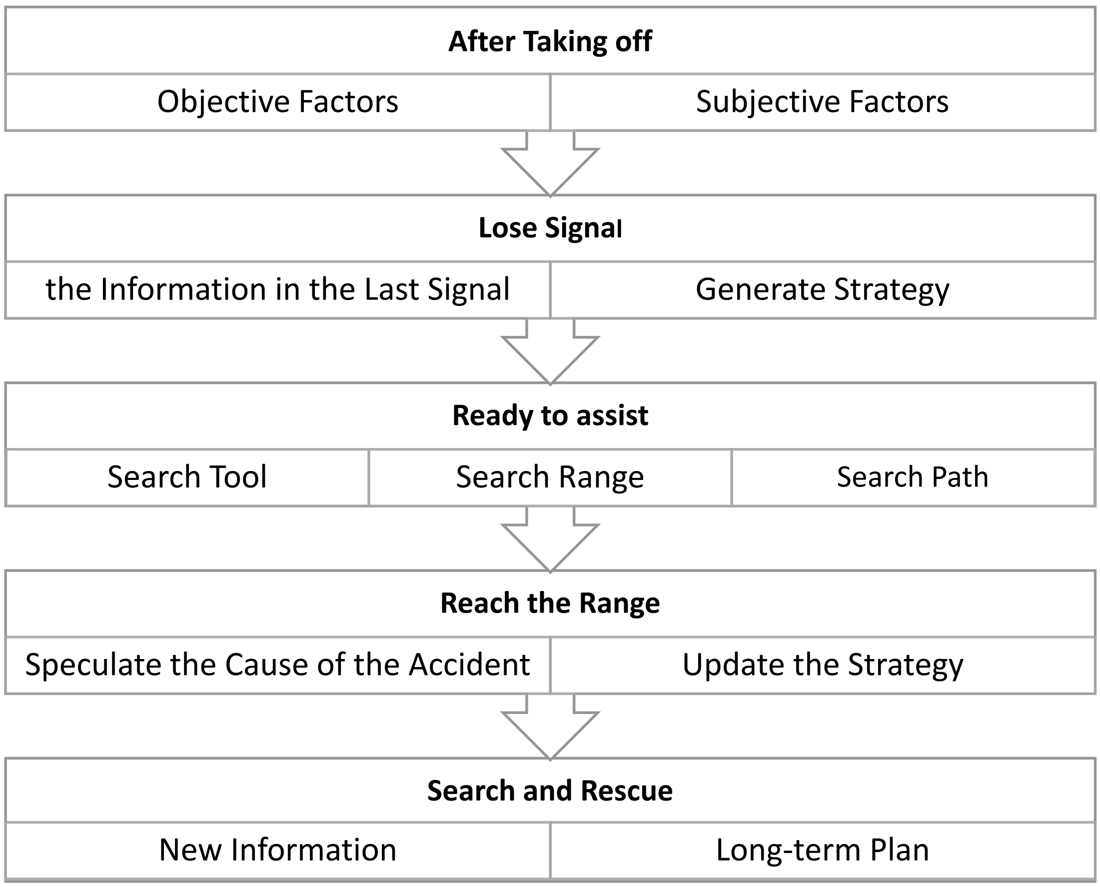

Figure 1 Search Process of an Aircraft Accident

2. Analysis of Causes

This part of paper primary presents the accident rates by inquiry about the famous aircraft accidents and information. We collect and analysis the statistics of aircraft accidents at sea in 1990-2014, try to conclude the causes and indicate that the rate of accident is not completely random. There are 7007 aircraft accidents from 1990 to 2014 including 89 marine accidents. The figure below is the statistical data of different types of air accidents.

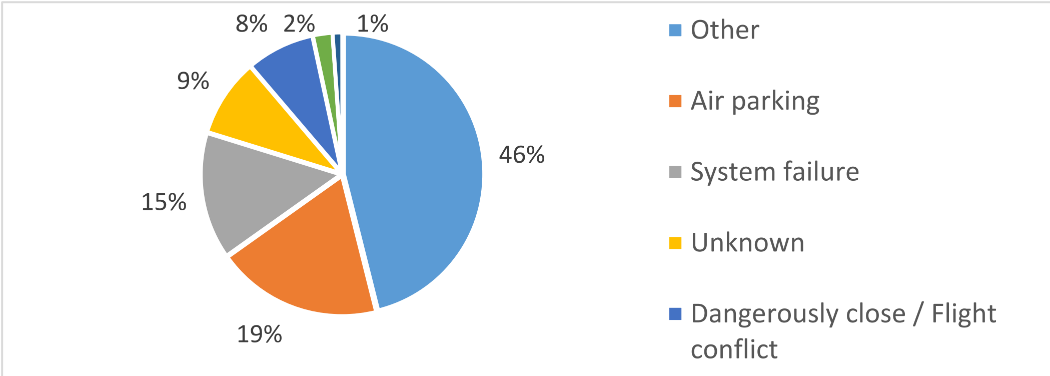

Figure 2 Accident Rates of Different Types

According to the results and experience, the factors affecting possibility of aircraft accident can be classified as either objective factors or subjective factors.

Objective factor: the factor which is not influenced by human, including weather, environment, airplane model, aircraft status.

Subjective factor: the factor which is human-induced, including aircraft commander, flight attendant, passengers.

2.1 Objective factors

According to the above data, we can see that objective factors mainly impact the accident rates. As is well-known, when flying through area with adverse weather condition, accident rates could be enhance beyond doubt. It can be regarded as an obvious reason why weather has a great impact on aircraft accident. To a large extent, the terrible state of weather impacts the flight regime, especially thick frog, strong breeze, storm rainfall and heavy snowfall. For instance, the plane carrying Polish President Lech Kaczynski crashed because of low visibility leaded by bad weather in 2010.

By analyzing the above result, we can find that nearly 47% of accidents happened from August to November, and this period could be regarded as the high-incidence season of accidents. Also we can draw a conclusion from Figure5 that most accidents happened on Atlantic, as the percentage is 64%, at the same time, there are many aircraft accidents on Pacific, too.

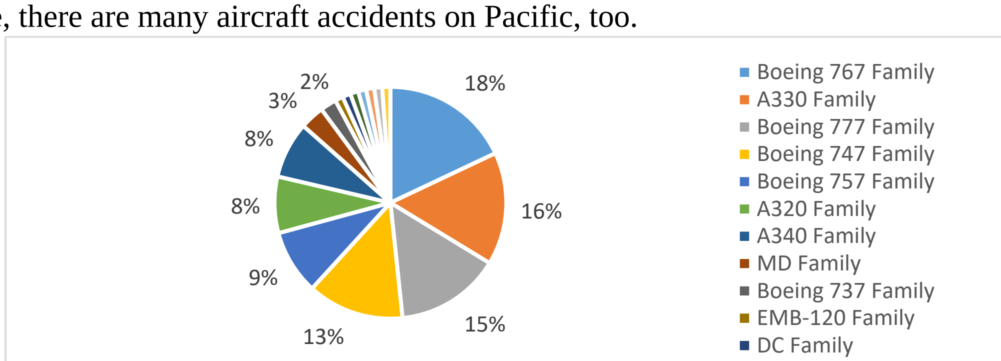

Figure3 the Number of Accidents Occurring in Different Type of Aircraft in the Proportion of All

Table1 Features that Aircrafts Happening Accidents Have in Common

Aircraft Classification	Jets
Operation type	Airline transport: passenger transport, regular, international
Flight phase	Cruise / Job

Besides the over-all situation, the type of aircraft also contributes to the accident rates. The results of this analysis are presented in Figure6 and Table1.

2.2 Subjective factors

In some ways, the possibility of aircraft accident is also under the human-induced influence. The airplane captains usually make pilot error which likely result in aircraft accident when they are tired or in bad moods. So do the crew. And if the passengers do something out of rule, chances are that it increases the accident rate.

3. Model

Our model can be divided in 4 parts:

The first part is about the Kinetic Analysis during dropping out and drifting. It analyses the force and simulates the processes.

The second part is the Drifting Model, which uses Monte Carlo stochastic process and provides the area of proposed searching plan.

The third part is the usage of probability from the very beginning of the loss of signals till the suggestions. Further, Bayesian Network is built to guarantee the efficiency of routing.

Finally, the last part is about generic suggestions and plans for rescuing in both local and global ways. Divided with time and area, we could handle all these situations.

3.1 Drift-diffuse Model Based on Tidal Motion

1) Factors of Tidal Drifting

A Flotage's motion trial is mainly influenced by the local sea condition and environment. Besides, the own characters of itself decide the direction.

Concerning the external factors, we have wind pressure, wind driven current and ocean current to push the obstacle. And the own characters are immersion ratio and ballast statement.

B According to the wreckage, tidal motion, submarine topography and marine organisms influence more.

2) Simulation of Tidal Drifting

To simulate the possibility area of wreckage under water, we have graphs as below.

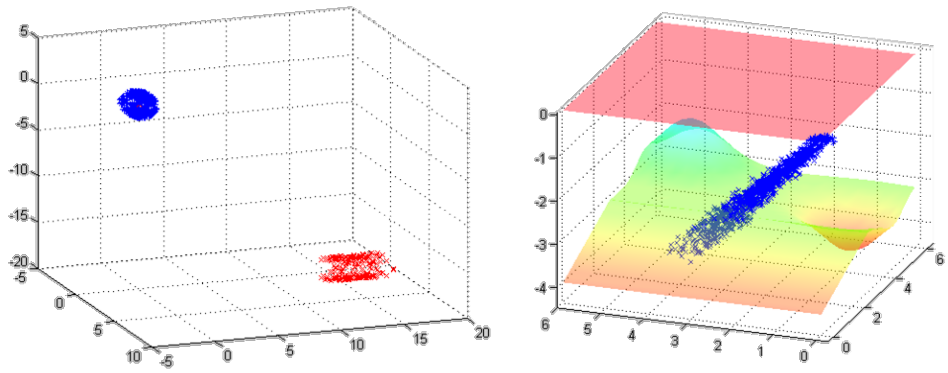

Figure 4 Simulate the possibility area of wreckage under water

Taking the submarine topography into consideration, the possibility area of wreckage is limited.

To make the model, we use Monte Carlo Method simulate the possible process of moving in a planar way.

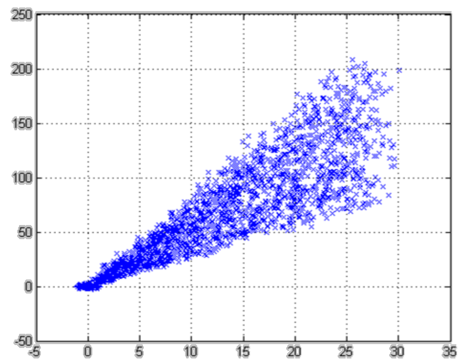

Figure 5 Simulation result

3) The Determination of the Search Area

A Basic Search Area

The area is a circle which its radius is the maximum random error. In actual actions, we can expand the shape to a square.

B The actual search area is zonal.

3.2 Optimize the Search Process

3.2.1 Come up with all the factors during the search and discuss their relationships

A depth of water h

B Meteorological conditions during the search such as weather and wave w

C conditions undiscovered but in this place q

There into, h and w are quite separate and affect q. When the water is deep, the possibility of being discovered decreases. When the weather is bad with terrible wind and wave, it is less likely to be discovered and q increases even if the wreckage located in this area.

H directly contributes to p (possibility). When water is deep, the wreckage is more like to stay and the possibility of moving with tide will reduces.

Q affects q. q, which means the possibility of the situation that the wreckage locates here but undiscovered due to depth of water or other conditions, is more, the corresponding p increases too.

H is irrelevant to time t and w changes depending on t.

Here is the simulation contour of h

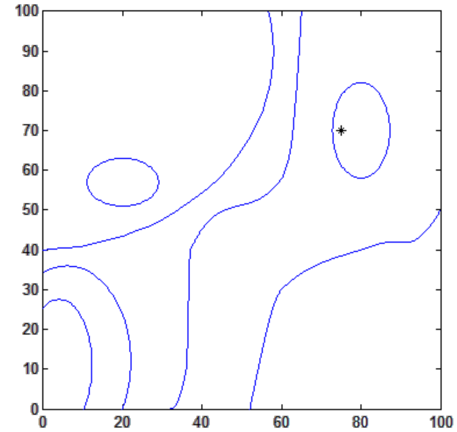

Figure 6 The simulation contour of h

3.2.2 Rasterization of the search area

Rasterize the area into triangle or square. According to the actual situation, choose to rasterize into square. The probability in unit area is only and certain.

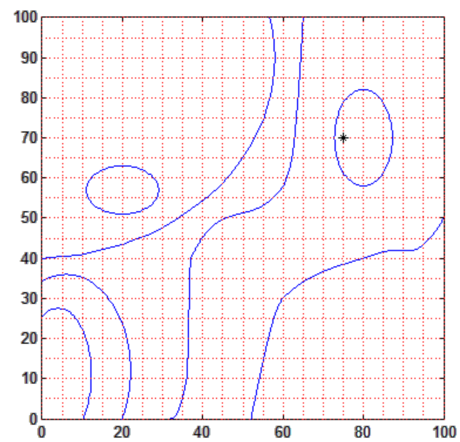

Figure 7 The probability in unit area

3.2.3 For every factor, calculate the spatial probabilistic on every point

A relative to h, consider different areas to calculate the different probability. There into, the probability of the most shallow area is ph, of the deeper water is Ph*ki…of the deepest water is ph*kn（ki…kn>1）（0<ph<1）

As the boundary of rasterization, consider choosing the corresponding probability on the basis of where the area of unit cell in boundary is bigger than half of the area of unit cell. Simulating the area is divided as follow and the area where painted red is deepest and most possible. The area painted blue is lower and the yellow area is lowest.

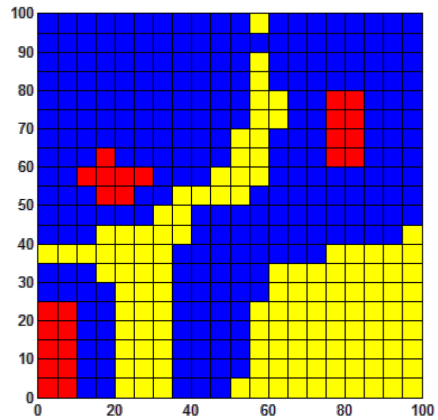

Figure 8 Simulation result

B According to meteorological conditions during the search such as weather and wave w, consider predicted average weather condition in search time pw.

As the simulation diagram below, the area where is yellow is supposed to be in good weather condition and is less likely. On the opposite, the blue area is where bad weather is and its pw is larger.

C The possibility of the situation that the wreckage locates here but undiscovered q is set to be q0 based on experience.

3.2.4 Establish BAYESIAN Net and combine every factor to construct the probability distribution of unification space in every point

Consider the probability distribution of every point

Set node N as 4. The corresponding weather condition w, the depth of water h, the probabilities that conditions undiscovered but in this place p and the probability that the wreckage locate here p, in sequence match the node 1,2,3,4 in the net.

Turn into the corresponding BAYESIAN Net as follow:

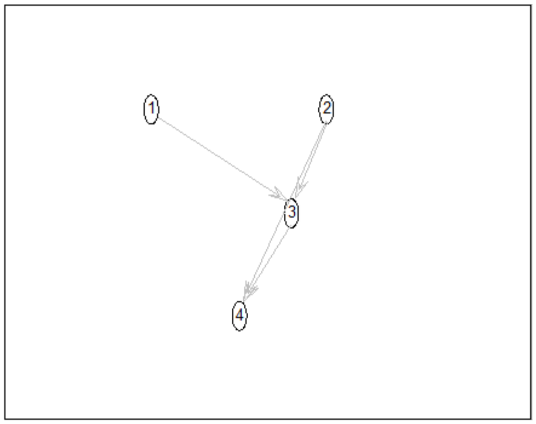

Figure 9 Simulation result

Consider features of node, the corresponding node is discrete nodes 1,2,3,4.

Set state matrix of node node_sizes1row N columns. 1 stands for the condition does not happen, while 2 stands for it happens.

Then confirm the contingent probability of w, h, q, p.

5 construct the search path, combine distance with synthetic probability and take advantage of Bayes Theorem to update the newest probability distribution.

Compute and choose global path. Give preference to the near path through no redundant area with high probability. Obtain the figure as follow:

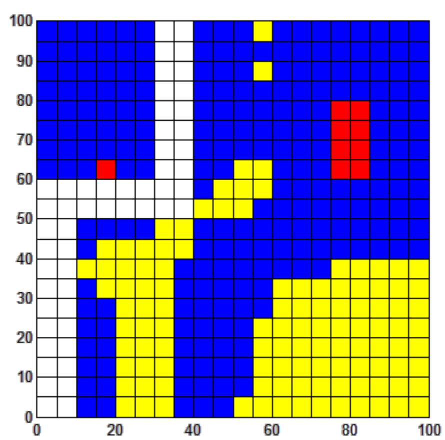

Figure 10 Simulation result

Simultaneously, consider multi unit do the search process at the same time: divide into subdomains and compute the locally optimal solution. There is the figure below:

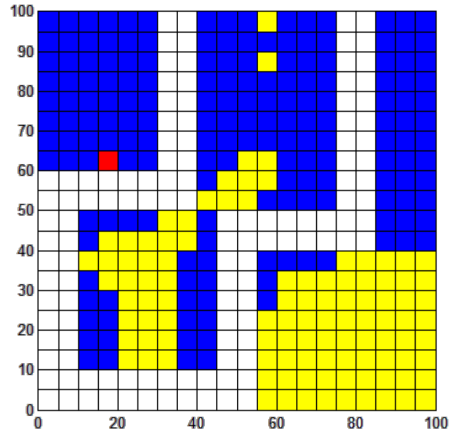

Figure 11 Simulation result

As for synthetic probability of some area p, the corresponding probability of undiscovered is q. If it failed to discover the wreckage, the probability here would be updated to

$$p' = \frac{p(1-q)}{(1-p)+p(1-q)} = p\frac{1-q}{1-pq} < p$$

（change 1-q to q in the formula）

The corresponding probability of other area r is updated to

$$r' = r\frac{1}{1-pq} > r$$

（There is in a similar way）

As for after search some primary simulating point(1,1), calculate primary joint probability p0 is 0.2883. After search, the probability of this point is updated to:

pt=0.0003。

The figure shows the probability after computing the update:

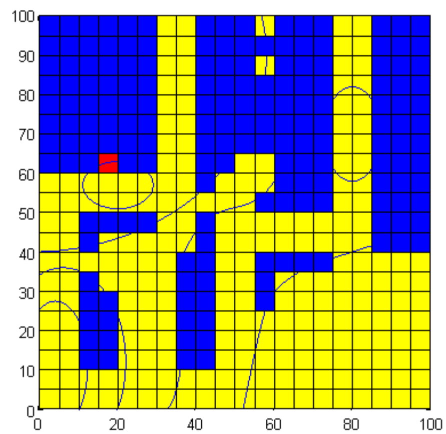

Figure 12 Simulation result

4. Discussion and Conclusion

4.1 Solutions to All Problems

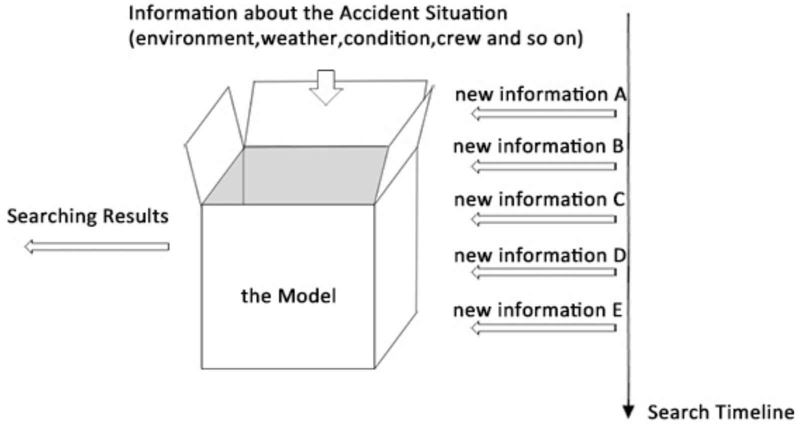

Figure 13 deal the information with two types: Probability and the selection conditions

4.2 Evaluations of Model

Strengths:

The model aims to predict the movement trace of wreckage and flotage through simulation. In order to be closer to the actual, the biggest factor is the center of attention.

The model can be repeated and controllable.

Deal with the complete information in advance (including history of the plane and airline, environment, weather, crew) and generate consolidated probability value to speculate the accident situation and correct the preconditions used in iterative process of Bayes Formula.

Instead of normal distribution or equipartition, the model firstly calculates the probability distribution of the initial reach of rescue workers and during the process, we conditionally set location with low probability to zero .All these steps are for purpose to minimize iterative time of bays formula.

Grading the search range and use distinguished strategies from global to local.

Attach importance to flotage and oil slick and set useful life to place the boundaries owe to them. Once beyond the time, they will lose the reference value.

Take the safety of the search and rescue team into account.

Weaknesses:

The model is still an approximate on a large scale and fails to accurately emulate the real situation. In the face of the complex marine environment, this model just applies to when the movement of wreckage only influenced by tide and ocean currents. For simplified calculate the trace, many factors are ignored such as the rest of fuel, in fact, they play important roles in the move of wreckage and flotage.

The model is not able to distinguish the explosion from other situations, in the real-life situations they tend to be very different. The comprehensive analysis of aerodynamic factors which affect the falling process is not thorough. Due to deficient preconditions, the efficiency during iterative process of Bayes Formula may be reduce.

The model soundness increases over a time period. The preconditions are supposed to be updated beyond the time period.

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