Research and Realization of Airport Security Simulation System

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Abstract. This paper put forward a new security assessment method for solving the problem of airport security assessment. In this method, the computer simulation technology is used to establish airport's virtual model, the perspective projection method is applied to achieve simulation roaming, and the fault tree analysis is utilized to evaluate the virtual model's security. By modularizing the method described above, the Airport Security Simulation System is developed successfully basing on the UG platform. An example, at the end of the paper, is given to show the application of the system. The result shows that this system is rational and pragmatic in airport security and safety risk evaluation.

Introduction

The safety operation of airport relates to the entire air transport system. Currently, the safety management of domestic and international airport is mainly relies on the rules, regulations and post-accident processing measures. Commonly used methods are the scoring method, AHP, and the fuzzy evaluation method[1]. Since the civil airport is a complex giant system, there are many factors that are difficult to measure. By using the methods mentioned above are sometimes difficult to obtain satisfactory result. In practical applications, those methods not only can't get rid of the randomness but also full of assessment expert's subjective uncertainty[2].

To improve the situation described above, this paper developes the Airport Security Simulation System, meanwhile it analyses some related technology. This article is divided into three parts, first, it explores the rapid establishment method directed by virtual scene quickly modeling idea; second, it researches the visual scene roaming method on the basis of perspective view and Windows message response; third, it build an evaluation model for expressing the abstract concept, and base on the evaluation model finish assessment work. Fig. 1 shows the main components of the Airport Security Simulation System.
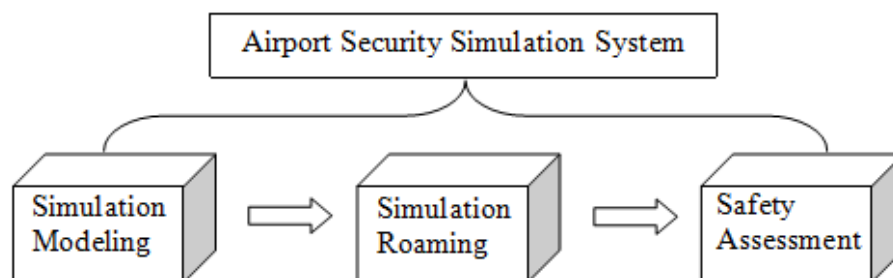

Fig. 1. The components of the Airport Security Simulation System

Simulation Modeling. How to rapidly establish an airport's virtual model? We know that an airport is composed of many scene objects such as wall, door, roof, check-in counters, airplane etc. Therefore, we can use these scene objects as standard objects to build a standard object library. During the simulation modeling process, we could select a standard object as a template, and then combine all the standard objects with each other according to the position and connection between them, finally an airport's simulation model is built up. The general idea of simulation modeling can be expressed as Fig. 2.
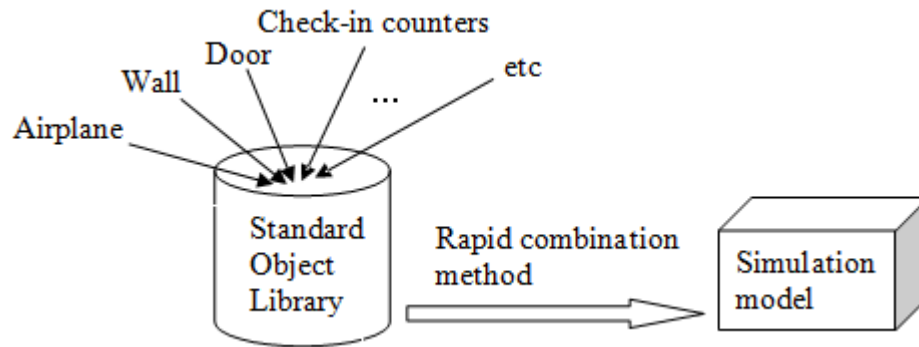
Fig. 2. The general idea of simulation modeling

Standard Object Library. The standard object library is composed of many standard objects, and during the simulation modeling process those standard objects are used as templates, but these standard objects are modeled by what means? To solve this problem, we can divide standard objects into two categories according to their different functions. One type is the scene layout objects, another type is the scene decorative objects. The scene layout objects have simple structure but changeable size such as wall, roof, door, glass fence etc. Therefore, these objects using parametric modeling, we just need to change the design parameters of the standard objects, their size would change correspondingly. On the other hand, the scene decorative objects have complex structure and fixed size, so direct modeling for these objects. The classification and modeling method of the standard objects shown in Fig. 3.
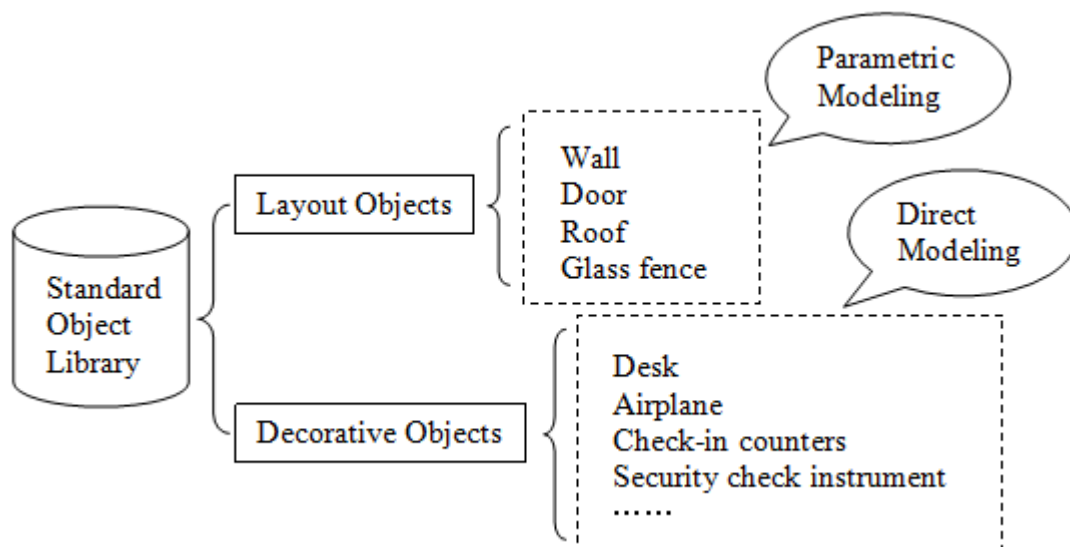

Fig.3. The classification and modeling method of the standard objects

Rapid Combination Method. We have completed the establishment of a standard object library in the above. The next problem to be solved is how to achieve the rapid combination of the standard library objects. The rapid combination of standard objects can also be divided into two parts. Because of the location and connection relationship of the scene layout objects is fixed, for example, there is a fixed connection relationship between walls. Therefore, for this type of layout objects using the automatic matching method. Since the uncertainty position of the decorative objects in the scene, so their layout method is manually adjust. The combination method of standard objects shown in Fig. 4.
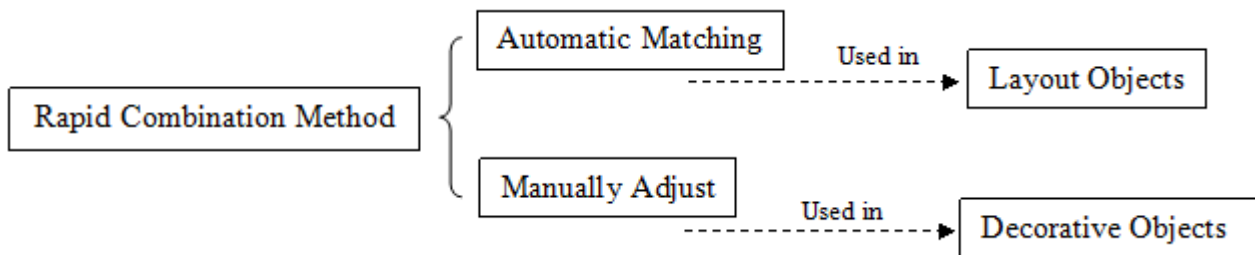
Fig. 4. The Rapid Combination Method

Simulation Model. Through researching and developing the method described above, now we can use the Airport Security Simulation System to build an airport model. Fig. 5 is a simple airport model.
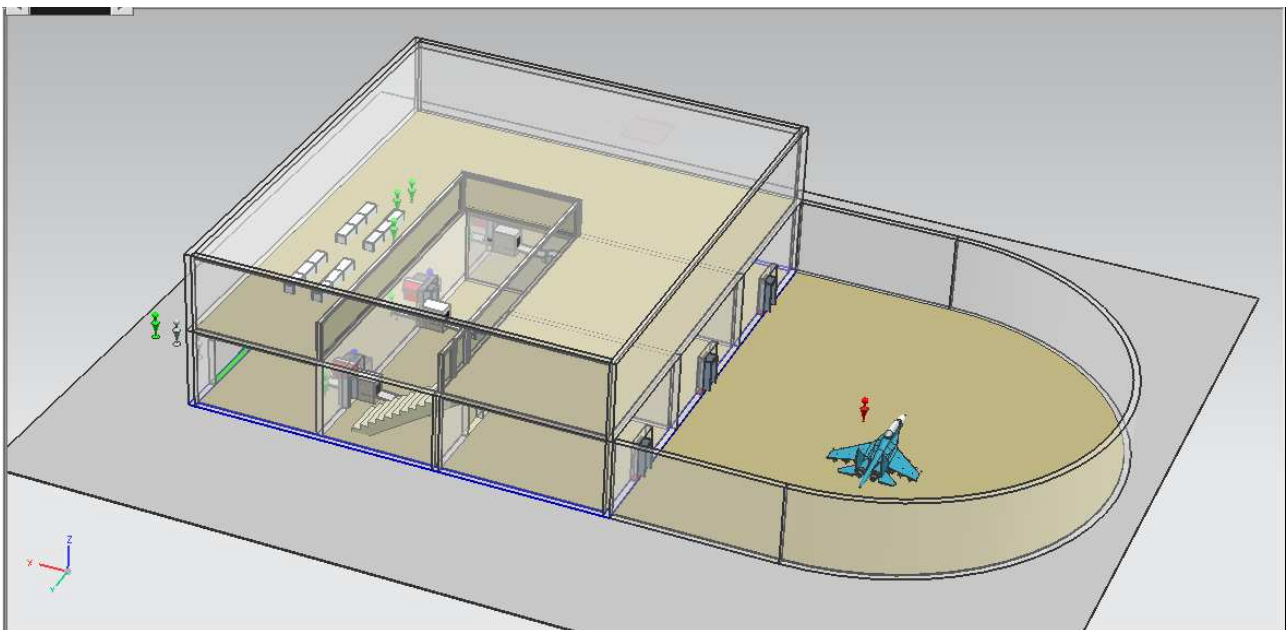

Fig. 5. A simple airport model

Simulation Roaming. In the above, we have established a virtual model of the airport, and now we want to achieve simulation roaming, so comes the question, what is the simulation roaming? Simulation roaming is a travel in the simulation model using the first-person perspective. Simulation roaming makes experts can enter a virtual model of the airport to do security assessments, on one hand, it reduces the cost of manpower and resources, meanwhile improves the assessment efficiency, on the other hand, it allows experts to enter the place where site assessment can not reach, Thus it reduces the flaws and improves the reliability and credibility of the assessment.

An important feature of the simulation roaming is immersion, which means the virtual environment gives people an immersive feeling, and makes a people feel like he has entered a real world, and just like in real life, the scenes he observed have 3D visual effect[3].

In order to achieve this effect we can use the function(uc6439) [4]provided by UG to control the perspective view. This function can be flexibly set the parameters of the perspective view, which lays the foundation for the simulation roaming. Fig. 6 shows the perspective effect[5].

Fig. 6. Perspective effect

Although the perspective projection method can provide the visual effects of the simulation roaming, we still need to define some appropriate actions for keyboard and mouse in order to achieve roaming in the virtual model. Through researching the Windows message response mechanism found that Windows real-time message response mechanism can well control the projection view's continuous. Fig. 7 is a simple hall roaming effect.
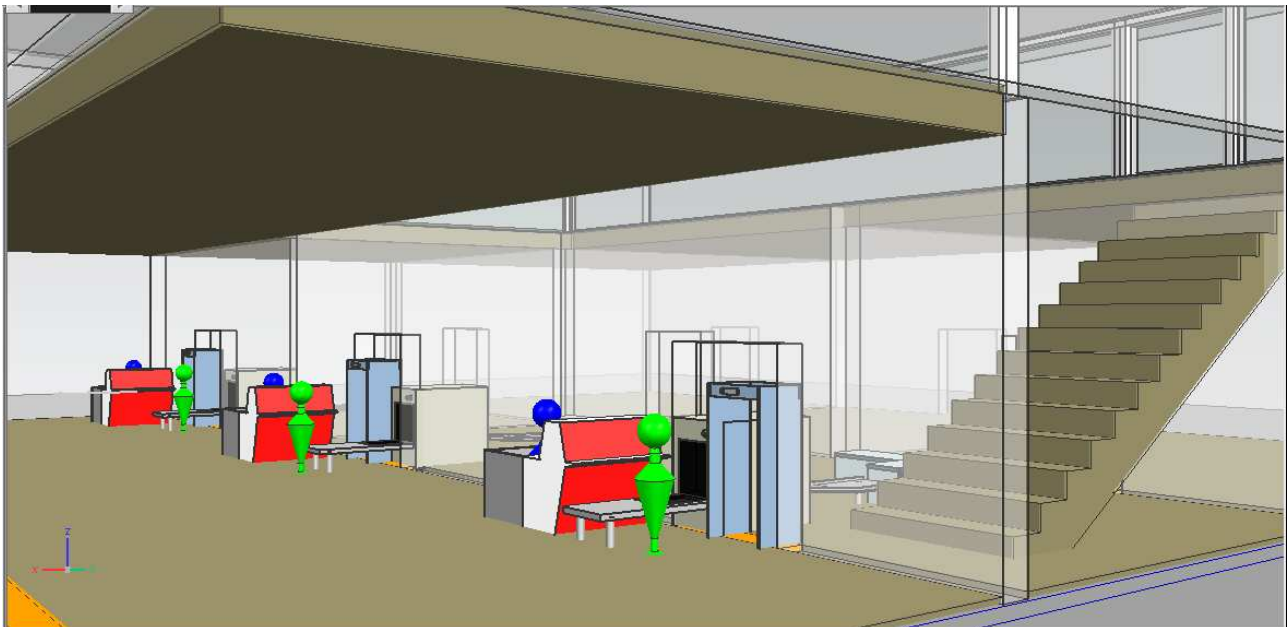

Fig. 7. A simple hall roaming effect

Safety Assessment. The safety assessment is the ultimate goal of the Airport Security Simulation System, through simulation roaming we basically achieved a visual assessment, and now what we want to do is a more accurate calculation for the airport's security, so we need to establish an evaluation model. This model records the logical relationship of the airport, and then use the FTA to analyze this model. Safety assessment processes shown in Fig. 8.
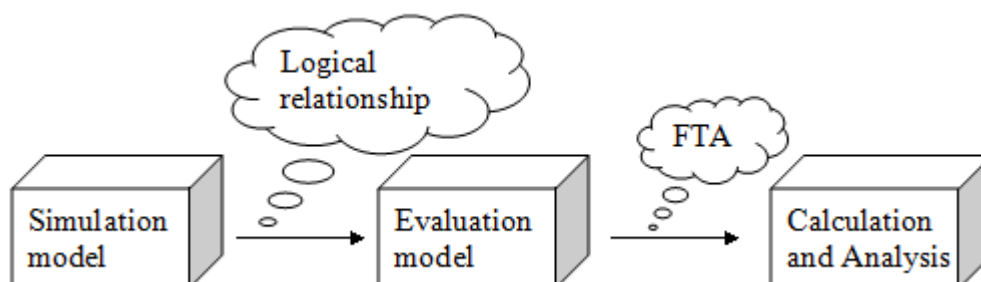

Fig. 8. Safety assessment processes

Evaluation Model. Evaluation model includes region and channel two parts. Region is a space surrounded by walls and channel is the space connecting the two regions. In the model, each region connected to a number of channels, meanwhile each channel connected to two regions, by this way, regional and channel records the connection relationship of the whole model, and this connection relationship is the logical relationship that we need. Fig. 9 shows the evaluation model.
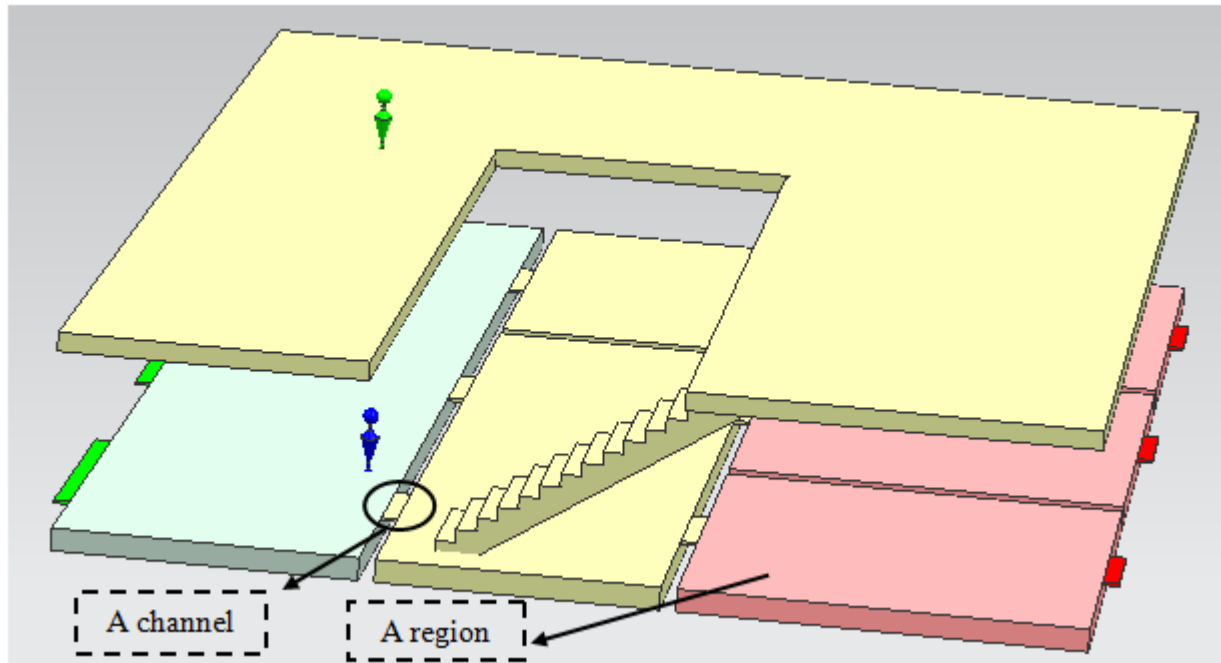

Fig. 9. The evaluation model

Fault Tree Analysis. FTA is the abbreviation of the Fault Tree Analysis. FTA is a method widely used in the analysis of complex systems security and reliability, and it selects the incident which the system doesn't want to happen as the fault tree top event, and it uses specified logic symbols from top to bottom to analyze all the possible reasons which could lead to the occurrence of top event, gradually in-depth analysis until it finds the basic reasons[6]. Fig. 10 shows the process of FTA.
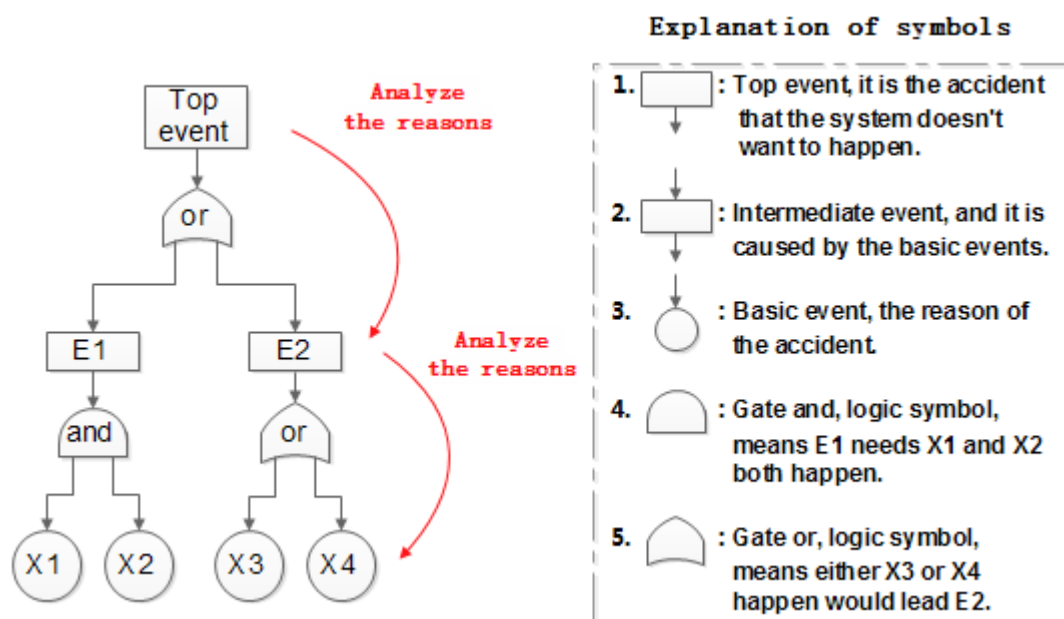

Fig. 10. The process of FTA

Calculation And Analysis. Now is time to do the most exciting thing, that is calculating the airport's security. We know that an airport is a giant system, so we would base on the evaluation model of the airport to establish a fault tree. In order to illustrate how to calculate the airport's security, we select the simple model mentioned before as an example, and its evaluation model shows in Fig. 11.
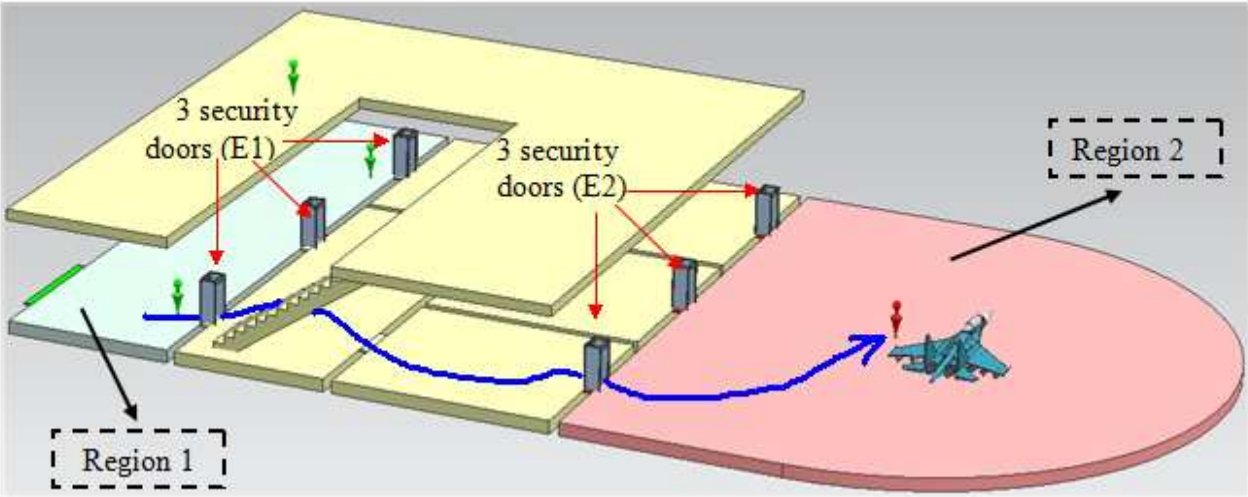

Fig. 11. The evaluation model of a simple airport

We assume that a person in Region 1, he wants to reach Region 2 to destroy an aircraft, so he needs to break through some of the security doors. As Fig. 11 shows, the evaluation model records the logical relationship of the airport, and now we can use it to build a simple fault tree. Fig. 12 shows the fault tree.
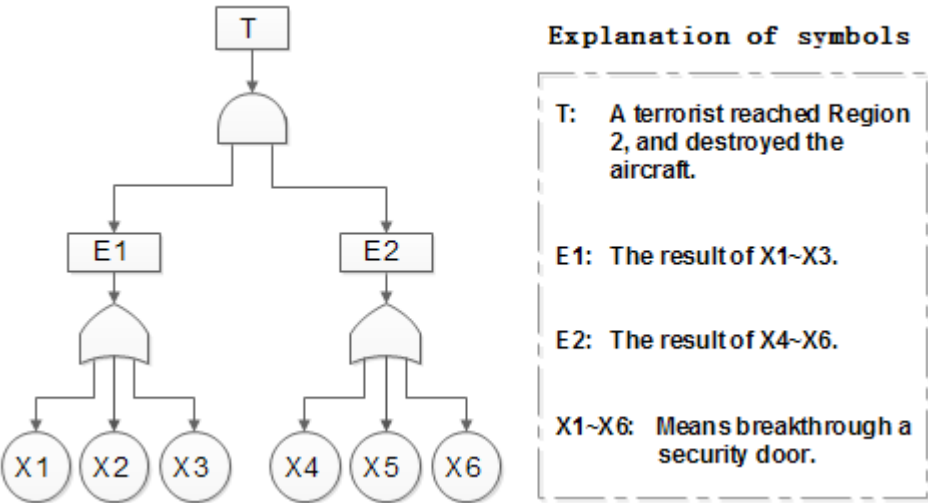

Fig. 12. A simple fault tree

Now we will calculate the fault tree to obtain useful data, but comes the question, what data can we obtain? And the data is how to play its important role in airport security?

Dangerous Mode. We can calculate the minimal cut sets of the fault tree. A minimal cut sets stands for a possible combination of basic events. If all basic events of a minimal sets happened that would lead top event happened. In other words, a minimal cut sets is a dangerous mode. Base on these dangerous modes we can find the weakest link in the airport security system and the dangerous mode also guide us in how to take preventive measures. Table 1 shows the dangerous mode of the fault tree built above.

Table 1. Dangerous mode

Dangerous mode	Basic event
Mode1	X1, X4
Mode2	X1, X5
Mode3	X1, X6
Mode4	X2, X4
Mode5	X2, X5
Mode6	X2, X6
Mode7	X3, X4
Mode8	X3, X5
Mode9	X3, X6

Safety Suggestion. Similarly, we can get the minimal path sets of the fault tree. In order to avoid accidents, we just need to ensure that all basic events of a minimal path are not happen. So a minimal path sets stands for a safety suggestion. By comparing various safety suggestions, we can select accident prevention programs economically and effectively. Table 2 shows the safety suggestion of the fault tree built above.

Table 2. Safety suggestion

Safety suggestion	Basic event
Suggestion1	X1, X2, X3
Suggestion2	X4, X5, X6

The Importance Of Basic Event. There are 3 kinds of basic event importance, they are Probability Importance, Structure Importance and The Relative Importance. They reflect the importance of basic events from different point, and these data can guide us in the airport security to make a better job. Table 3 shows the importance of basic event. In Table 3 we assumed the probability value of basic events for subsequent calculations. In practical applications, these probability values should be obtained from statistical data.

Table 3. The importance of basic event

Symbol	Probability	Probability Importance	Structure Importance	Relative Importance
X1	0.01	0.141475	1.500000	0.157810
X2	0.02	0.141700	1.500000	0.316122
X3	0.03	0.141925	1.500000	0.474936
X4	0.04	0.058504	1.500000	0.261036
X5	0.05	0.058540	1.500000	0.326496
X6	0.06	0.058576	1.500000	0.392036

Probability Value. We can obtain the probability value of the top event is 0.008965.

Conclusions

Through the realization of simulation modeling, simulation roaming and security assessment, the Airport Security Simulation System makes it possible that the site assessment work carried out in the computer. Actually the method proposed by this paper can be seen as a universal method, the Airport Security Simulation System is just an application of this method. This method can also be applied to other field, such as prisons, banks etc.

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