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The Optimization Model of Airport Security based on Cellular Automaton

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Abstract: The cellular automaton model is put forward to evaluate the effect of airport security bottlenecks. The cellular automaton will stimulate the document check, baggage check, passenger baggage examination for airport security, and find out the project of the airport security bottleneck, then diverse passenger and adding VIP channel for airport security to optimization the simulation, finally constructs an optimization model for airport security process based on cellular automaton.

Keywords: Cellular automata; Bottleneck effect; Poisson distribution

1. Introduction

During 2016, the U.S. Transportation Security Agency (TSA) came under sharp criticism for extremely long lines, at Chicago's O'Hare international airport. Following this public attention, the TSA invested in several modifications to their checkpoint equipment and procedures and increased staffing in the more highly congested airports. While these modifications were somewhat successful in reducing waiting times, it is unclear how much cost the TSA incurred to implement the new measures and increase staffing. In addition to the issues at O'Hare, there have also been incidents of unexplained and unpredicted long lines at other airports, including airports that normally have short wait times. This high variance in checkpoint lines can be extremely costly to passengers as they decide between arriving unnecessarily early or potentially missing their scheduled flight.

In this paper we will use Cellular Automaton to simulate the Configuration of staffing from every security *checkpoints in the airport* to identify potential bottlenecks that disrupt passenger throughput, so that they could make creative solutions that both increase checkpoint throughput and reduce variance in wait time, all while maintaining the same standards of safety and security.

Cellular automata, also known as chessboard automata, homogeneous structures, cellular structures, checkerboard structures and iterative arrays, are time and space discrete, finite state matrices of cellular models, it was put forward by Von Neumann and his colleagues Elam in the 1950s in the process of simulating self-replication in biological systems[1, 2], because it can produce complex phenomena through simple units and simple rules, and thus has the ability to simulate complex systems, so it is widely used in physics [3,4], chemistry [5,6], biology [7,8], computer science [9,10] and other natural science fields.

In the process of simulation, we put the passengers as an orderly only speed characteristic of the single cell and we put the airport security channels as objects move forward. At the security desk set cellular retention time, we used to denote the time of passenger security. We simulate the airport security check passage of both state and bottlenecks, through constant iterative simulation passengers at security channel first line acceleration, deceleration, security, etc.

2. Limiting Factor Construct of Cellular Automata

2.1. Rules for passengers arriving at the detection area

The passengers arrived at the area of incident are a random event per unit time, sin this paper, the event was described by Poisson distribution.

$$P(x)=\frac{m^x}{x!}\times e^{-m} \tag{1}$$

Among them, m is the frequency of the passengers to arrive at the testing area in unit time. $P(x)$ is the probability of a certain time period x passengers to arrive at the testing area in the actual cases.

2.2. Rules for random transform speed of passengers

Considering the change in the velocity of passengers in the detection of channel is a random event, and according to the fact of the work, we simulate the passengers to go forward by cellular automat.

Step1.Rules for Acceleration of passengers if the passenger's status satisfied

$$Gap(x,t)V(x,t),V(x,t)+1\langle V(\max) \tag{2}$$

and the next time the passenger's speed will change to

$$V(x,t+1)=V(x,t)+1 \quad (3)$$

Step2.Rules for Deceleration of passengers, if detection channels were congestion, then passengers will slow down.

$$V(x,t)=\max(V(x,t),0) \quad (4)$$

Step3.Rules for collision avoidance, simulate a situation in which passengers avoid obstacles while traveling.

$$V(x,t)=gap(x,t) \quad (5)$$

Here, $Gap(x,t)$ is the distance of the cell x from its previous cell at the moment, $V(x,t)$ is the speed of the cellular x at the t moment, $V(\max)$ is the maximum velocity of the cell.

2.3. Passenger classification

In order to make model is closer to the reality, we now simulate all kinds of passengers who are waiting for entering the Checking area and put them into three parts and use different cellular colors to simulate different passengers and according to reality (Table 1).

Table 1. Passenger Classification

Items	Passenger classification	Colors
First	Passenger who are dangerous	Yello
Second	Passenger with small luggage	Bulle
Third	Passenger with bigger luggage	Blue

We set different time for diverse passengers who will pass the checkpoints. One thing we need to know is that the checking time in document check does not change with the passengers' objective factors. details below (Table 2).

Table 2. Different Checking Time

Items	The cost time
First	1
Second	1.5
Third	1.8

3. Simulation-optimization

3.1. Setting the common security check

Normal security channels run alone in the airport, there is one-to-one relationship without forked working. (Fig 1)

3.2. Optimize the security channel

Now, to increase the passenger throughput and reduce the waiting time as well as maximizing the security and minimizing inconvenience, We will Shunts can be created during the processing in the baggage security and personal security, It could reduce the pressure of security checkpoints in the airport. At the same time, we will build the VIP channel to make vip custom to pass channel quickly.

When a passenger pass the Document checkpoints *document checking*, they have two channels to choose. Such as the luggage and body screening(There is the baggage screening system and body screening system. And also, the probability of the two channels is the same.

In the airport security channel, set up a vip channel, when the vip customer arrives that they can be directly through the VIP channel for security check, to avoid congestion or special identity which may cause by the chaos of the airport order.(Fig 1)

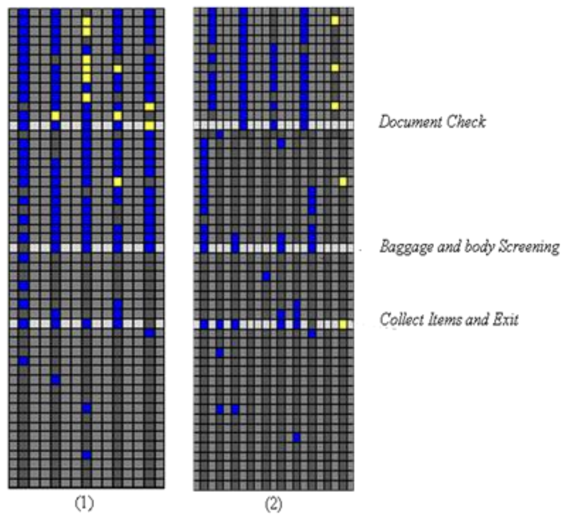

Figure 1. Renderings

4. Optimization Models for Impact Analysis

We will set up different people flow to simulate, compared the effectiveness of the optimization model and the general model, and then analysis optimization results from the security efficiency and security. as follows (Fig 2).

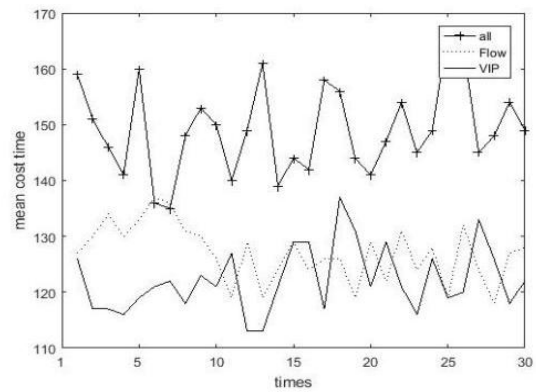

Figure 2. The analysis of efficiency

From the graph above, all means the checking area of basic status; flow means the checking area of reposition status; VIP means the VIP checking area. From what we means it saves a lot of time and increase the passengers throughout and shorten the variance of waiting time (Fig 3).

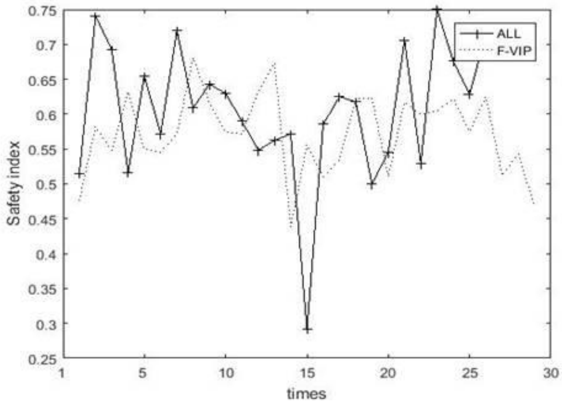

Figure 3. The analysis of safety

For the line graph above (Fig 3), all means the security efficiency of the security checking model; F-VIP means the security's efficiency of optimizing security checking module. From the graph above we could notice that the lines are almost to coincide, which means the two groups of security coefficient are almost the same. So that it could make sure the security of the airport.

5 . Conclusions

In this paper, We use cellular automata model to simulate and optimize the airport security process. Based on the consideration of airport security, we will take two methods, Shunts can be created during the processing in the baggage security and personal security of the two links, talked above, we know that after the two kinds of optimization, the average time every cellular spend passing has decreased greatly and keep a speed about 120, which or setting up the VIP channel. Under the premise of ensuring the airport security, improve the airport security efficiency, solve the problem of security bottlenecks.

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