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2015 Mathematical Contest in Modeling (MCM) Summary Sheet

It is great to hear that the WMA find the medication which can cure the patients who get infected by Ebola. Our main goal is trying to find a method to control the production process of the medicine and develop a system to deliver the medicine to patients as soon as possible.

Aiming at that goal, we build our Epidemic model to imitate the spread of the disease. In order to simply describe the location and how our model works, we introduce the concept of two-dimensional network. We use nodes in the network to denote the cities in a certain district and use the edge to describe the distance and connection between cities. Considering the **geometry property** of the network, we quantify the epidemic situation of a city and abstract it to the physical concept of Mass. Then we introduce the law in physics called: **Center of mass**. We use this law to find out the center city of a finite district, and that is the place where we build our medication factory. Then we build our **water-flow model** to deliver the medication based on the spread of the disease and we also take geographic effect into consideration.

In the simulation stage, we complete our model in a network. In the first case the manufacturing speed is not limit, we develop our controlling system, which can **automatically control** the manufacturing speed and the delivering process, as a result to limit the ratio of patients in the whole district to an **equilibrium condition**. In another case, when the speed of manufacturing remains to a constant, medical factory are require to send out drugs periodically. We can find the relationship between the manufacturing speed and the **patient ratio** through our model. From this results we can find the manufacturing speed required for the purpose of limiting the patients ratio to a certain level. These results is quite practical.

Our model is quite simple but it is really efficient, and also very flexible, we can easily attach more details to it, by that way we can apply our model in the real world situation.

content

Introduction

Ebola's outbreak in 2014 became one of the biggest world health threats in recent memory. So it is great to hear that the world medical association announced that their new medication could stop Ebola. Our present task is to develop a system which can automatically provide us with the best ways to anticipate the spread of the disease, to decide where to manufacturing the medication, to take control the quantity and the speed of the production, to deliver the medication efficiently. So that we can take control the spread of the disease, and finally reach the goal to eradicate Ebola.

In order to achieve this goal, we analyzed the problems above and then bread it up with the following approaches.

We should make a deeper understanding about how the diseases spread.

We need to decide where to build the manufacturing center in a certain district.

We will try to figure out how to deliver the medicine as fast as we can, and make a plan for the quantity and the speed of the production.

Finally, we optimize our model and get a better result.

The Epidemic model The modeling of infectious diseases is a tool which has been used to study the mechanisms by which diseases spread, to predict the future course of an outbreak and to evaluate strategies to control an epidemic. Those models has been studying for a long time. [1] In 1927, W. O. Kermack and A. G. Mc Kendrick created a model known as SIR model. Follow by models know as SIS and SIRS and so on.

These model was successful in predicting the behavior of outbreaks very similar to that observed in many recorded epidemics. Inspire by their work, we develop our own epidemic model.

And we plan to build our delivering model on a two dimensional network, where we can take geographic influence into consideration. We all agree that our main purpose is developing a system to control the production and delivering of the medicine produced a medication factory. So at first, we should decide where to build our medication factory.

And in order to simplify our model, we ignore several factor, we will discuss them in the further discussion section. Also we will conduct a sensitive analysis to text our model to find out whether the model can work in different condition.

Assumptions and Justifications

Our central idea is that we build a mathematic model which can imitate a certain affected area, and use our method to find out the best way to solve the problem in real circumstances. To simplify the problem, we make the following basic assumptions.

There are just three kinds of people: First, healthy people (we call them HP):

people in a healthy condition and not affected by Ebola. Second the patients whose disease is not advance (we call them NP) and can be cure completely immediately by using the drug or vaccine. Third, patients whose disease is advanced (we call them AP), which can't be cure.

We consider each certain city as a node in a network, there are connection between these cities, so we take the connection as edges of the network.

We build Medication factory in one of the node in a finite network. Medication transport from one node to another trough the edges between nodes. We define the length of edges according to the geographic distance between corresponding districts.

We also assume that the when we are delivering the medication through the edges between node, the speed of delivering is constant in all edges and at any time. And the delivering system chronically deliver the medication in all direction. Cities only deliver the drugs to the cities who are directly connected. In other words, the delivering just happen between neighbor cities.

In reality, communication between nodes promote the spread of the disease, but in order to simplify the model, we ignore the interactions between nodes at first (we will discuss this situation in Further discussion). We assume that the disease can't spread from one district to another, so to speak, the disease just spread inside a city, just change the ratio among healthy people, patients and patients whose disease is advanced. The influence of population change including birth and death can be neglected, for our future model, we will add more detail to the current work.

Model overview

We develop our delivering system step by step, from a single node to a very complex network, and eventually we can apply our method in random network and get the satisfactory result.

Our first layer of the model is a single node, represent a city, the node contain the information of corresponding city: the population of HP, the population of NP, and the Population of AP. We define a unit time in order to imitate the spread of the disease, we assume that the condition of node changes through time. And we abstract the road connection between cities as the edges. Therefore, we can build an undirected network to represent the geographical condition of the area which is disturb by Ebola virus, and the area contains a number of cities. And for each city, which is represented as a node in our established network, we build an Ebola epidemic model. In the Ebola epidemic Model, those three types of people are concerned. In our model, we will record the condition of each city in order to understand the spread and growth of the disease. Then we build the water flow model which provide the method to deliver the

drug from the center to the nearby cities. We use a physical law called the Center of math to determine where to build the medication center. Finally we establish our delivering system which can automatically control the spread of the disease. The details of the Models will be stated below.

Epidemic model

First we classify people into three types, healthy people without disease, patients whose disease is not advanced, and patients with advanced disease, which are represented as HP, NAP, and AP respectively. NAP is the kind of people who can be cured, and AP cannot be cured.

We also classify HP into two types, people who can get infected, and people who will never get infected, and we store the numbers as N_{HP1}, and N_{HP2} respectively. Assume that a non-advanced patient will become advanced patient after n days, therefore we have n types of NAP, which will be stored in an n-by-1 array, and $N_{NAPj}(1 \leq j \leq n)$ represents the number of patients who have been infected for j days. And finally we use AP to represent the number of patients with advanced disease.

As the time goes by, the amount of the three types of people will evolve. Our model is a discrete model, which consider the time as discrete. When a unit time passes, the amount of each types of people will evolve as follow:

$$N_{HP1}(k+1) = N_{HP1}(k) - N_{HP1}(k) \cdot p$$
$$N_{NAP1}(k+1) = N_{HP1}(k) \cdot p$$
$$N_{NAPj}(k+1) = N_{NAP(j-1)}(k) \quad 2 \leq j \leq n$$
$$N_{AP}(k+1) = N_{NAPn}(k) + N_{AP}(k)$$

In which p is the probability that healthy people get infected, and p is given by:

$$p = \frac{2}{1 + e^{-\frac{\delta}{S}(N_{NAP}(i) + N_{AP}(i))}} - 1$$

Where S is the area of the city we concern, we think that the density of population might be a key factor for epidemic model.

δ is an adjustable parameter which we can use to adjust the value of the probability.

In general, the patient density of a city determines the infection probability of healthy people.

It is fairly to think that if there are more patient around you, the more you are likely to get infected. If the density is 0, the probability should be 0, and if the density approaches infinite, the probability should approach 1. Therefore we choose the following function to calculate the probability:

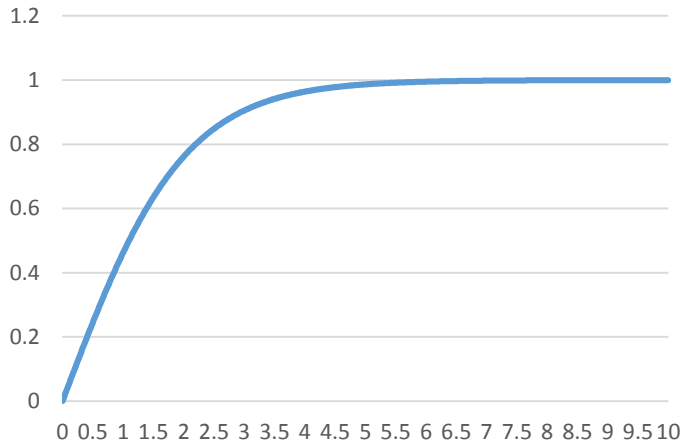


Figure.1 function for probability calculation

Whose mathematical expression is as follow:

$$S(x) = \frac{2}{1+e^{-x}} - 1$$

When a city receive medicine, patients can be cured immediately. We assume that a patient can be cured with a probability. We cure patients with priority, and the longer the patient get infected the higher priority the patient has. And the number of HP would change:

$$N_{HPi}(2, k+1) = N_{HPi}(2, k) + QCP_i(k)$$

Where $QCP_i(k)$ is the number of people who are cured by the medicine a. The number of HP increase follow by the decrease number of NAP.

Center of Mass method

Establish Network

To abstract the cities and the roads connecting them mathematically, we establish a network, in which the nodes represent the cities, and the edges represent the roads connecting the cities. Therefore, we can use an adjacent matrix, and a distance matrix which store the distance between two cities to represent the network.

Here we use N to represent the adjacent matrix, and N_{dis} to represent the distance matrix.

Decide the location of medicine manufacturing center

Center of mass.

We think that the medical center should be close to the district where the illness condition is more severe. Some the concept of “center of mass” come in to our mind.

To decide the “mass” of each city, which indicate how severe the disease condition is, we define the “mass” of each city as follow:

$$M_i(k) = \sum_j N_{NAPi}(j,k) + N_{APi}(k) + N_{HPi}(1,k) \cdot p_i(k)$$

Where $M_i(k)$ represents the “mass” of city i at time k.

Find the Center of mass in a system of particles:

[2]The center of mass is the unique point at the center of a distribution of mass in space that has the property that the weighted position vectors relative to this point sum to zero. In analogy to statistics, the center of mass is the mean location of a distribution of mass in space.

In the case of a system of particles P_i, $\mathrm{i} = 1, \ldots \mathrm{n}$, each with mass m_i that are located in space with coordinates r_i, $\mathrm{i} = 1, \ldots \mathrm{n}$, the coordinates R of the center of mas satisfy the condition:

$$\sum_i^n m_i(r_i - R) = 0$$

Solve this equation of R to obtain the formula:

$$R = \frac{\sum_{i=1}^n m_i r_i}{\sum_{i=1}^n m_i}$$

In the formula above, we replace the m_i with $M_i(k)$, we get the “mass center” of our city:

$$R_M = \frac{\sum_{i=1}^n M_i(k) r_i}{\sum_{i=1}^n M_i(k)}$$

R_M is a coordinate in the district, we just choose the city whose coordinate is the closest to R_M to be the city where we build our medical factory.

Medicine delivery

To make the delivery as fast as possible, we try a method called Water Flow method. Think of the edges of the network as tubes, and we can pour water into those tube from a node. Of course the water will follow the path with minimum distance to get the other nodes.

In real world, we can apply this method by sending medicine from the manufacturing center to its neighbor cities, the neighbor cities then send medicine to its own neighbors, and so on, until all the cities receive medicine.

In the Water Flow method, we can define the speed of water as P, which is a constant value.

Solution

Establish The Network

In order to test our model, we need a virtual network which represent an area attacked by Ebola. Here we build a network manually, and present as figure.1:

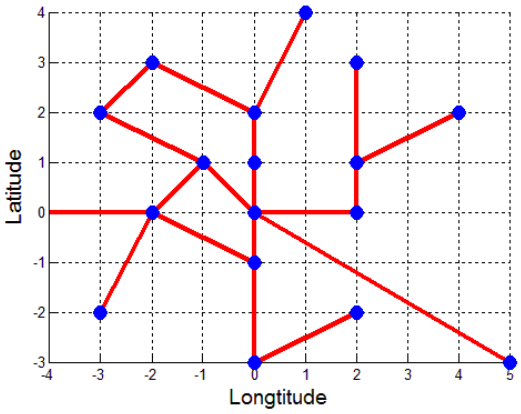


Figure.2 The network

Where the blue nodes represent the cities, and the red edges represent the connections between cities.

For each city (the node in the network), we need to initialize the number of HP, NAP, and AP. To make our example more general, we randomly decide the number of the three types of people. But the ratio of NAP and HP is roughly 0.01, and it is the same with the ratio of AP and NAP.

After that, we will use this network as an example to demonstrate how our model can help The World Medical Association to make decision about how to deliver the medicine in an efficient way.

Decide the Location of Medicine Manufacturing Center

In our model, we use the Barycenter Method to decide the location of medicine manufacturing center. In our model, we decide mass of each node by the numbers of HP, NAP, and AP, but the numbers will change will time, therefore the mass of each node would change. If the medicine manufacturing center can be moved to another city from time to time, we can move the center following the barycenter. Here we assume that once the location of the center is decided, it can never be moved to other cities. Therefore we decide the location of the center by the initial numbers of HP, NAP, and AP.

We program to calculate the masses of the cities. We calculate the barycenter of the cities, and get (0.1151, 0.4834). And node 1 in the previous network has the

minimum distance from the barycenter. Therefore we choose node 1 as our medicine manufacturing center.

Medicine Delivery Visualization

In order to minimize the time of medicine delivery we use the Water Flow method to do the medicine delivery. Think of the edges in the network as tubes, and we can pouring water into those tubes from the medicine manufacturing center (node 1). Water will flow from node in the center to every other nodes through the path with minimum distance. Here we visualize the process in figure 3:

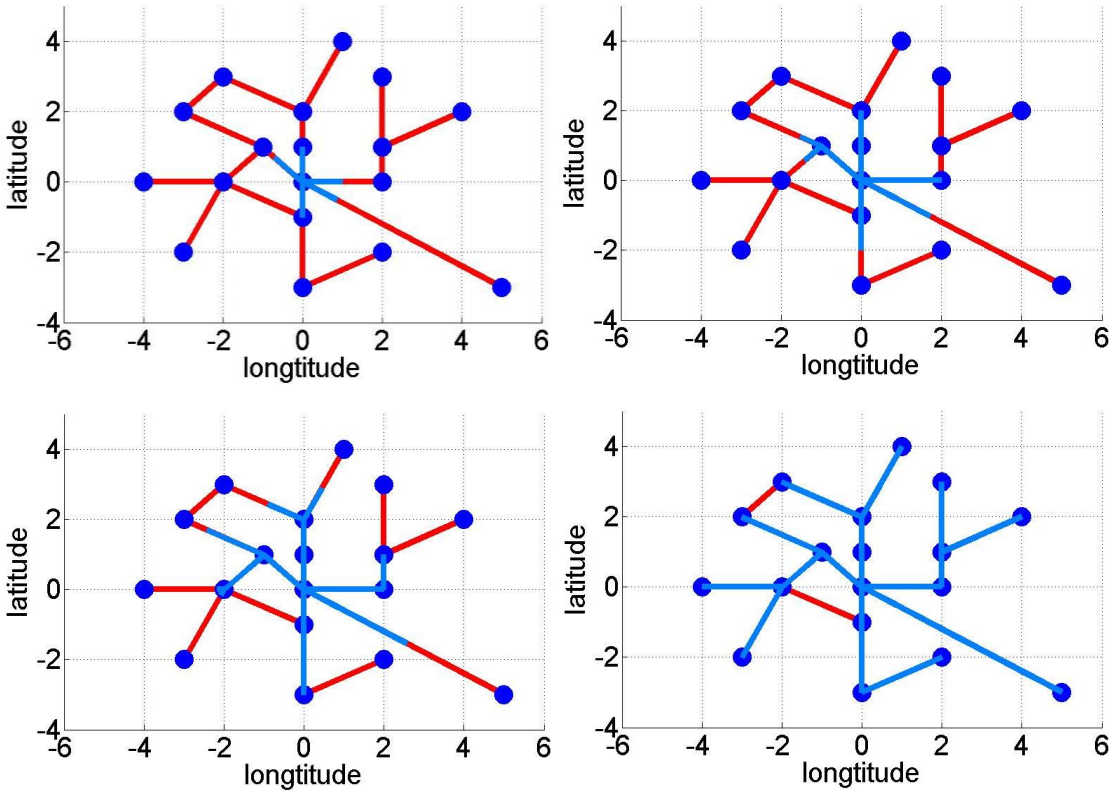


Figure.3 Medicine Delivery Visualization

[3]As we can see from figure.2, every time we send out delivery, it will cover all the cities, but the quantity of the medicine delivered is divided during the water pouring process.

Patient Ratio Variation

When medicine is available, medicine should be delivered to cities to cure patients, and the patient ratio would change. We have decided the location of medicine manufacturing center and the delivery method previously, therefore we can run our model to see how the patient ratio would change with time. And the patient

ratio is defined as:

$$PR_i(\mathrm{k}) = \frac{\sum_j N_{NAPi}(j,k) + N_{APi}(k)}{\sum_j N_{HPi}(j,k) + \sum_j N_{NAPi}(j,k) + N_{APi}(k)}$$

Where $PR_i(\mathrm{k})$ is the patient ratio of city i at the time k.

Here we consider two situation. In the first situation, we consider the speed of medicine manufacturing is adjustable, which means the speed can satisfy our medicine needs, no matter how much we need. While in the second situation, we consider the speed of medicine manufacturing as a constant, we cannot adjust it.

(1) Adjustable Speed of Manufacturing

In this situation, we can deliver medicine as much as we want, therefore we only need to decide when we should deliver and how much we should deliver. Here we set a threshold, and we deliver medicine whenever the patient ratio is higher than the threshold. And the quantity of medicine is defined as follow:

$$DMQ(k) = \sum_i \sum_j N_{NAPi}(j,k)$$

Where $DMQ(k)$ represents the quantity of medicine that will be delivered at time k, and $N_{NAPi}(k)$ is the number of patient with not advanced disease of city i, and also the quantity of medicine city i will receive.

At first, we simulate the condition that without the delivering of drugs. We obtain the population change in 141 unit of time, and get the result below:

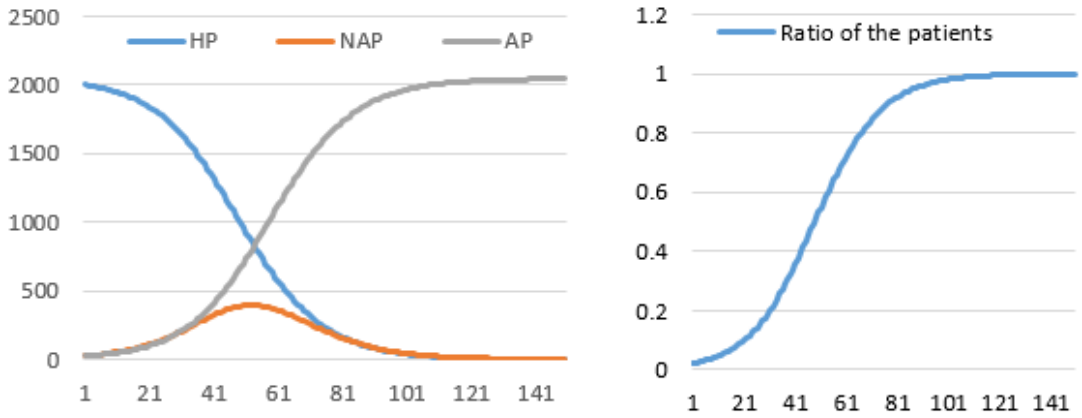


Figure.4 Situation without drug

We can see from the figure 4, HP in the district quickly get infected and become the NAP, at the same time the NAP gradually transformed and become AP. The ratio of the patients begin at a very low level, and come to approximately 1(which means all our people get infected). Finally there is just AP remain in the district. It is a total disaster if it is put in real situation.

Then our system come into use. By using the deliver method stated above, we set the threshold at 0.05, and we begin to send out our drugs at time 20. Our simulation gives us the result below:

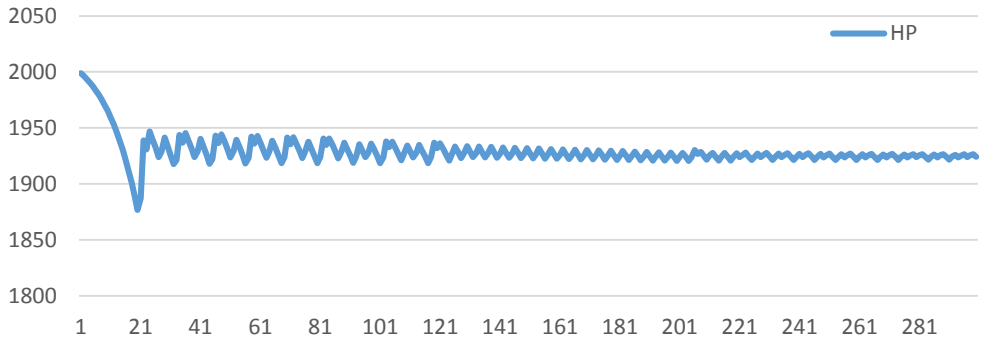


Figure.5 Population change of HP patient

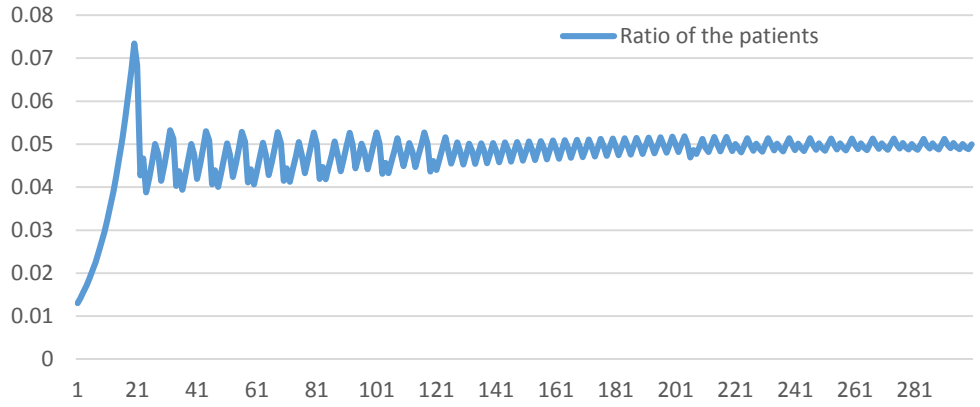


Figure.6 The ratio of the patients

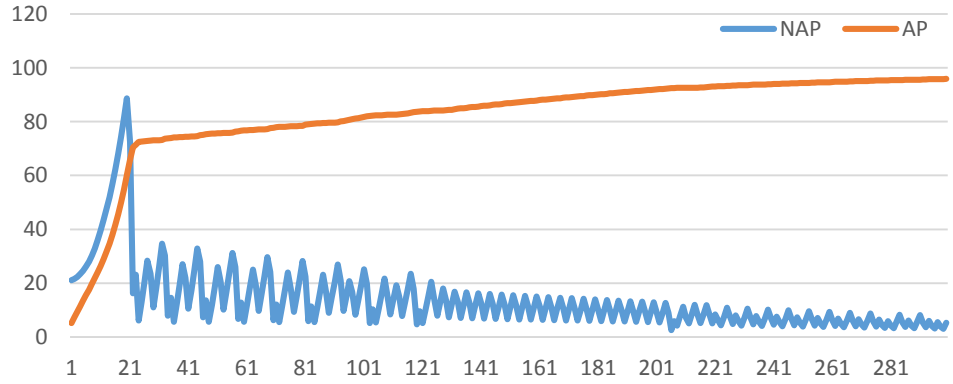


Figure.7 Population change of NAP and AP

We can see that before the time of 20, the population of HP drops to around 1800 because people get infected. After the medication is automatically given, the population turn back to a relatively higher level and begin to vibrate and finally reach an equilibrium and remain unchanged at a level of 1925. Figure 5 show the same trend as the Figure 4 does. We can all see that in the figure 6, NAP jump high in the beginning and return back in a low level, the AP cure become flat at the final time and hold on its speed of growth. By the result we get above, we believe that our system actually control the spread of the disease.

And we also calculate the quantity of the medicine which send out in a center time. We get our figure 6 below:

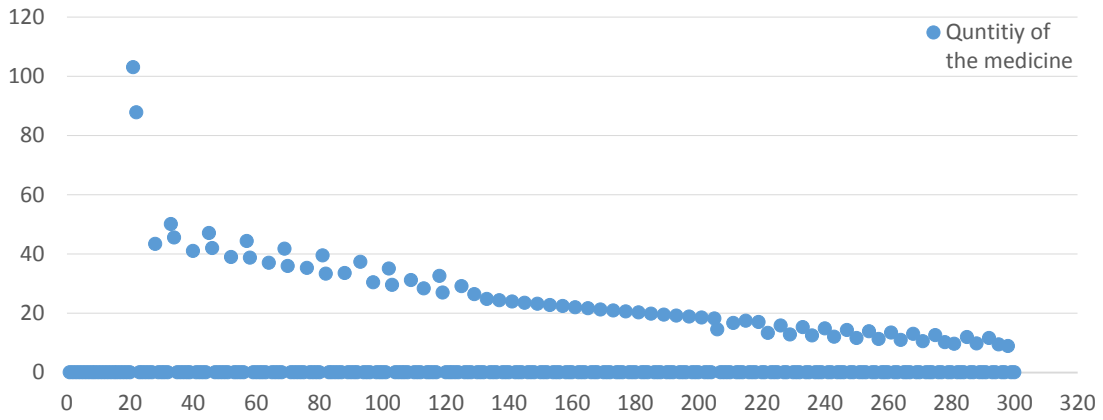


Figure.8 The amount of medication given

We test that the process is invertible. In other word, if we send out our medicine to the district according to the amount given in Figure 6. We can get the same result as the Figure 4, 5, 6 showed below. So if our model is a fine simulation of the epidemic disease. We can predict the trend of the disease and send out our drugs in a head of time, and then we can save more lives.

(2) Constant Speed of Manufacturing

When the speed of manufacturing is constant, the quantity of the delivered medicine is limited. Therefore, we need to decide how much medicine each city should receive. It is acceptable that the more severe a city is, the more medicine should it receive. According to our method of estimate the "mass" of each city, we can use the "masses" to represent how severe a city is. Therefore, the quantity of medicine each city receive is defined as follow:

$$Q_i(k) = MQ(k) \cdot \frac{M_i(k)}{\sum_j M_j(k)}$$

Where $Q_i(k)$ represent the quantity of medicine delivered to city i at time k, $MQ(k)$ represents the total quantity of medicine available at time k, and $M_i(k)$ represents the "mass" of city i at time k.

We also use the Water Flow method to deliver the medicine, but when should we deliver? We can first set a threshold, and deliver medicine when the patient ratio is higher than that threshold. Or just simply deliver medicine when every single unit time pass.

Deliver When Patient Ratio Is Higher Than Threshold

Assume we get a given speed of manufacturing, we wonder if we can control the patient ratio roughly stable around the threshold. Here we demonstrate the patient ratio variation with different speeds of manufacturing in figure 9 and figure 10:

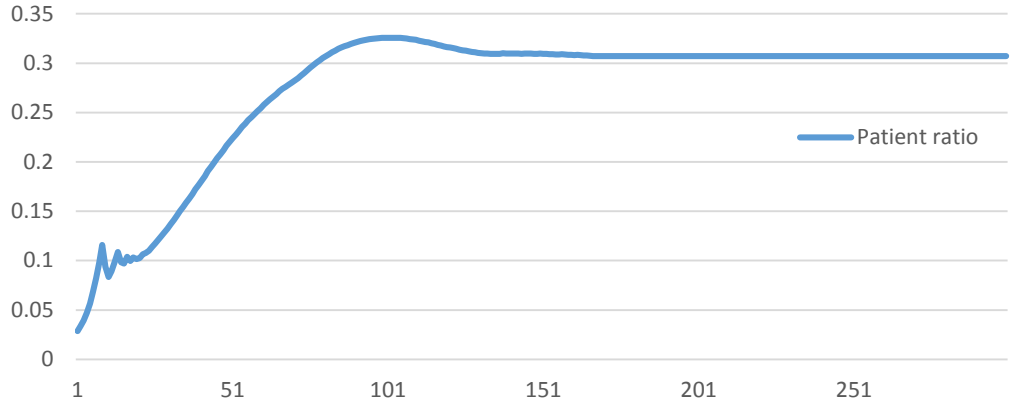


Figure.9 patient ratio with speed of 100 doses per unit time

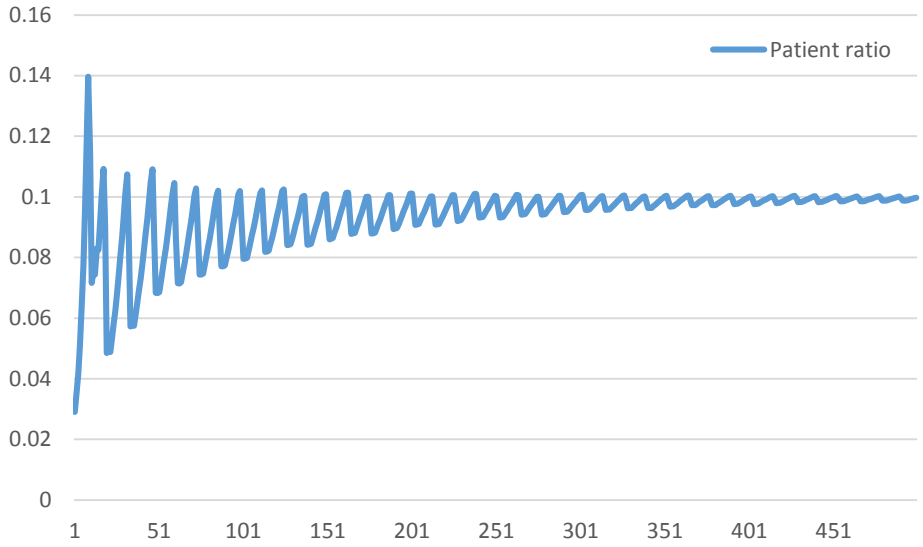


Figure.10 patient ratio with speed of 100 doses per unit time

From the figures above, we know that in order to control the patient ratio around the threshold, we need keep the speed of manufacturing higher than a certain level. Here we show how fast the speed of manufacturing should be at least to control the patient ratio around a certain threshold in figure.11:

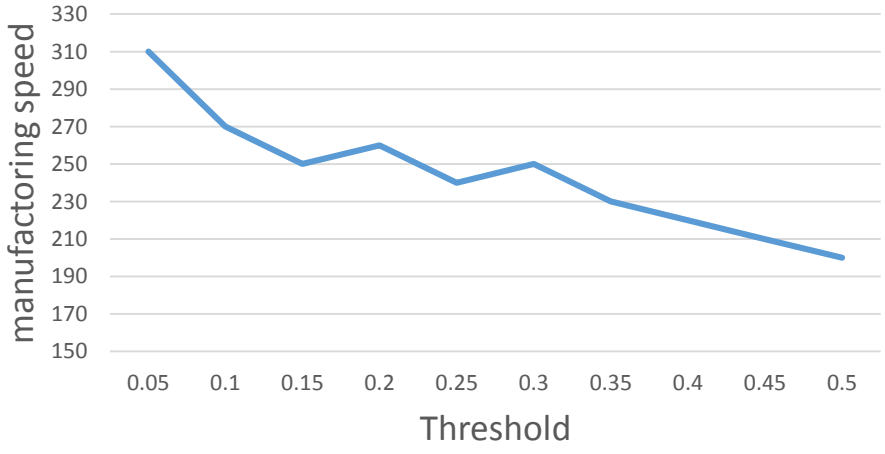


Figure.11 relation between threshold and manufacturing speed

In actual situation, we can decide how fast should we manufacturing medicine to control the patient ratio by looking up the figure.11, which is highly practical.

Deliver every certain Time Pass

In this kind of situation, we have no threshold like the previous one. What we want to know in this situation is the value that the patient ratio finally stable at for a certain speed of manufacturing. Here we show a curve of patient ratio for the speed of 180 doses per unit time in figure 12:

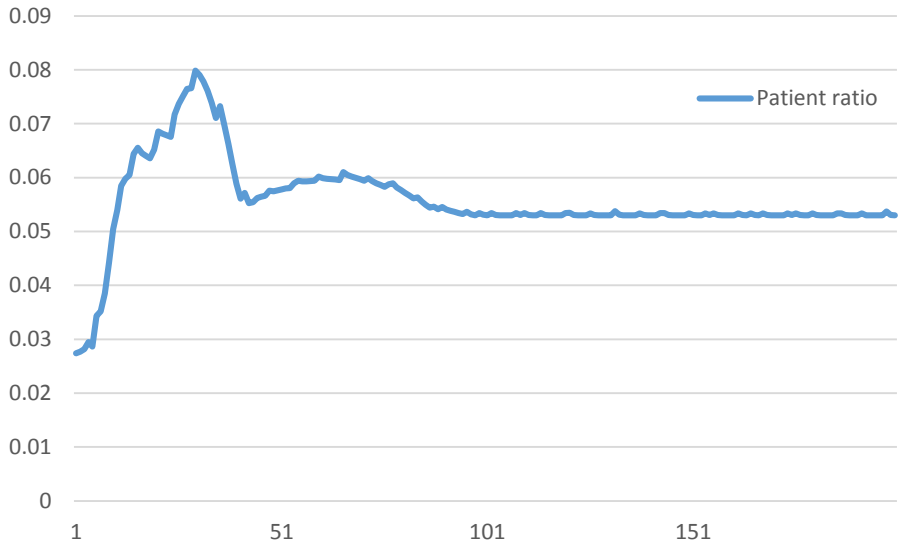


Figure.12 patient ratio with speed of 180 doses per unit time

In the following, we show the relation between the manufacturing speed and the stable value of patient ratio in figure.13:

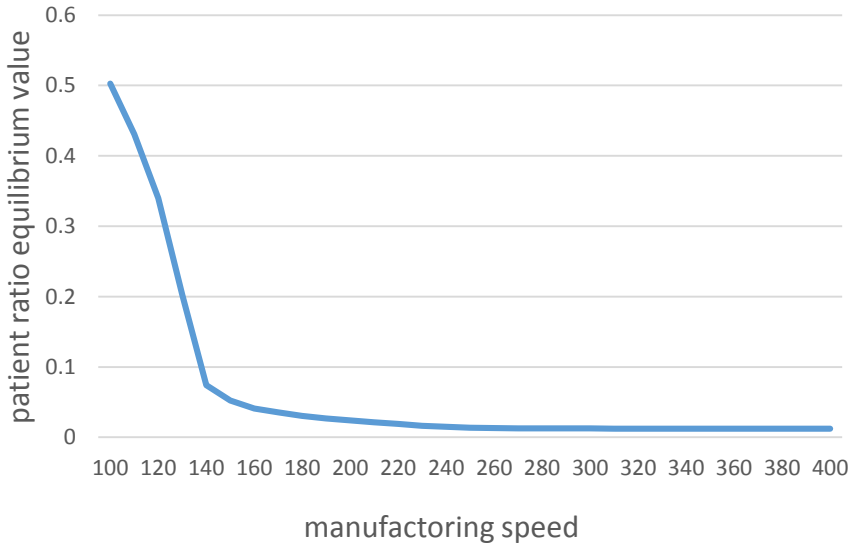


Figure.13 relation between manufacturing speed and ratio equilibrium

By using the graph above, we can know the stable patient ratio for a certain manufacturing speed. Which can also help us to make decision in practical work.

Sensitive analysis

In our delivering system, we test our model in a specific network. We wonder that if we change the properties of the network, whether our system can still find the delivering strategy to limit the patient ratio to an equilibrium. So we test our model on 80 new networks which has the same number of nodes compare with our previous network, but with different position and connection.
The people's combination in each city is randomly formed, the initial ratio of the patients is around 0.01. It turn out that our method can be applied in different network, and can find the equilibrium method.

We also consider a situation, in which medicine is delivered when each unit time passes and the manufacturing speed is a constant. In this situation, the patient ratio will be stable around a certain value. For a stable model, when the population of cities changes or the network change, the patient ratio equilibrium value should not change so much.

When Population changes

We keep the network unchanged, and set the population of each city randomly. Repeat the model 100 times, to see how the patient ratio equilibrium will change. Here we show the patient ratio equilibrium values in figure.14.

We use the formula below to evaluate the variation of patient ratio:

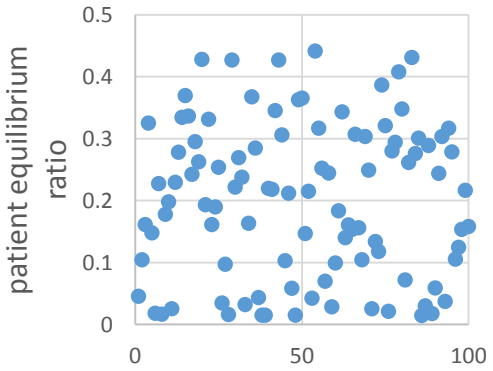
$$\text{var} = \frac{\frac{1}{100}\sum_i |PRE(i) - mean(PRE)|}{mean(PRE)}$$

where $PRE(i)$ is the patient ratio equilibrium value for each time, and $mean(PRE)$ is the mean value of the patient ratio equilibrium values.

After calculation, the variation of patient ratio is 0.3806, which means the patient ratio equilibrium value changes largely when the population changes.

When network changes

We keep the population of each city unchanged, and initial the network randomly. And also run the model 100 times, to see the variation of patient ratio equilibrium value. And we show the process in figure.15.



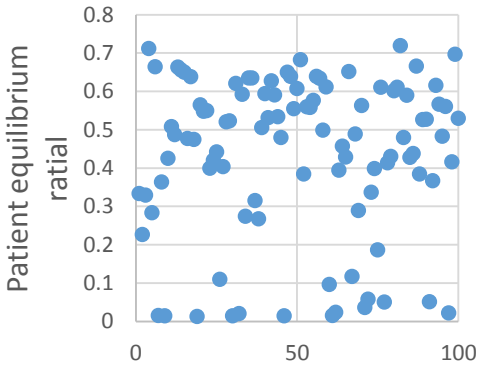


Figure.14 stable patient ratio(population change) Figure.15 stable patient ratio(network change)

We use the same formula to calculate the variation, and get 0.5251, which indicates that the patient ratio equilibrium value varies largely when network changes. What we should mention here is that the large variation is a reflection of the real world. With different number of nodes and different distance between nodes, getting a different patient ratio equilibrium value is reasonable.

Further discussion

Although we have already consider quite a lot of factor in our models, the factor in real world is much more complex. Here in the discussion section, we try to add more factor into our model to show that our model is very open for future improving.

Considering Death of People

In the model we establish we classify people into three types, HP, NAP, and AP. But we didn't consider the death of people which is caused by Ebola, therefore in the solution section we can see that the patient ratio can never be reduced to zero. Here we add a new types of people DP, whose death is caused by Ebola.

Assume that people will die in m days after their disease becoming advanced. Therefore the numbers of HP, NAP, AP, and DP will change after a unit time according to the rule stated below:

$$N_{HP}(1,k+1) = N_{HP}(1,k) - N_{HP}(1,k)\cdot p$$
$$N_{NAP}(1,k+1) = N_{HP}(1,k)\cdot p$$
$$N_{NAP}(j,k+1) = N_{NAP}(j-1,k) \quad 2 \le j \le n$$
$$N_{AP}(1,k+1) = N_{NAP}(n,k) + N_{AP}(1,k)$$
$$N_{AP}(j,k+1) = N_{AP}(j-1,k) \quad 2 \le j \le m$$
$$N_{DP}(k+1) = N_{AP}(m,k) + N_{DP}(k)$$

Applying this new model to the nodes of the network, we can get some new results. We can find that the patient ratio can be reduced to 0, less medicine are required and the patient ratio takes less time to get stable.

We use the network showed in figure.1 to test our modified model, the manufacturing speed is adjustable, and the medicine is delivered whenever the patient ratio gets higher than threshold. Then we get the patient ratio variation curve in figure.16, and the quantity medicine curve in figure.17

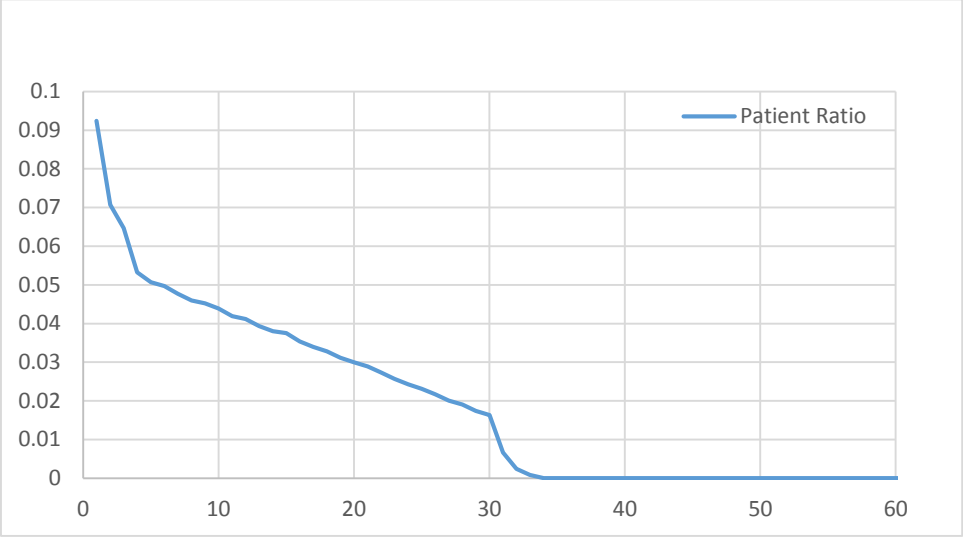


Figure.16 patient ratio curve

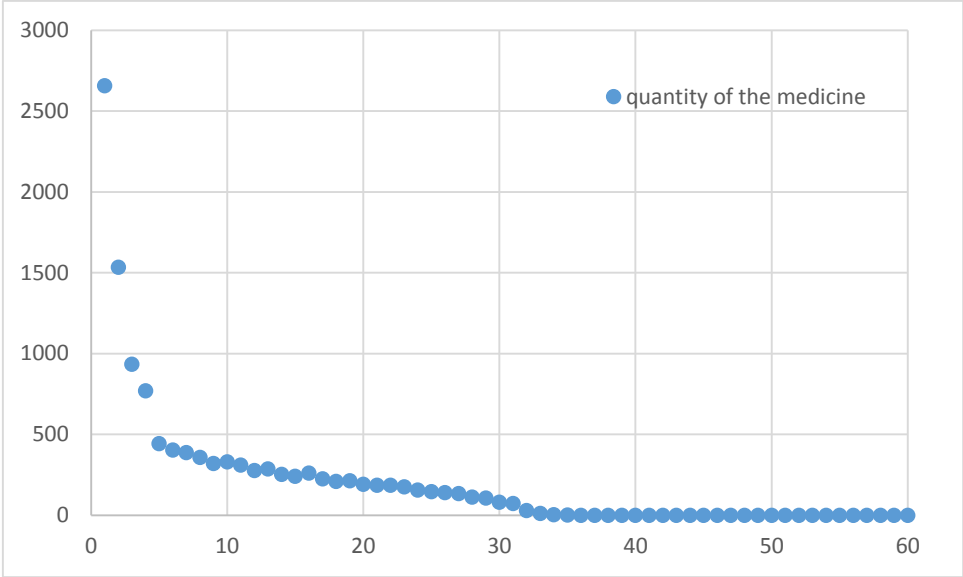


Figure.17 quantity medicine curve

Consider Interaction between cities

In real world, people can move from a city to another. When patients migrate, they carry disease from city to city. Here we define the migration happens between cities that are directly connected. And the migration between city i and city j is given as follow:

$$M_i(k) = \frac{\gamma}{d(i,j)} \cdot \left(\sum_l N_{HPi}(l,k) + \sum_l N_{NAPi}(l,k) + \sum_l N_{APi}(l,k)\right)$$

$$M_j(k) = \frac{\gamma}{d(i,j)} \cdot \left(\sum_l N_{HPj}(l,k) + \sum_l N_{NAPj}(l,k) + \sum_l N_{APj}(l,k)\right)$$

$$N_{HPi}(l,k+1) = N_{HPi}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{HPi}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{HPj}(l,k)\ 1 \le l \le 2$$

$$N_{NAPi}(l,k+1) = N_{NAPi}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{NAPi}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{NAPj}(l,k)\ 1 \le l \le n$$

$$N_{APi}(l,k+1) = N_{APi}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{APi}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{APj}(l,k)\ 1 \le l \le m$$

$$N_{HPj}(l,k+1) = N_{HPj}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{HPj}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{HPi}(l,k)\ 1 \le l \le 2$$

$$N_{NAPj}(l,k+1) = N_{NAPj}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{NAPj}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{NAPi}(l,k)\ 1 \le l \le n$$

$$N_{APj}(l,k+1) = N_{APj}(l,k) - \frac{\gamma}{d(i,j)} \cdot N_{APj}(l,k) + \frac{\gamma}{d(i,j)} \cdot N_{APi}(l,k)\ 1 \le l \le m$$

Where $M_i(k)$ is the total amount of people that moves out of city i, $d(i,j)$ is the distance between city i and city j, and γ is the migration rate that can be used to adjust the how many people migrate in a unit time.

From the formula above, we can see that the number of people migrating is proportional to the total population of a city and counter proportional to the distance between two cities.

Consider isolation of Patients

In real world, Ebola patients might get isolated to stop the spread of disease, but not all the patients can be isolated. And we define the amount of people get isolated as follow:

$$N_{IPi}(k+1) = N_{IPi}(k) + \tau \cdot (\sum_{l} N_{NAPi}(l,k) + \sum_{l} N_{APi}(l,k))$$

$$N_{NAPi}(l,k+1) = N_{NAPi}(l,k) - \tau \cdot N_{NAPi}(l,k)\ 1 \le l \le n$$
$$N_{APi}(l,k+1) = N_{APi}(l,k) - \tau \cdot N_{APi}(l,k)\ 1 \le l \le m$$

Where $N_{IPi}(k)$ represents the number of people get isolation in city i at time k, and τ is isolation rate.

The previous consideration is reasonable and is quite easy to be added to our model, which indicates that our model is very flexible. Because of the openness of our model, we can easily add many more factor, and make our model more and more realistic.

Strength and weakness

Strength

Our model effectively achieved all of the goals we set initially. Our model not only consider the spread of the disease and also develop a system which can automatically control the spread of the disease by delivering the drugs in an effective way.

It was fast and could handle large quantities of data, but also had the flexibility we desired. We apply our model to different network to test its stability and get good result. We do not test our model with real data but we believe that its flexibility and sensitivity will enable it to produced high-quality results with virtually no added difficulty.

Weaknesses

Some real data can’t be found, and it makes that we have to do some proper assumption before the solution of our models. A more abundant data resource can guarantee a better result in our models.

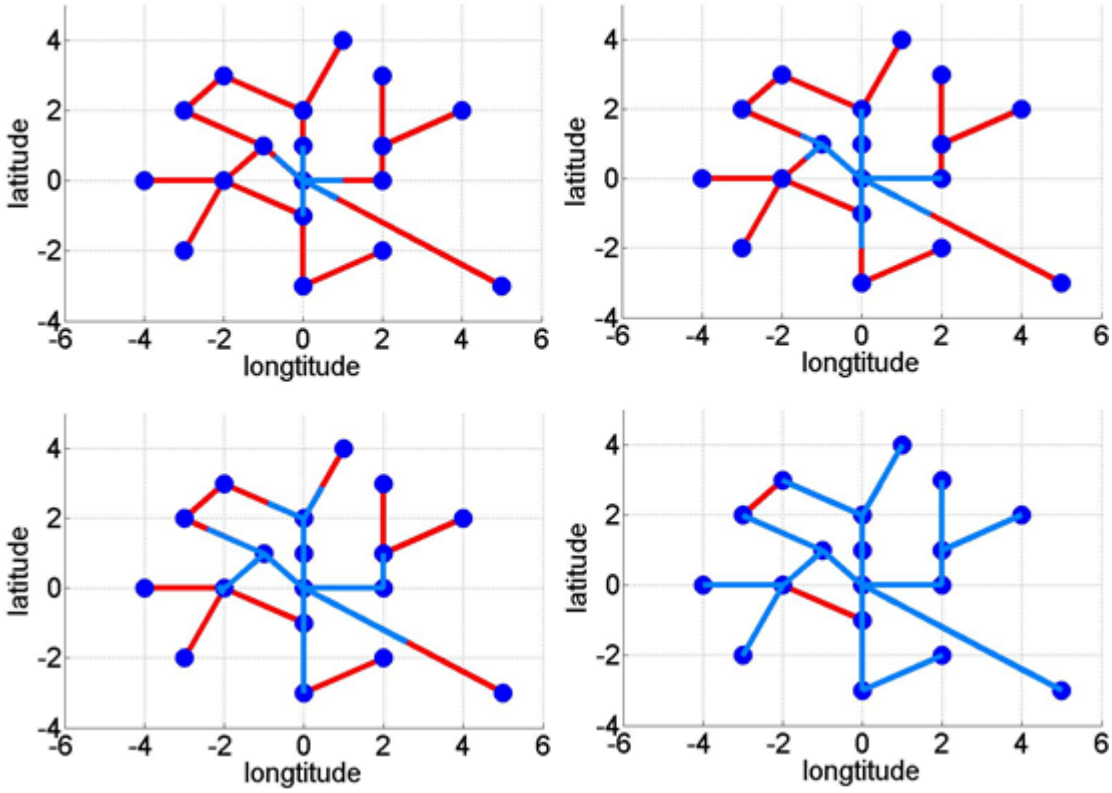
In order to simplify our model, we didn’t take more other factor into consideration, but in order to make our model more realistic, given the extra time, we will introduce more factors into our model.

The accuracy of the model can’t be tested. For our epidemic model may be a little simpler compared with the real situation. Our whole model is a discrete model, we can also make it a continuous one.

Reference

[1]. Kermack, W. O.; Mc Kendrick, A. G. (1927). "A Contribution to the Mathematical Theory of Epidemics". Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences 115 (772): 700.
[2].http://en.wikipedia.org/wiki/Center_of_mass#In_two_dimensions
[3]http://en.wikipedia.org/wiki/Floyd%E2%80%93Warshall_algorithm

Our new medication can stop Ebola and cure patients whose disease is not advanced. We find a systems which can effectively produce the medicine and delivering the medication to the people who need it as soon as possible.
We will build the medication factories as many as possible in those city where the situation is more severe. We will produce our medication and vaccine in those city and we will use our delivery system to automatically send out our drugs in an effective way.
In our system, one medication factory is built in one of our central city. The medication center deliver the drugs to its neighbor city. Those cities who receive the drugs will follow the instruction which medication center give them to send some portion of drugs to their nearest cities, just like the reservoir sent out the water flow. We believe it is the fastest ways to deliver the medicine to the people who need it.



And also the medication center can anticipate the drugs needed in city before the medication actually reach the place. So the medication center just control the total amount of drug produced in the factory. And those drugs can automatically be divided and sent to all cities in the district. We took a deep analysis to the epidemic disease and find out the way and trend it spreads. So we can anticipate it growth in a certain city, then we can send out our drugs in advance, as a result to control the spread of the disease and save people's lives. The battle between Ebola virus and human will finally come to an end.