International Meeting Location Model Based on Time Difference and Flight Fatigue

Explanation

This abstract is a translated excerpt (original text in Chinese) from my co-authored, 55-page research paper submitted to the International Mathematical Modeling Challenge 2017. The research was conducted in 120 hours from March 31 to April 4, 2017 and it won the Finalist Award in the IMMC International Contest in May. In the research, I was the main contributor to the mathematics of the Time Difference Sub-model by solving for the coefficients of the circadian rhythm function and homeostatic efficiency function (both second-order differential equations). I programmed the MATLAB GUI implementation of the model and was in charge of drafting stability analysis and further improvements in the research paper.

Abstract

For international conferences, jet lag and flight fatigue have a significant negative impact on participants' productivity. Meeting organizers can expect to reduce the loss of work efficiency by prolonging the participants' rest time in the target city, but this also increases the organizational cost of the meeting organizer. Therefore, the balance of the relationship between time difference, travel fatigue and rest time after arrival is especially important for a conference organizer with a limited budget. In order to better assist the organizers in this balance, this paper explores the impact of jet lag and flight fatigue on the initial working conditions of the participants when they arrive at the target city and their recovery after the arrival. Organizing international conferences at the recommended locations calculated in this paper will maximize the efficiency of the participants during the meeting. This recommendation will provide a reference for the organizer to select the conference city.

In this paper, we first calculate the working efficiency of the participants when they arrive at the target city on the first day of a certain time zone by using the **Time Difference Sub-model**, and then subtract the fatigue factor of the participants on the first day through the **Flight Fatigue Sub-model** to calculate the actual first-day work efficiency. After that, we obtain the number of days the participants can rest by calculating the budget and spending. In the **Recovery Sub-model**, by entering the number of days to rest and the efficiency of the first day of the arrival in the destination city, we get the sum of the efficiencies for all participants during the meeting. In this paper, the overall efficiency of all participants obtained from each candidate target city is scored and ranked, resulting in a list of candidate cities.

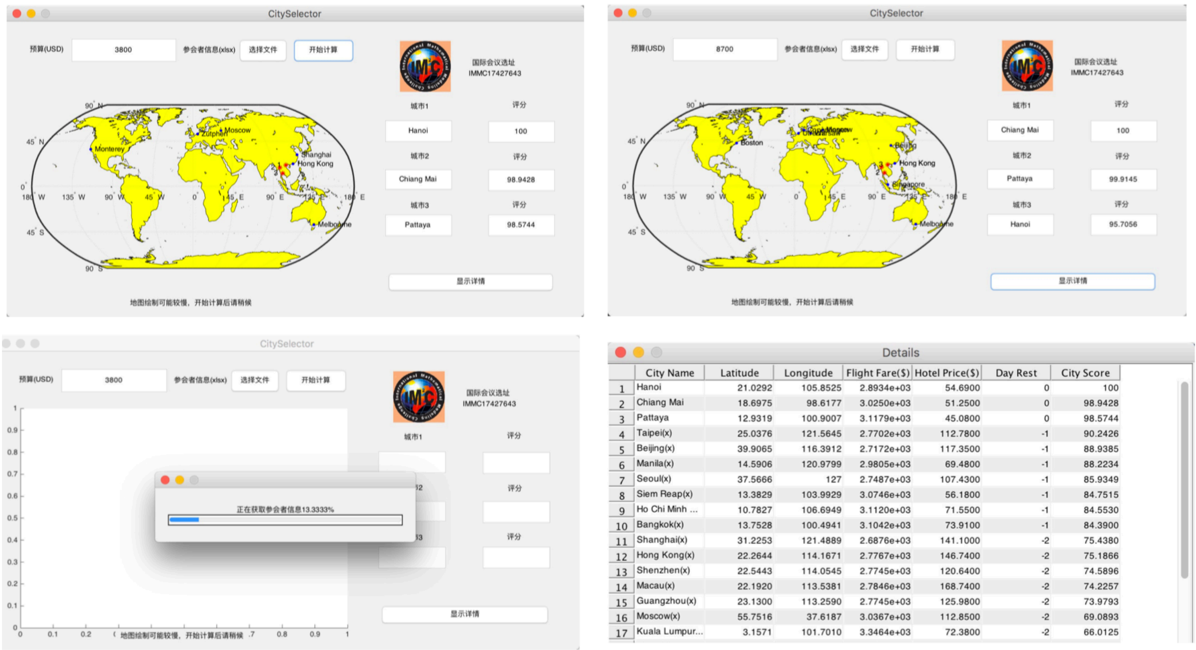
In the **Time Difference Sub-model**, this paper solves the circadian rhythm function and homeostatic efficiency function of participants in the original city by using the Two-Process Model. Based on this model, we explore the changes of the Two-Process Model function under various time differences to calculate the impact of time difference on the efficiency of participants. The Two-Process Model was

obtained after rigorous scientific experiments, and thus basing our model on it produces good prediction ability. This model can accurately find the ratio of the working efficiency in target city to the state in departure city, and the results align with a large number of literature and experience description.

In the **Flight Fatigue Sub-model**, this paper performs regression on the flight fatigue data in psychology literature and obtains the function of flight fatigue on flight time. The model calculates the flight distance by the distance between two points on the standard ellipsoid of the Earth and substitutes it into the fatigue function to get the flight fatigue index of the participants. In this paper, we combine the work productivity in the Time Difference Sub-model and the flight fatigue index to get the initial efficiency of the participant in the target city.

In the **Recovery Sub-model**, this paper derives the working efficiency differential equation based on literature and experience. The differential equation adopted in this paper is autonomous; that is, the recovery is only related to the value of work efficiency, not to the specific time. This is consistent with the physical implications of the effects of jet lag and fatigue. The coefficient of the differential equation is determined empirically according to the description that "the recovery time is two-thirds of the time span across the time zone", and we bring the time difference and the corresponding empirical recovery time into the differential equation to obtain the coefficients under different time differences. This effectively reduces the occurrence of extremes and allows the recovery under various time differences to be in line with the data. This article assumes that the organizers' budgets exclude all airfare and hotel costs during the meeting and are all used in extra hotel money to bring participants in advance to the target city. This article uses real hotel prices from business reports.

To facilitate organizer calculations, we implemented the model using MATLAB GUI and the program allows users to customize the budget. After the user imports the participant's city information by spreadsheets in the graphical interface, the program will calculate the recommended city ranking according to the model and mark it on the map. The program has built-in information of 77 cities around the world, including latitude and longitude and hotel price information; these real data increase the reliability of the prediction results. In addition, we localized the database to save from internet query and increase the computing speed.



	City Name	Latitude	Longitude	Flight Fare($)	Hotel Price($)	Day Rest	City Score
1	Hanoi	21.0292	105.8525	2.8934e+03	54.6900	0	100
2	Chiang Mai	18.6975	98.6177	3.0250e+03	51.2500	0	98.9428
3	Pattaya	12.9319	100.9007	3.1179e+03	45.0800	0	98.5744
4	Taipei(x)	25.0376	121.5645	2.7702e+03	112.7800	-1	90.2426
5	Beijing(x)	39.9065	116.3912	2.7172e+03	117.3500	-1	88.9385
6	Manila(x)	14.5906	120.9799	2.9805e+03	69.4800	-1	88.2234
7	Seoul(x)	37.5666	127	2.7487e+03	107.4300	-1	85.9349
8	Siem Reap(x)	13.3829	103.9929	3.0746e+03	56.1800	-1	84.7515
9	Ho Chi Minh ...	10.7827	106.6949	3.1120e+03	71.5500	-1	84.5530
10	Bangkok(x)	13.7528	100.4941	3.1042e+03	73.9100	-1	84.3900
11	Shanghai(x)	31.2253	121.4889	2.6876e+03	141.1000	-2	75.4380
12	Hong Kong(x)	22.2644	114.1671	2.7767e+03	146.7400	-2	75.1866
13	Shenzhen(x)	22.5443	114.0545	2.7745e+03	120.6400	-2	74.5896
14	Macau(x)	22.1920	113.5381	2.7846e+03	168.7400	-2	74.2257
15	Guangzhou(x)	23.1300	113.2590	2.7745e+03	125.9800	-2	73.9793
16	Moscow(x)	55.7516	37.6187	3.0367e+03	112.8500	-2	69.0893
17	Kuala Lumpur...	3.1571	101.7010	3.3464e+03	72.3800	-2	66.0125

Figure 1: MATLAB GUI implementation of the model

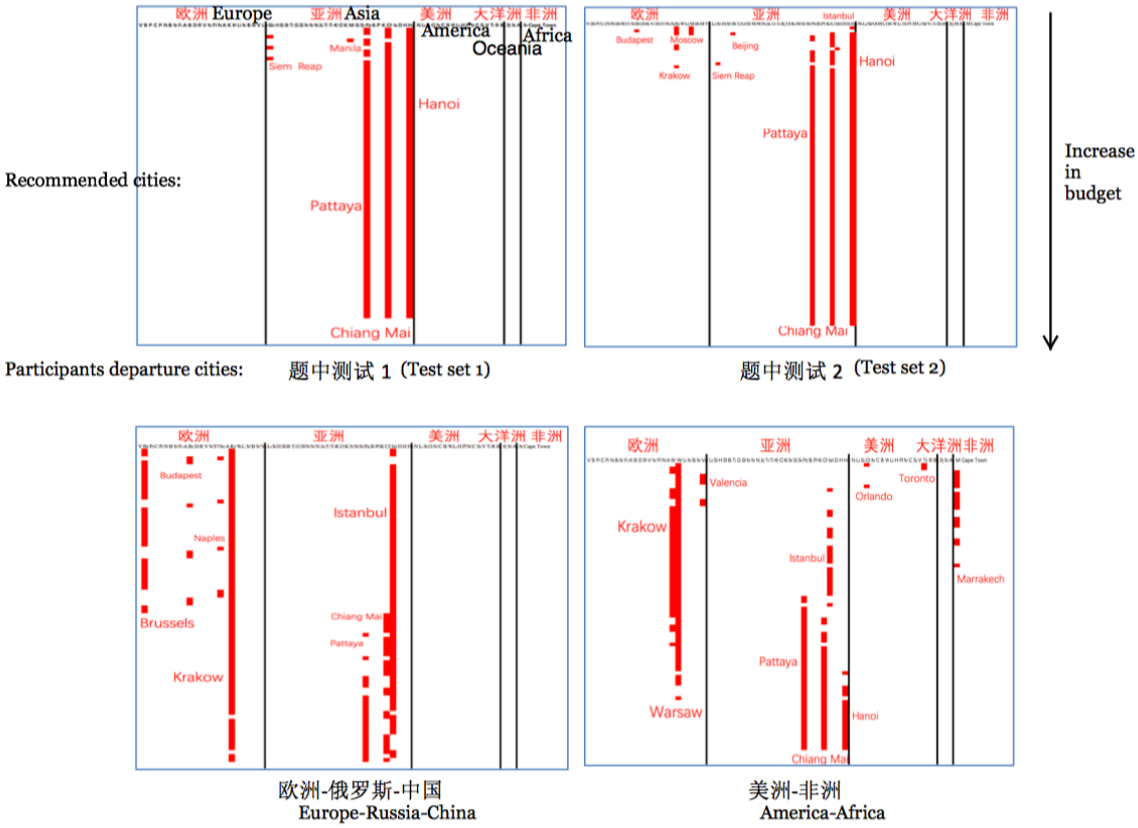


Figure 2: Visualization of model outputs under varying budget given certain participants departure cities