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Author(s)	徳丸，翔也
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On Sector Decision Problem of Aircraft Positions in CARATS Open Data

Shoya Tokumaru (1610132)

School of Information Science, JAIST, s1610132@jaist.ac.jp

Extended Abstract

Since February 2015, the Ministry of Land, Infrastructure and Transportation offers data describing information on aircraft flying over Japan, called CARATS Open Data. As a result, domestic researches have been actively conducted using this data. The number of air transportation passengers in countries around the world centering on developing countries is increasing. Even in developed countries, the population of using aircrafts as a means of transportation has increased, and Japan is no exception to this. In response to the increase in the number of passengers and the number of shipments, expansion of air capacity and efficient control have been demanded by airport maintenance, air space reorganization, and control over the entire airspace.

The airspace where aircrafts are flying is divided into sectors. The sector defines an appropriate size, range and shape in consideration of the location of the airport, the composition of flight paths and the traffic volume, etc., so that the air traffic control unit can control the aircrafts safely and efficiently . If the sector is too large, the number of aircrafts handled by the traffic controllers are exceeded and the traffic volume must be reduced. Also, if the shape of the sector is not appropriate, restrictions are imposed so as to prevent the aircrafts from operating smoothly, and the control by the traffic controllers becomes inefficient. If such a situation happens, an overall delay occurs. Each sector has capacity of the aircrafts. The control within the sector capacity is required to be safe and minimize the delay in handling aviation traffic without any problem by human control. To do this, the position information of the aircraft, the accuracy of the speed, the cycle of updating that information, and the delay in the update are important. In order to predict and solve the balance of demand capacity across the sectors, optimization and a high performance processing technology are required. In this paper, we aim to build a model that predicts the sectors of the entire aircrafts. As the first step, we propose a method to shorten processing time to compute information on when and where each aircraft exists using CARATS Open Data. In addition, we compare the proposed method with the all point search in the computation time, and describe the usefulness of the proposed method.

In order to shorten the processing time to determine the sector of aircrafts, we divided the flight trajectory of the aircraft into "stable section" and "non-stable section". Stable section is the section in which the aircraft cruises in a

certain direction toward the destination. Non-stable section is the section where the altitude changes during takeoff and landing.

Since the aircraft in the stable section is performing uniform linear motion, it is easy to predict the time and the position crossing the next sector. Regarding the altitude, after reaching a certain height, the aircraft keeps the altitude, but due to the nature of the aircraft, it is necessary to keep a constant balance of the lift force and the gravity force in order not to lower the fuel efficiency. At first, even though the lift and the gravity are balanced, the weight of aircraft gradually becomes lighter and as a result, they becomes unbalanced. In order to solve this problem, it is necessary to lower the wind pressure surrounding the aircraft under the condition that the speed is constant. In the nature of the Earth ' s atmosphere, its density decreases as the altitude rises, and the wind pressure can be lowered accordingly. Therefore, even for aircraft operating steadily at a constant speed, the upper and lower power balance is kept by gradually increasing the altitude.

In CARATS Open Data, time, flight number, longitude, latitude, altitude, and aircraft type data are provided. In order to decide the stable section among that limited information, we choose the "minimum altitude", "altitude change amount" and "aircraft direction" as parameters and decide the stable section satisfying the condition of each parameter. Although the altitude is basically constant in the stable section, as mentioned above, since the altitude is gradually increased in order to maintain the force balance, the start point and the end point of the stable section are obtained, we define all points between them as the stable section.

We find the boundary point of the sector with respect to the obtained stable section. We use the property of uniform linear motion within the stable section. First, from the point designated as the reference point in the stable section, we draw a straight line passing through the reference point and the neighbor point, and set the intersection point with the sector as the predicted intersection point. Next, we assume that the speed is constant, and find the elapsed time between the reference point and the predicted intersection. Finally, we refer to the point in the real data close to the elapsed time, and obtain the exact sector boundary point from that point. Since the boundary points of the final sector are referenced from the actual data, it is clear that the result of the obtained boundary points is correct. This is repeated until the end point of the stable section, using the obtained boundary point as a new reference point. Also, in the next sector to be found, the time for searching all the sectors is omitted by creating a list of adjacent sectors in advance and searching from there. We verified how the processing time is reduced by changing the parameter that determines the stable section.

As a result of this method, the processing time is reduced about six times as compared with the all point search. In addition, it is found that if the parameter conditions are too strict, the proportion occupied by the non-stable section increases and the processing time increases. By using parameters suitable for flight characteristics of aircrafts, the processing time is greatly shortened. Moreover,

although the error rate when determining the boundary point of the sector from the straight line is also verified, since there is also a large error in some cases, improvement of this method is expected to further shorten the processing time.

In this method, in order to develop a sector prediction model using actual data of aircraft trajectory, as the first step, we propose to shorten processing time by using trajectory characteristics of aircrafts in order to give information on the sectors. In the future, we are planning to predict the actual aircraft trajectory in real time. For real-time prediction, we would like to implement models considering actual weather information and future weather forecasts, and also to implement models suitable for Japan's aviation information with high air demand density. In addition, we would like to propose and implement algorithms that reduces errors by the deviation from the predicted trajectory of the aircraft by this method.