CSIS0801 Final Year Project

Pilot's Dilemma

Project Plan

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Section 1 – Introduction

In bad weather, commercial aircraft pilots have to make complex decision quickly to ensure flight safety. When there are rainstorms or cumulonimbus (Cb, a type of cloud associated with thunderstorms) near Hong Kong International Airport, the approaching paths of aircrafts may be affected as these are hazardous to aircraft structure and safety. There are 4 situations that pilots may decide to do or experience: holding, slowdown, missed approach and deviation. The resultant situation, or pilot decision, mainly depends on cloud size, movement and position.

With the support of historical time series of radar data and flight path data, it is possible to build an automatic system to predict pilot decision when they encounter rainstorm or cumulonimbus. This project combines aircraft position and radar data to quantify weather impact on aircraft movement. After quantifying and analyzing data, we hope to build a system to predict the probabilities of different pilot decisions: holding, slowdown, missed approach and deviation. We hope this prediction system can aid the air traffic controller in estimating the weather impact and flight planning.

Section 2 – Project Objectives

The objectives of this project is to:

1 Explore and analyze historical weather radar and flight path data provided by Hong Kong Observatory.
2 Categorise historical flight path into five situations: normal approach, holding, slowdown, missed approach and deviation.
3 Establish a model that consists of rules and criteria of pattern identification.
4 Build an automatic system to predict pilot decision with time series of radar and flight path data based on the pattern identification model.

Section 3 – Problem Setting

3.1 Project Description

This project is to build an automatic system that can predict what the aircraft pilot is likely to do in face of different rainstorm situation. To reach this goal, Hong Kong Observatory has provided at least 10 periods of aircraft position data and radar data in 2011 and 2013 for analysis and modeling. There are more than 1000 flights in total with time, latitude and longitude, call sign, flight level, ground speed and bearing information. Besides, weather radar data of the corresponding period of time is also provided. The data pack includes radar reflectivity, vertically integrated liquid, maximum reflectivity of echoes, and echo top information.

With the above data provided, first of all we need to visualise the flight path and combine the radar data on the map. This is to categorise the historical flights into five situations: normal approach, holding, slowdown, missed approach and deviation. From the five subsets of data, the criteria and patterns of each situation shall be found and established. A pattern identification model then can be built up to define the five situations for all historical data. After that the weather information and categorized flight data shall be paired up and stored in database. By referring the paired up data, when there is time series of radar data and initial flight path data, the system shall be able to compare the historical data and input data, and calculate the probability of different situations.

3.2 Data Processing

Data processing is a main part of this project, discovering the flight and weather pattern from historical data. The aircraft position data from Hong Kong Observatory is in CSV format while the radar data are 480 x 480 pixel grey scale pictures. To integrate these two types of data, they need to be visualised and filtered.

The aircraft position data set includes all aircrafts visible to radar in certain period of time. As there are not only aircrafts approaching or taking off from Hong Kong International Airport (HKIA), but also aircrafts passing through Hong Kong airspace shown in the dataset, it is necessary to filter the data set to show only aircrafts approaching HKIA.

The weather radar data are grey scale pictures of radar reflectivity, vertically integrated liquid, maximum reflectivity of echoes, and echo top separately. For better readability, the picture color needs to be rescaled to an appropriate RGB value. Also there is radar noise shown on the pictures that needs to be filtered. After the color rescale and noise filtering, the weather radar pictures are easy to read and better for further calculation.

3.3 Pilot Decision Prediction

There are four abnormal situations when aircraft pilots are facing rainstorm situations: holding, slowdown, deviation and missed approach. Holding is circling the aircraft at a certain position to avoid the weather along the planned trajectory or to wait for the rainstorm to move away from the planned track. Slowdown is flying the aircraft in a zig-zag way to delay the arrival time due to the weather impact ahead or at airport area. Deviation is flying the aircraft along another acceptable flight path around the thunderstorm or in the gap between convection. This can minimize the weather impact on the planned trajectory of the flight. Missed approach is a situation that in case the pilot decides to land the aircraft, the landing has to be cancelled at the last second and the approaching aircraft has to fly up again to go ground the airport and try landing again later. These four situations happen under different weather circumstances. The position, vertical thickness, movement and size of the clouds or thunderstorms matter the pilot decision to one of these situations. Therefore quantifying the cloud movement and its impact is essential in this project.

Section 4 – System Features

This project is to develop a system with the following features and assumptions:

Assumptions

The system shall be developed to tackle different weather situations, which the weather or rainstorm may appear everywhere: ahead of aircraft, near the airport or along the flight path. The prediction shall be calculated regardless of whether the decision involves air traffic controllers or pilots. Also the system shall assume there is no planned or filed flight path.

Data Processing

The system shall be able to minimise the radar noise, filter and rescale the RGB value of the input time series of weather radar images. The processed images shall be store in the database with appropriate format for the next stage of calculation.

Situation Prediction

The system shall be able to calculate the probabilities of the 5 different situations based on input weather radar charts and initial flight position. The calculation shall base on the pattern identification model, which will have been developed in the early stage of project.

(Optional) Flight Path Visualisation

The system ideally shall be able to visualise the predicted flight path of different situations with the provided weather radar charts. It is hope that the system can provide an animation of predicted flight path.

Section 5 – Project Schedule