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Airport Ground Movement: Real World Data Sets and Approaches to Handling Uncertainty

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1 Abstract

Two related topics are considered in this presentation, both concerning the ground movement of aircraft. The first describes the collection of data from publicly available websites and the second discusses the issue of uncertainty in this problem.

The airport ground movement problem [1] connects together the problems of runway scheduling and gate allocation, which are often tackled separately in the research literature. The overall problem involves allocating routes for aircraft to take as they proceed along the taxiways between the runways and the gates (stands), and timings or orders for them to take them. The aim is to find a schedule that reduces delays, reduces the fuel burn associated with taxiing, and is resilient to last-minute changes. This represents a challenging problem because there are typically several pinch points where congestion is more likely to occur, and the uncertainty inherent in aircraft landing times, pushback times and taxi speeds means that routes need to be constantly updated to reflect the current situation. In addition, any solution method must be efficient enough that it can be executed within a couple of minutes, at most, to accommodate incoming, changing data. Furthermore, once an aircraft has had a route allocated and commenced its movement, it is undesirable (and

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avoided at most airports) for a new route to be assigned. This means that any route allocation should be robust enough to cope with uncertainties that arise during the ground movements such as variations in taxi speed.

Innovation in this area is potentially limited by the difficulty in accessing real-world data sets. While some freely-available toy problems exist in the literature, none truly reflect the inherent complexity of operations at a real airport. Existing works have made use of data provided through partnerships with airports, but typically this is the subject of a non-disclosure agreement. This means that there are currently no up-to-date common datasets for researchers to compare approaches on. This acts as a barrier to new researchers entering the field, who would have to develop working relationships with airport staff to obtain relevant data, and we intend to resolve this problem.

This work explores several freely available sources of data related to airport ground movement, considering the ways in which these can be combined to confront this challenge. Initial attempts have also been made to quantify and address the important issue of uncertainty in taxi time estimation. The freely available data sets include layout information derived from open street map (OSM) (www.openstreetmap.org), which is free to use under an open licence, and the NATS Aeronautical Information Service (www.ais.org.uk). A tool has been developed and made available to generate layouts taken from raw data downloaded from these sites. Some example layouts for UK airports have also been made available. Furthermore, the work has explored the use of live flight track information taken from the site Flight Radar 24 (FR24) (http://www.flightradar24.com). These tracks are available for the majority of flights at most European and US airports and are detailed enough to allow analysis of the real movements of aircraft at an airport. However, due to measurement errors the recorded data appear to be precise but is not actually accurate (for example on occasions an aircraft is recorded as travelling along a path parallel to the actual runway rather than along it). In order to retain as much valuable data as possible, these paths can often be "repaired" by applying a linear transformation to the recorded trajectory and forcing the path of the data to coincide with the closest runway. To recover the most likely path, the raw data is snapped to the taxiways, from which taxi speeds and routes taken can be analysed. A tool has also been made available to conduct this snapping process from raw GPS track coordinates obtained from a site such as FR24.

Existing work [3] has quantified the uncertainty in terms of taxi time estimation using existing taxi time modelling. This work has expanded upon that by using the real flight data taken from FR24. The QPPTW algorithm (quickest path problem with time windows) is an existing state of the art approach for optimising the ground movement problem [2]. This finds the shortest path for a given aircraft given the routes which have already been allocated to other aircraft. However, the algorithm assumes that taxi time estimates are known exactly, which may not be the case. One approach for extending this work is to add a buffer time (slack) to aircraft movements to allow for variations in taxi speed. However, this impacts on the overall capacity of the airport and

can add unnecessary delay to aircraft movements. An existing approach to handling the similar problem of flow shop scheduling with uncertain (fuzzy) processing times can be adapted to the ground movement problem. Some preliminary results are presented exploring and contrasting the impact on final taxi-times and ground movement efficiency of adding padding and applying the fuzzy approach.

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