The Flightschedule Profiler: An Attempt to Synthetise Visually an Airport's Flight Offer in Time and Space

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Keywords: Information Visualisation, Time-oriented Data, Transport.

Abstract: Online route planners and travel reservations systems have become in the past years part of our everyday lives. Such sites, originating from the airlines themselves or oriented on "search and compare" tasks, do provide valuable services. But the very nature of the queries users formulate (ultimate result: *one* flight) limits the type of information one can expect to retrieve, and in particular does not allow to get an overall view of an airport's flight offer over time and in space. In this contribution we introduce a proof-of-concept visualisation that sums up in a synthetic way the [where to, when to] profile of an airport, its realm of possibilities. The visualisation acts as an upstream service, independently of any actual reservation loop: its main role is to help unveiling significant *spatio-temporal patterns* (densities and continuity over time for instance). The prototype is implemented on a real life data set: the winter 2013/2014 schedule of the airport in Nice. Ultimately, beyond a discussion on the issue, on the pluses and minuses of the prototype, this position paper questions the way travel data is presented, and as such can promote debates over the potential impact of information visualisation solutions in that context.

1 INTRODUCTION

Air transport has become in the last decades something quite common: 842 million passengers in the EU in 2013, according to Eurostat. The following statement can be found in an *Opinion of the European Economic and Social Committee*: "Air transport has developed from a luxury to a mode of mass transport" (EEC 2004). As a consequence, along with a growing numbers of travellers, we have witnessed the emergence of new flight routes, new flight schedules, new airports, new airlines. Hence one could assume that with this move came a need to renew the way information about flights can be communicated and *visualised*, that innovative solutions have been introduced in order to allow travellers to compare in a synthetic way alternative routes and schedules, and to allow airport authorities to post their offers in a readable, clear-cut manner.

To the best of our knowledge, however, *visual* and *comprehensive* presentations of an airport's flight schedule (in time ***and*** space) are simply not available at end-user level. There definitely is a lot of information available on the net through for instance airlines reservation systems, airports destination maps, airline route maps, etc. But is that *space + time* information really synthetic, easy to read, efficiently presented? Would applying *information visualisation* (Infovis) principles help designing solutions that can help users get a global view of what an airport can offer?

The above mentioned existing solutions, often either form-based or map-based, hit three major limits: (a) they do not allow for a consistent context + focus presentation of the information, (b) they do not allow for a time + space visualisation of the information, (c) they are stuck in a discrete time model that is inherently space consuming in terms of visualisation.

In this position paper we introduce a proof-of-concept visualisation that sums up in a synthetic way an airport's flight offer. The visualisation combines spatial and temporal information, and thereby helps unveiling *spatio-temporal patterns* by summarising visually parameters such as *destination*, *frequency*, *schedule*, *seasonality (operating periods)*. It is primarily used in a context view, in order to profile the airport's offer globally, thereby summing up visually its specific "to and fro" profile in time, and space. But the visualisation also allows for focus views (day-by day reading, destination per destination, etc.). Finally, it allows users to switch from a visualisation in ordinal time (only the order is known, not the exact time) where temporal densities

Blaise, J-Y. and Dudek, I.
The Flightschedule Profiler: An Attempt to Synthetise Visually an Airport's Flight Offer in Time and Space.
DOI: 10.5220/0006081804070412
In *Proceedings of the 8th International Joint Conference on Knowledge Discovery, Knowledge Engineering and Knowledge Management (IC3K 2016) - Volume 1: KDIR*, pages 407-412
ISBN: 978-989-758-203-5

are assessed in a clear-cut manner to a visualisation in discrete time where the exact time schedule of each flight can be read.

The approach is tested on data concerning the airport in Nice, the second largest in France (over 12 million passengers in 2015, according to the airport authorities). Initially developed as a static graphic it is now an online web prototype (Figure 1).

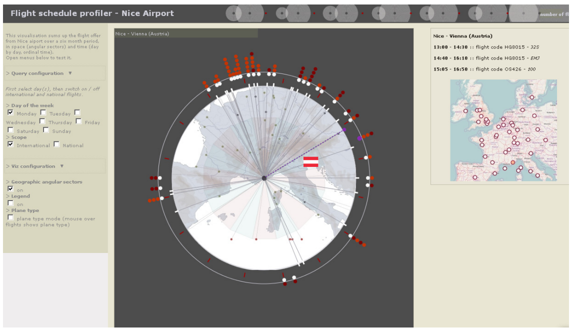

Figure 1: A screenshot of the online prototype, showing (top) densities of flight per half-day over the week, (left) user options, (centre) flight directions and densities in ordinal time, (right) flight details and a cartography (OSM).

It has to be said straightaway that what we are presenting in this paper is closer to an experiment than to a fully operational system: hence no claim will be made on the potential impact of our contribution. Yet beyond this limitation, and others to be mentioned in the paper's last sections, we think the issue is worth discussing. The preliminary results (and method) we report can act as food for thinking (and this beyond Air transport as such - railway transport for instance faces the same challenges).

The paper is structured as follows: section 2 narrows the questions this position paper wishes to address. In section 3 we comment on pre-computer era or contemporary designs that we consider as inspiring. Section 4 presents our proof-of-concept experiment in details, while section 5 summarises the approach's potential benefits, as well as its limitations. Finally, section 6 sums up what we think can be considered as fruitful feedbacks from this study, and potential perspectives of development.

2 THE ISSUE

Flight reservations are today commonly done on the Internet – 67% of the EU air passengers booked online according to a 2016 Eurostat report (Eurostat 2016). A significant number of travel planning and reservations systems have emerged in the past years (either these of the airlines themselves, or of third parties). They indeed provide a most valuable service for users, but the very nature of the query one fires on such systems (typically "*find flights from A to B on day D, order them by price / duration etc.*") strongly impacts the type of information the users will retrieve, and the way it will be displayed. Shortly said, such queries end up on:

- sequential data series (one flight after the other, page per page)
- verbose presentations (time slots and routes are given as textual indications, temporal densities are not clearly assessed)
- focus views (details on one flight at a time)
- the time parameter is present (departure and arrival time, durations) but the space parameter is limited to a textual list of airports.

Naturally this short list is an over-simplification of the current offer: a number of flight planners do propose significant improvements (including by proposing alternative modes of transportation). The introduction in a number of reservation systems of services such as "*show all week*" or "*find neighbouring airports*" shows the above issues are taken into consideration. But because they are included as an add-on in a sequential querying process these new services are little more than a band-aid solution if wanting to get a global overview of a given airport's flight offer profile.

The *flightSchedule profiler* prototype clearly does not aim at replacing reservation systems, but rather provides an upstream service : the possibility to get a quick, visual, space + time overview of the availability of flights to and from an airport, and consequently to map visually its specific realm of possibilities. So on what legacy, on what existing solutions can one base on when wanting to achieve this goal? In the next section we underline the largely untapped potential of some examples stemming from the history of Infovis.

3 RELATED WORKS

M. Friendly' s research highlights how visualisation has emerged over the years (over the centuries, in fact) as a major challenge in fostering insight on data sets. He mentions two major legacies - cartography and statistics - that he considers as rooting the development of data and information visualisation (Friendly, 2006). And indeed a full range of stunning examples can be quoted in the specific context of "travel data". E. J Marey's 1885 train schedule (see Tufte, 2006) proposes a still unchallenged context+focus visualisation of relations between two railway stations (Figure 2). It offers a global view, on a 24 hour slot, of all trains from Paris to Lyon (and back), assessing not only departure / arrival times but also speed on each segment of the travel or duration of stopovers at a glance. Although focusing on time (and cyclic time in fact) a spatial information is present: distances between stopovers on the graphic is proportional to the real distances.

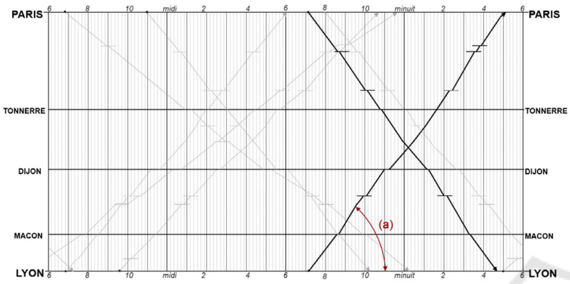

Figure 2: E.J. Marey's train schedule (redrawn and simplified). Time runs horizontally from left to right (24 hour slot, starting 6AM), stations are distributed vertically. Oblique lines corresponds to trains connecting Paris to Lyon and vice-versa. The angle (a) represents the speed of train (the duration of the travel in fact). Note for instance that it is straightforward to see that the two fastest trains, highlighted in black, depart at the same time.

The 1933 map + schedule visualisation of the Czechoslovakia Air Transport Company (Tufte, 2001) is another inspiring example: it combines in one unique visualisation space (position of cities) and time - departure / arrival times (Figure 3).

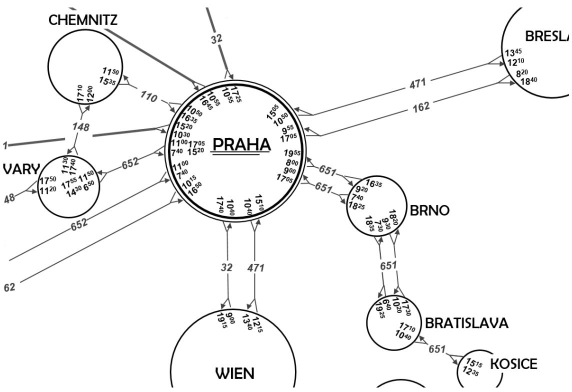

Figure 3: An extract of the 1933 Czech Airlines map and schedule (redrawn from Tufte, 2001). Each circle corresponds to a location in space, departure and arrival times are shown inside the circles, lines with flight code connect airports (the presence of an arrow differentiates inbound from outbound flights).

But with the above examples what we basically wish to pinpoint is there definitely is room for graphic creativity in the context of travel data. The omnipresence of reservation systems may have introduced a de-facto standardisation (including of *expectations*) that we think can be questioned. In parallel, an emphasis is now often put at research level on issues regarding the handling of massive movement data sets like in (Klein et al., 2014) – our concern in this paper is not about visualising trajectories, or trails, but basically about synthetizing end-user level information.

A broad look at time-oriented data visualisation shows there are today indeed promising research paths: the overview proposed by (Aigner et al., 2011) introduces some inspiring solutions more or less mixing time, space and quantities (ring maps, flow maps, space-time cube, space-time Path, etc.). In that context, the *flightSchedule profiler* prototype we experiment aims at investigating the way travel data can be displayed visually in a space + time combination. It bases on three major choices:

- ordinal time model – in order to minimize the amount of space needed to display all the information. This model of time is used in visual solutions like sparklines (Tufte, 2006b) or in historical data sets (Blaise and Dudek 2012).
- a somehow stylized cartography that only shows the essential: origin-destination vectors. This choice is in line with for instance the "Global map for accessibility" proposed in (Nelson, 2008).
- a "details on demand" design, in line with the Visual Information-Seeking Mantra, as worded by (Shneiderman, 1996).

4 THE PROTOTYPE

In this section we first present, one by one, the main information layers that are combined in the visualisation. Specific information on one flight or on one destination airport is available in the visualisation through user-side interaction – we do not detail that aspect at all since it is far from being a breakthrough.

4.1 The Geographic Layer

Cartography is used as a background – a sort of "mental image" in the sense of (Spence, 2001) – on which we position origin-destination vectors between Nice Airport and the airports it is connected to. In other words, the visualisation underlines the *orientation* information, and highlights in which geographic sectors the density of destinations is the biggest. For the destination airports that are close enough from Nice to be present on the map and those that are beyond the map's limits, the origin-destination vector connects the origin point (Nice) to a destination point projected on a circle that marks the limits of the map (Figure 4).

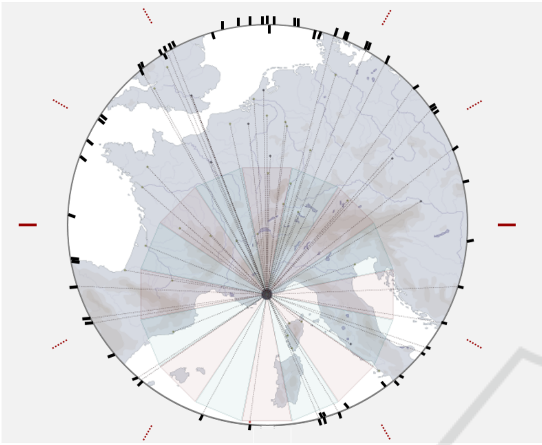

Figure 4: The cartography shows vectors connecting Nice to a destination point (represented here by small black lines) along a circle marking the map's limit.

Naturally, as can be observed on Figure 4, some of the origin-destination vectors almost overlap one another (typically, the vectors connecting Nice to the various airports in London).

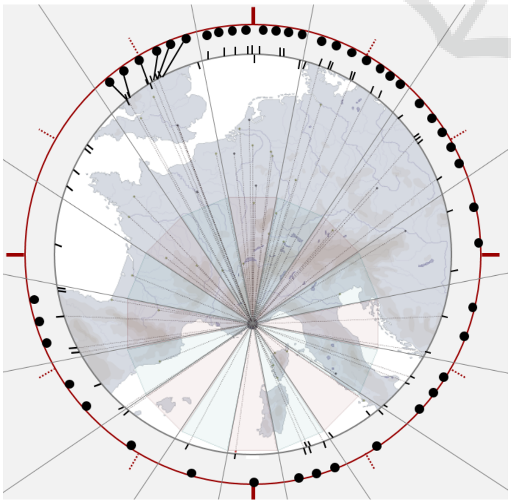

Figure 5: Dealing with overlapping vectors: - redistribution of the destination points inside 16 geographic sectors (see top left lines connecting the interior and external circles). Note that the visual comparison of densities is preserved, with an overwhelming proportion of northbound flights.

As an answer, we draw a second, larger, circle and redistribute all destination points regularly inside 16 geographic sectors: the solution still assesses visually densities in the various sectors, but a clear differentiation of each destination is made (Figure 5). User-side interaction is then added that allows the retrieval of additional pieces of information (name / code of airport, country, etc.). A filtering of national/international flights is also possible, and the retrieval of a "real" geographic map (online version - OpenStreetMap layer).

4.2 The Ordinal Time Layer

Once each destination airport is represented as a dot on the external circle we switch from a representation of space to a representation of time. To each black dot (*i.e.* destination airport) we attach one or several coloured dots that each represent a flight from Nice to that destination airport, in ordinal time. Noticeably the information delivered corresponds to one specific day inside a week. Flights that occur on a regular basis (everyday monday over the period) are differentiated from flights that are occasional, or do not operate throughout the whole 6 months period (Figure 6).

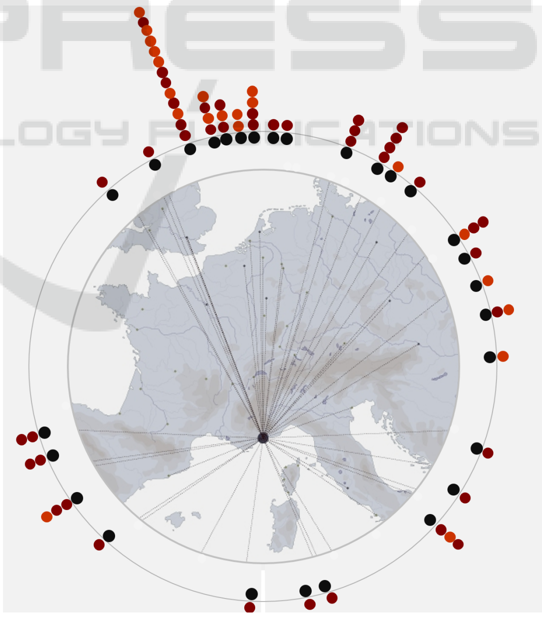

Figure 6: The ordinal time layer (Monday flights): each coloured dot corresponds to one flight. Dark red dots - *flights that occur on a regular basis*, light orange dots - *seasonal or occasional flights*. Note the varying proportion of non-regular flights between those heading north-west and others. User-side interaction triggers the displaying of textual and visual information about cities, airport codes, plane types, departure and arrival times, operating periods etc.

4.3 The Discrete Time Layer

The prototype was initially designed, as shown in Figure 6, in order to highlight densities in ordinal time. However we did test a solution based on the discrete time model, inspired by (Blaise and Dudek 2011). The result is shown on Figure 7: densities of flights, hour per hour, and destination per destination, are assessed visually – yet the usability of such a visualisation does require further investigation, and indeed a robust evaluation effort.

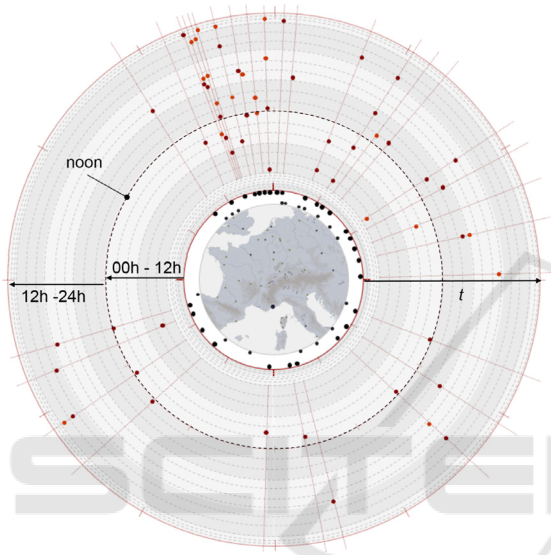

Figure 7: The discrete time layer (Monday flights): concentric circles correspond to hours of a day (time runs outwards). Each dot corresponds to a given flight, with the same colour codes as in the ordinal time layer.

5 BENEFITS AND LIMITATIONS

The prototype was intended to allow for a visual assessment of an airport's flight offer. At this stage what can be said is that it does help unveiling some significant spatio-temporal patterns such as a northbound flights trend, the predominance of non-regular flights in that geographic area, and in particular for UK flights, a majority of flights operating after midday, a significant variability in the number of flights depending on the day ***and*** on the destination, etc.

The visualisation can be used to investigate the offer for a given day, but also to allow for comparative or cumulative reading of the data, as illustrated in figure 8.

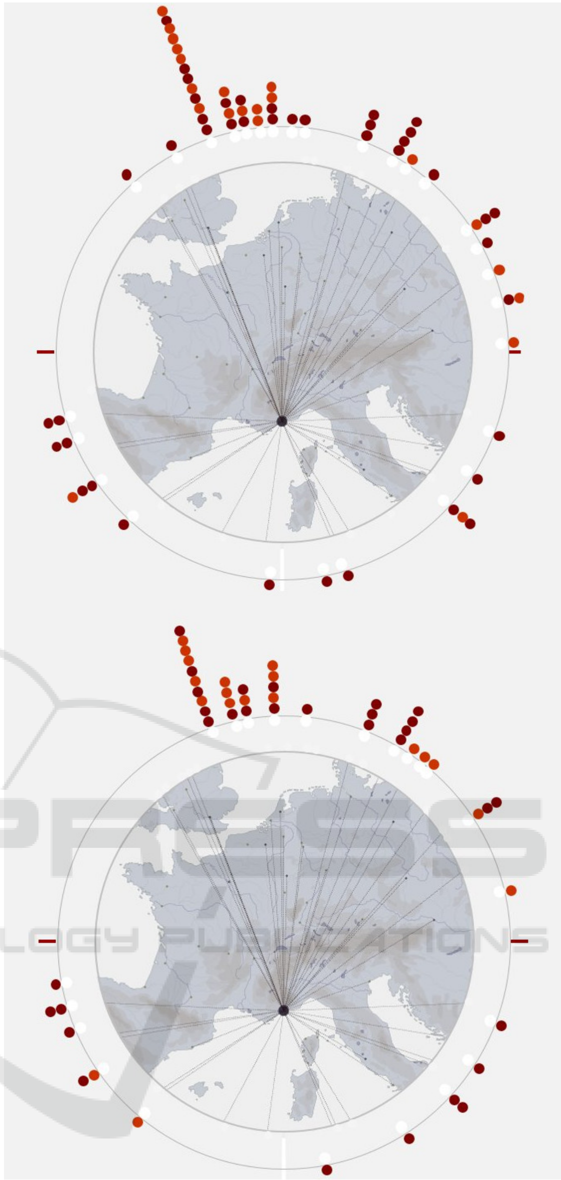

Figure 8: Allowing for comparisons: Monday flights (top): vs. Tuesday flights (bottom). Note differences in destinations, overall number of flights, and type of flights.

Yet, although we consider the result as providing a somehow valuable service, the visualisation at this stage has clear limitations:

- scalability: what can be seen as a credible option for a middle size airport like Nice would be irrelevant in the case of major hubs (or at least would require severe data filtering steps prior to the visualisation itself).
- Updating: at this stage the data is stored in an RDBMS and the visualisation produced on the fly – but no automatic feeding of the application is implemented.

- Connecting flights could be visualised but this feature is not implemented at this stage.
- The discrete time visualisation is relatively arduous to read: further development is needed in order to embed more user-side interaction (typically, brushing data items).
- Cumulative visualisations (several days shown in one same space) are rather dense, in particular in discrete time – yet they are useful to compare the flight offer on one day to possibilities on other days. This would require a specific visual encoding effort.

Furthermore, we did conduct an informal round of evaluation with a group of six testers – who were only asked to *decode* the information - but are fully aware that a robust evaluation effort remains to be done both in terms of readability of the visualisation, and of added-value. In short, what we present should definitely be understood as an early proof-of-concept prototype: we do acknowledge that there are at this stage significant limitations that minor its potential impact.

6 CONCLUSIONS

Online planners and travel reservations systems play today a prominent role in the everyday life of travellers, yet the very nature of the queries users formulate (ultimate result: ***one*** flight) limits the type of information one can expect to retrieve. We introduce a proof-of-concept visualisation that sums up in a synthetic way an airport's [where to, when to] profile and thereby allows users to get an overall view of its flight offer over time and in space.

The visualisation's role is not to replace the above mentioned reservation systems, but provides an upstream service, helping to unveil significant spatio-temporal patterns in relation with a given airport. It is implemented on a real life data set: the winter 2013/2014 schedule of the airport in Nice (*circ.* 200 flights per week). At this stage the development still leaves a lot of room for improvement, yet it already underlines the potential benefit of a *context + focus* information visualisation solution in renewing the way users portray an airport's flight offer. This experiment now needs to be questioned through a robust evaluation effort, and in terms of genericity (other transportation modes for instance). Future works will primarily focus on added-value assessment, user-side interaction and visual encoding issues, but at the end of the day we view this specific visualisation as *one in many*: it can be seen as *one* element of a toolbox to come that would include alternative solutions, suited to major hubs, including isochrones, *etc.*

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