Air traffic visualization in Europe

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Fig. 1. Air Traffic in Europe.

Index Terms—Data Visualization, Flight, Europe

1 Abstract

In this paper we discuss a visualisation of commercial air fligths in Europe. Our goal is to be able to see via a simple and clear visualization the favourite destinations for each European country. This type of visualization can help anyone who is interested in seeing the interactions between a set of countries and anyone interseted in air traffic especially a public interested in tourism and public relations.
We are going to use D3.js for the visualization and the softwares R and Python for data cleaning.

2 Introduction

European airspace is one of the busiest and most complex airspaces in the world. Every day thousands of air traffic controllers guide millions of passengers safely to their destinations.
Yet to most people, the choreography going on above them is entirely unnoticed it quite literally goes over their heads. Some might say that it is how it should be. Why do I need to know about air traffic as long as it gets me where I need to go? could be the argument.
But, this ignores one very important point. Airspace might be an invisible infrastructure, but it is every bit as important as the road, rail and utility networks we all rely on everyday. It is the lifeblood of our european economy.
Getting it right matters and we all have a stake in it !

This is why we want to create a data visualization showing the european air traffic for the last few years. The visualization will show, for a selected country, the most frequent destinations from that country and/or the most frequent flights coming in. We will also try to visualize the evolution through time of the most common destinations for a particular country.

3 Related Work

With the developpement of visualization tools today, we have many ways to see the importance of flight traffic all over the globe nowadays. One of these tools was developpd by NATS (National Air Traffic Services) which has the ability to feed a live stream in cinematic quality making a near real time air traffic visualization (figure 2). Here each currently flying plane is shown by a small plane accordingly to its position and direction.
Figure 3 is another type of visualization which can be encountered. It is a bit different as it aggregates the flights over a year and shows the entire planes' routes.
Both these examples help to locate visually the most busy air spaces and routes. However it is much harder to find visual information about the flow of people and especially about where the people of a specific country travel. Which routes carry the more people, and which countries interact the most ?
To get a more precise and visual answer, we have to make our own visualization.

We found an interesting article on automated layout of origindestination flow on maps(U.S. county-to-county migration 20092013)[6]. Their objective is to support the presentation and exploration of U.S. county-to-county migration through an interactive web-based flow map.

Fig. 2. Real time air traffic

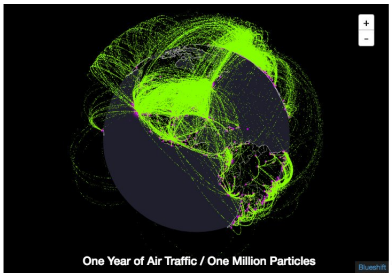

Fig. 3. Yearly air traffic

We also found a nice flow chart using d3 that could have been used (Fig 2).[7]

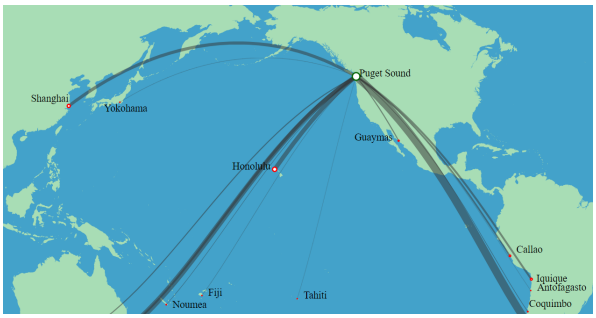

Fig. 4. Flow map

Finally, we found an awesome animation with a step by step tutorial of how to create flight animation on a map. This gave us a basic idea on how to move things quite easily. However this animation was using the third version of D3 so got some problem with deprecated functions like '.each()' (fig 3). [8]

Fig. 5. Planes animation

4 Conception Ideas

From several different datasets containing airport by airport European air traffic details over the last two decades, we formed a unique dataset centred on European air traffic passenger flow, by country and by year. As the more we get back in time, the more data were missing in the original datasets, we will only keep those covering the last five, six or seven years, a point still to debate.
The visualization will take form of an interactive map of Europe covering the most part of the web page as can be seen in Figure 4.. The different countries will be shown separated by their borders.
First, we want to define a colour coding illustrating the density of flight for each country compared to all flights within Europe. The higher the ratio of the number of passengers who travelled from/to the country divided by the total of European who travelled, the deeper its colour would be.
To illustrate the passenger flow from one country to another, we chose to use an arrow of which width comes accordingly to the percentage of flights this route reprensents among all of the country's flights. These arrows would show up for a country when passing the mouse over or cliking the country on the map. The clicking should hold the arrows whereas passing the mouse over a country would show them only temporarily, but enlighten or swell the country's borders to make it more noticeable.
A segment of the page would be dedicated to different option. One would allow to switch the visualization from "departure" to "arrival". The "departure" mode would show the outgoing flow of the country, while "arrival" could show the incoming flow.
Among them, we want to be able to use different cursors :

- a first cursor to select the year we want to visualize
- a second one to select the proportion of the flights we want to represent (for example selecting 50% would show only enough arrows to represent half of the flights from/to the country)

A space in this segment will be reserved to show figures when the mouse goes over a country or an arrow like the number of total passengers for a country, or the percentage a selected route represents among all routes... Another idea is to offer a scrolling field, where any of the European country could be selected and then play an animation of the evolution of its flow over the available years.

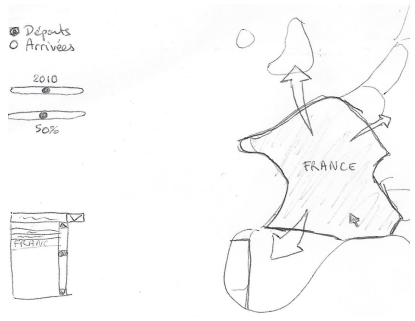

Fig. 6. Conception Scheme 1

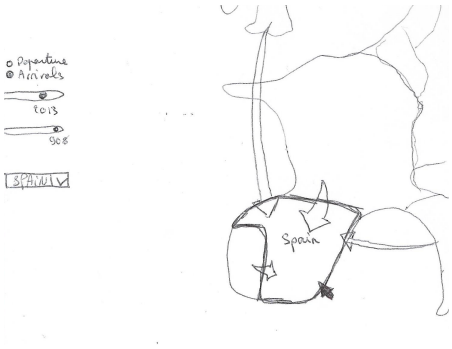

Fig. 7. Conception Scheme 2

5 Research and cleaning of Data

The first step of our work was to find a the data we wanted to illustrate. Ideally such data would have concerned all of the european countries, detailling the number of passengers from one another over a quitte large timespan (a decade or two). As we had a precise idea of the data we needed but no previous datasets, this occured to be a difficult task. Many data are available online about air traffic, however, those mainly concern only some companies and the few which seemed that they could match our needs were paying ones. Eventually we came across the website eurostat, the European commision's site, on which many different data on a wide variety of subjects are freely available. There we found datasets for air routes reporting, among other data, the number of passengers per months, quarters and year for every route (which means two airports connected by fligths) between 34 european countries. The data seemed to have been collected consistently since the begining of the decade, so for any further operation, we took the decision to use all the data from 2010 to now. The next step was generating usable data from these datasets : a clean dataframe aggregating the figures we wanted and sorting them by country (instead of aiports), date and direction (from which country to which). That work was done using the software R. The R code took the 34 datasets and generated for each country two csv dataframes one for the Arrivals and another one for the Departures. You can see in the next Figure an example of the departures' file genretaded for the UK.

	2017	2016	2015	2014	2013	2012	2011	2010
Autriche	359332	825613	700257	652042	606579	641728	641086	663828
Belgique	260392	644759	687991	618215	553914	526481	452776	436618
Bulgarie	210540	459876	339024	214461	201142	193639	187752	189876
Suisse	1434270	2618292	2558559	2517836	2464074	2443288	2436712	2248430
Chypre	361721	1089250	963272	832281	880236	943990	1084133	1026212
Tchéquie	308937	760976	699371	643215	602949	601155	569036	525669
Allemagne	2719619	6258363	6095734	5664833	5530888	5501380	5357822	5037185
Danemark	767591	1775224	1585978	1377393	1269221	1192546	1189774	1013423
Estonie	0	37049	0	0	0	0	40276	42511
Grece	433129	2094784	1878031	1627855	1365635	1285274	1362386	1418690
Espagne	8734054	19323963	16285738	15652659	14870165	14015992	13863503	12739830
Finlande	232145	497955	482316	470935	426810	376184	403783	391121
France	2060716	5059025	4799407	4501395	4322495	4235506	4164019	3793120
Croatie	87764	273286	251770	231976	206815	214301	141462	131663
Hongrie	377603	877139	769752	684667	583064	549253	498628	402028
Irlande	2772072	6055590	5528386	4822533	4561666	4429878	4361912	4349973

Fig. 8. UK Departure

Having a lot of different files and no hierarchy in them still would not fit our exigency. Consequently, we decided to convert those into one single practical json file. For this enterprise, we made an original code using Python language. The made parser can be found in the github project folder. The rendering file was composed of an array of lists identified by the code of each country, each of them containing two array : ARR for Arrivals and DEP for departures, themselves containg eight arrays for each year from 2010 to 2017 mentionning the number of passengers who traveled this route, this year in that direction.

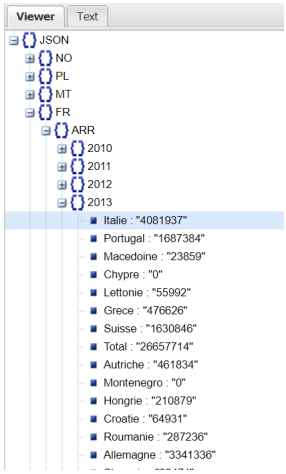

Fig. 9. json sample

6 Implementation with D3.js

6.1 Charging a european map

First of all we needed a blank european map in the geojson format, which can be easily used in d3.js. We found it on the website geojson-maps.ash.ms. and exported it with the desired quality. We choose the projection GeoConicConformal to display it in d3.

6.2 Coloring the map

Then we colored each country of our map according to the ratio

$$\frac{Total\ number\ of\ flights\ in\ the\ country}{Total\ number\ of\ flight\ in\ Europe}$$

We used for this a green colour range for countries where data were available and grey for the rest.

6.3 Adding slider 1

Secondly, we needed to incorporate to a space reserved for the menu options a first slider to change the displayed data. Our objective was to be able to see the evolution of the state of flights repartition in Europe year after year. For this purpose we implemented a first slider along a function *update* to update the used data for the coloration as the slider handle is moved.

Fig. 10. Slider for years

6.4 Departures/Arrivals button

One of our aims was to be able to compare the data for the flights **from** the countries and **to** them. The next menu option implemented was consequently a couple of button to switch between a visualization of the departures and another for the arrivals.

Fig. 11. Button

6.5 Adding tooltip

Then we added a tooltip to display, as the mouse pass through a country, the name and the total number of flights for the country matching the the selected year and direction.

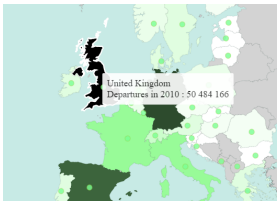

Fig. 12. Tooltip

6.6 The flows

At this point the base elements were already put and we could really start working on the visualization of the information upon the relations *between* countries.

6.6.1 Which segments between them ?

The first idea we had was about putting simple arrows to represent the flows between countries. After a few tests, we asked a restrained number of classmates and friends who confirmed our impression of a motionless visualization. Finding this quite contradictory for a visualization supposed to be about transportation, we made a few more researches and encountered some interesting work over moving svg planes. The decision was unanimously taken to try to implement a similar object for our representation.

6.6.2 Coordinates of destinations

Our planes would have to land somewhere on each country map, so that they would not be confused with cities or airports, the landing points were chosen never exactly on a country's capital city but a near place more central to it.

6.6.3 Moving planes

We found and redraw an svg plane which would take the place of the arrows. Then managed, after a few headaches, to adapt the example we had to our code and data. The goal was to continuously see them fly their route, so we used the setInterval function in d3 to do so. At first we set the interval to see them to fly one by one the routes and, last but not least, their size according to the number of passengers the route represented.

It was there obvious that the info wasn't clear enough this way : we had to wait the whole plane flight to be sure of its destination, and after the different planes had gone in separate directions, it was complicated to compare their size... This was a pleasant and relaxing display, but truly not answering our goals. We thought it back and decided to reduce drastically the interval between the planes' launches so that they would form a distinct flow between the two destinations while still providing playful viewing of the routes.

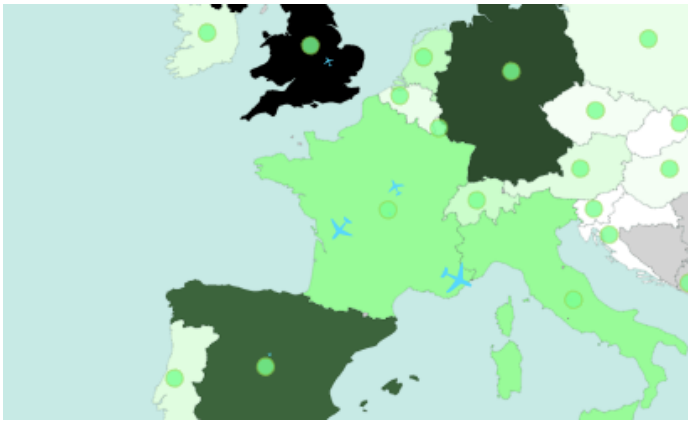

Fig. 13. Planes one by one

6.7 Adding slider 2

Last, we had to define which routes the user could display. To follow our first decision, we sorted the destinations which had the more importance in a country's total passengers number and created a slider to select a threshold for the minimum proportion of passengers by country:
Using this slider we can select the proportion of passengers on the visualization. This allows the user to discover a country's favourite destinations which our main goals.

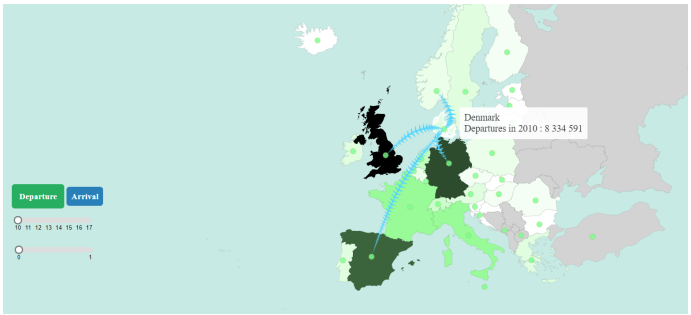

Fig. 14. visualization with planes for departure

And this look for arrival:

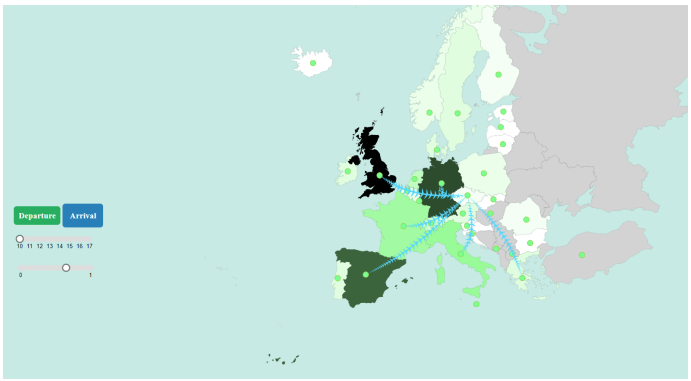

Fig. 15. visualization with planes for arrival

7 Evaluation

Overall we achieved almost exactly the visualization we were looking for in **Conception Scheme** except we replaced the arrows with a flow of airplanes. We thought a flow would look better, (which we still think does except for some routes which are very short and busy) and make the visualization more dynamic.

8 Discussion

This paper presented a data visualization of European air traffic. Using two sliders and a button we can visualize data for different years and different thresholds according to departure/arrival.
We found that our work provided relevant information via a simple visualization of passenger interaction between European countries. We think that this display can be used by anyone interested in geography, air traffic, and the distant relations countries, and especially their people, can maintain through air traffic and that some interesting info can simply and clearly be noticed thanks to it, for example the links between Germany and Turkey, the high dependency of european countries to British aiports, the connection between some specific eastern countries with SCandinavian ones... or naturally that there is not much difference between the number of flights, from and to a particular country, within Europe at least.

9 Conclusion

In the end we would like to thank all our colleagues and professors who made the realization of this visualization possible as we think we can lean on it in the future to make interesting and unique visualizations.

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