Live Air Traffic Network

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This paper shows the analysis of the global air traffic network in a precise moment and it compares three different datasets of this network with the goal of understanding if the global air traffic changes based on time.

1 Introduction

In the last few years air traffic increased a lot and for this reasons some web pages were created to monitor and observe it. One of this web pages is *flightradar24*, which tracks every air travel in real time, showing the departure airport, arrival airport, the type of plane, airlines and various flight details. Therefore, with the support of this website, I built an air traffic network. In particular, this type of network is ”live”, because every time I will build a dataset I will have a different network based on air traffic in that moment. But, how different are these networks? To better understand this, I took three datasets at different hour (08:30 am, 02:45 pm and 06:00 pm local time Rome) and I analyzed them.

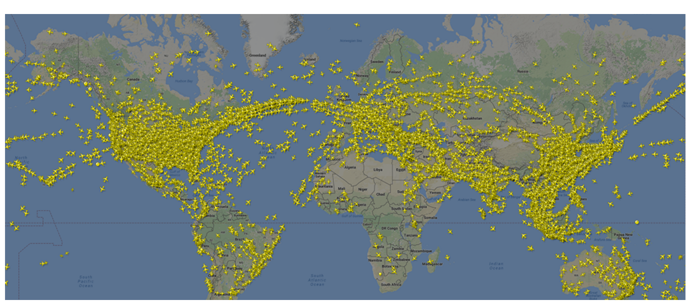

Figure 1: View of *flighradar24*

2 Networks analysis

The live air traffic networks can be direct or undirect because they can have air travels from an airport A to airport B, i.e. travels in only one direction, but also in the same moment a different air travel from B to A. The three networks analyzed are directed, indeed the adjacency matrices are asymmetric (Figure 2). Table 1 shows the main properties of the networks.

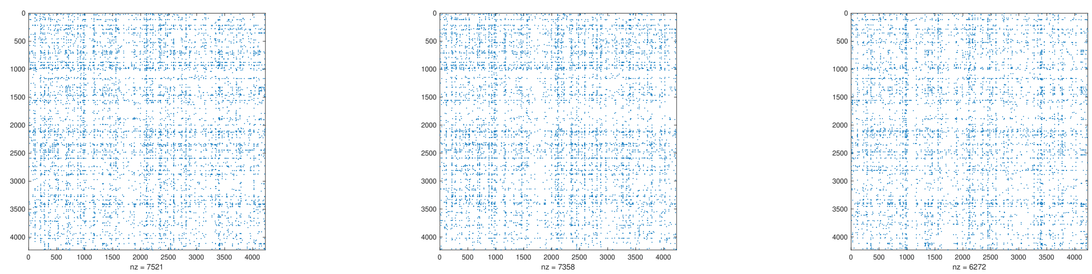

Figure 2: (a) Adjacency matrix dataset 1; (b) Adjacency matrix dataset 2; (c) Adjacency matrix dataset 3;

	Dataset 1	Dataset 2	Dataset 3
# nodes	4224	4231	4232
# links	9537	9609	8013
Mean indegree	2.2567	2.2711	1.8934
Second moment indegree	115.438	123.3437	82.5721
Third moment indegree	10715.2326	12482.6554	7114.5106
Mean outdegree	2.2567	2.2711	1.8934
Second moment outdegrees	95.8701	122.0631	76.383
Third moment outdegrees	7391.0892	12248.3505	5687.2238
Biggest hub indegree	183	212	192
Biggest hub outdegree	142	196	149
Biggest hub degree	269	408	256
Indegree inhomogeneity ratio	51.1525	54.3102	43.6098
Outdegree inhomogeneity ratio	42.4816	53.7464	40.3411
Average distance	3.9366	3.8777	4.0208
Diameter	12	13	11
Nodes of the giant component	1057	1013	1018

Table 1: Main parameters of the three networks

2.1 Degree distribution

As we can see from Figure 2, which shows indegree distributions (outdegree are very similar), the three networks have the scale-free property and so the degree distributions follow a power law. Fitting the indegree and the outdegree distribution using the Maximum Likelihood Estimation, I found that all the networks are in the scale-free regime because γ is near to 2, but between 2 and 3. Moreover, I can observed that there are a lot of airports with few flights and few airports with a lot of flights.

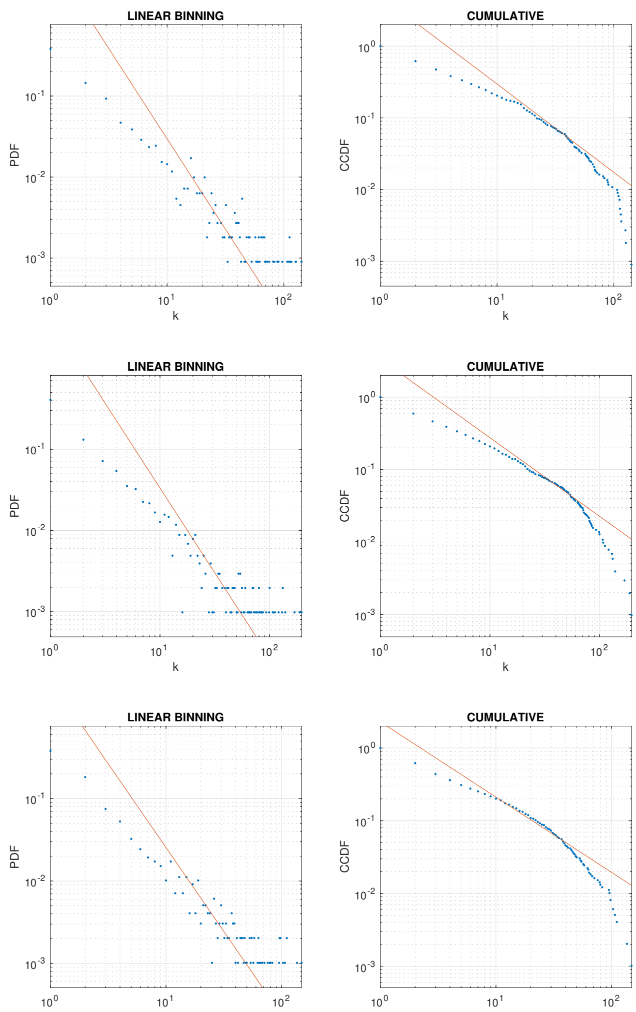

Figure 3: (a) Indegree distribution dataset 1; (b) Indegree distribution dataset 2; (c) Indegree distribution dataset 3;

2.2 Clustering

The average clustering coefficients of the three networks are similar. In all of them, I observed that the coefficients are quite low. This means that there is small probability of travelling with fewer transfers in the network, i.e the cities have in average fewer direct links to other cities.

	Dataset 1	Dataset 2	Dataset 3
Mean indegree clustering coefficent	0.22479	0.17131	0.16656
Mean outdegree clustering coefficent	0.15251	0.15962	0.16158

Table 2: Average clustering coefficients for incoming and outgoing links

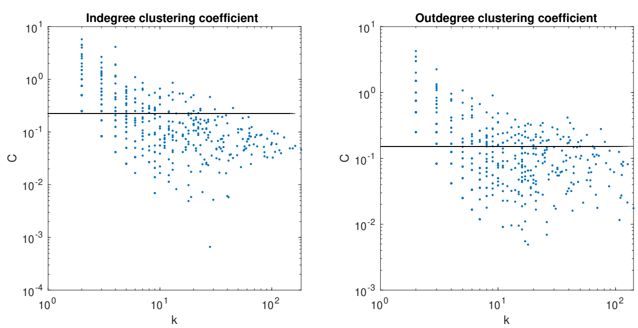

Figure 4: (a) Indegree clustering coefficient of dataset 1; (b) Outdegree clustering coefficient of dataset 1;

2.3 Assortativity

In all the plots of assortativity I noticed that network looks neutral, i.e. nodes with low degree don't tend to connect most with nodes with high degree or low degree and nodes with high degree don't tend to connect most with nodes with high degree or low degree. This means that the hub airports (they have high number of departures and arrivals) don't connect with other hub airports more than the small airports. I found this in all three air traffic datasets, indeed the assortativity factor shown in Table 3 are in the same magnitude order and near to zero.

	Dataset 1	Dataset 2	Dataset 3
$\mu_{out,in}$	0.03033	0.047747	0.039127
$\mu_{out,out}$	0.024252	0.060092	0.05625
$\mu_{in,in}$	0.018712	0.044504	0.070292
$\mu_{in,out}$	0.029434	0.055154	0.068692

Table 3: Average clustering coefficients for incoming and outgoing links

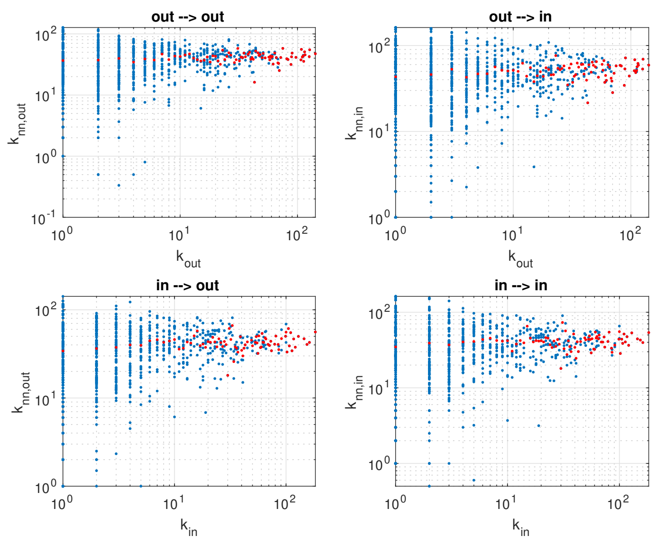

Figure 5: Assortativity evaluation of the dataset 1

2.4 Robustness

For robustness, I plotted three types of graph. First, I computed the robustness to random failures, in which I removed all the nodes randomly. The result is a linear trend in accordance with the scale-free property of the network. Next, I computed robustness to attacks for indegree and outdegree, in which I removed the hub every time. Also in this test, the air traffic network is in accordance with the scale-free property. Furthermore, attacks to indegree and outdegree are very similar and I noticed that the network tend to disconnect early respect the random failures. In all the three datasets we have the same results.

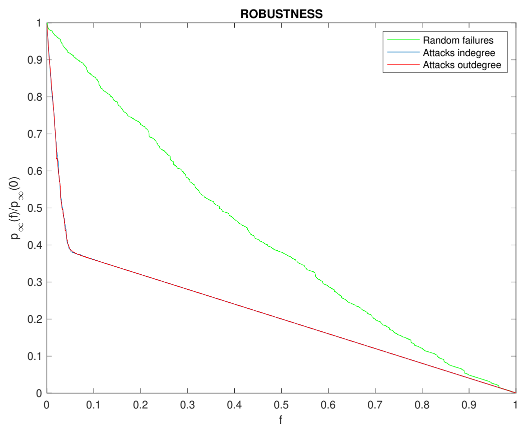

Figure 6: Robustness evaluation of the dataset 1

3 Conclusion

In conclusion, we can say that the ”Live Air Traffic Network” is a scale-free network with few hubs airports and a lot of few connected airports. The analyisis shows thta the network does not have degree correlations, does not tend to clustering and it is not very tolerant to attacks to the hub. Analyzing the datasets, I understood that the moments of the day in which there is more air traffic in the hub airports is in the morning between 07:30 am and 09:00 am. This is because when I created the datasets the major hub airport were Atlanta Hartsfield-Jackson Airport (ATL) at 08:45 am, Los Angels International Airport (LAX) at 09:00 am and London Haethrow Airport (LHR) 07:30. Despite the three datasets are taken in three different moments, the major hub change and the links change, the three networks are very similar. So, as I expected the ”Live Air Traffic Network” does not change its main characteristics based on real time traffic.