Detecting Migrations in Senegal through Data Analysis

S. Martin-Gutierrez[1], J. Borondo, A. J. Morales[1], J. C. Losada[1], A. M. Tarquis[1,2], and R. M. Benito[1]

[1]Grupo de Sistemas Complejos, ETS Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Avda. Complutense s/n 28040 Madrid, Spain
[2]CEIGRAM, ETS de Ingeniería Agronómica, Alimentaria y de Biosistemas, Universidad Politécnica de Madrid, Senda del Rey 13 28040 Madrid, Spain.

During the last few years, there has been an explosion of human behavioral studies using data generated by different kinds of Information and Communication Technologies (ICT). One of the main causes can be found in the increasing availability of data, which is stimulated by the pervasiveness of mobile phones. Although most of the works are focused on the developed world, there are also some studies on developing countries. In this work, we focus on the study of the mobility patterns of the country of Senegal by means of mobile phone data generated by the interactions of 9 million users during 2013. Our findings [1] show that agricultural activities have a key role in shaping the phenomena recorded in the data. Another important factor would be the traditional religious festivities.

Agriculture workers in Senegal represent over 70% of its labor force. We have found an increase of the number of migrants throughout the country during the harvest season. In order to do that we have built a special kind of mobility networks that we call migration networks. In a migration network the nodes are locations that, depending on the scale, can correspond to cities, districts, regions, etc.

By looking at the times and places from which a user makes her calls, we can infer the location that corresponds to her *regular residence*, as well as detect if she has changed her residence for a signiticant period of time; that is, if she has migrated, and where. This second location corresponds to her *temporary residence*. The links of the migration network are directed and traced from *usual residence* nodes to *temporary residence* nodes. The weights w_{ij} of the links correspond to the number of users that have migrated from node i to node j during a given time period.

In figure 1 we show the temporal evolution of the monthly migration networks for the year 2013 in Senegal. There, the nodes are the administrative regions. The color of each region is associated to the corresponding *in-strength* of its node $s_i = \sum_j w_{ji}$. It can be noticed that migration increases during the harvest season, that corresponds to the months of September, October and Novermber (shadowed panels).

We have also identified and characterized displacement of large masses of people related to religious festivities by means of temporal evolving networks of trajectories. In these networks, nodes are locations that, depending on the scale, can correspond to cities, districts, regions, etc. A link between nodes i and j is established when a user that has made a call at time t from i makes a call at a posterior time $t + \Delta t$ from j. The result is a weighted directed network, where the weights w_{ij} are the number of displacements from location i to location j during a given time interval. We treat this as a memoryless process. If a given user makes a call from A at time t_1, from B at time t_2 and from C at time t_3 such that $t_1 < t_2 < t_3$, we make a link from A to B and from B to C, but not from A to C. With this methodology we have built trajectories networks corresponding to different times. In particular we have detected several relevant religious holidays, as for example the birth of prophet Muhammad, the *mawlid*, which is celebrated in the city of Tivaouane and the Grand Magal of Touba.

In summary, in this work we have extracted information from geolocalized mobile phone datasets in order to obtain insight about the mobility patterns of the people of Senegal. To this end, we have analyzed the temporal evolution of different kinds of mobility networks. This has enabled us to show the influence of the harvest season on the migration flows and study the impact of religious events on the trajectories networks.

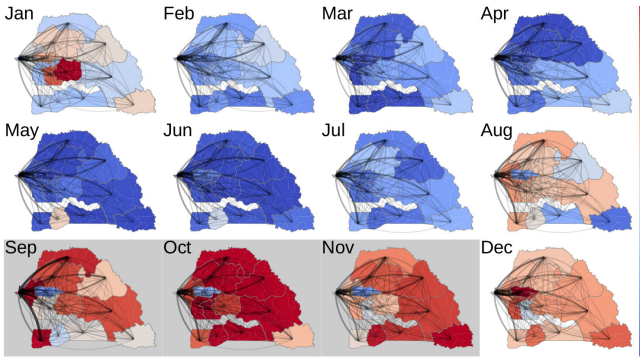

Figure 1: Temporal evolution of the monthly migration networks at the administrative region level. Link width corresponds to link weight. Arrows are traced from the *usual residence* to the *monthly residence*. The colors of each region give a notion of the number of *foreign* users within each region; that is, users whose home during a given month is not their regular home. The shadowed panels (September, October and November) correspond to the harvest season.

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