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Visualizing the World's Refugee Data with JFlowMap

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Abstract

In this poster we present visualizations of the UNHCR Refugee Dataset produced with JFlowMap, a graphical tool for the visualization and exploration of spatial interactions and their development in time. The basic view provided by the tool is the flow map which represents entities flowing between geographical locations with lines connecting the flow sources and the destinations. We show example visualizations produced by our tool, briefly discuss the tool's support for interaction and the advanced techniques for reducing the cluttering of the flow map visualizations: namely, flow aggregation and bundling. Finally, we discuss the analysis of the changes over time in the dataset and the future research directions.

1. Introduction

The UNHCR Refugee Dataset has been collected yearly since 1975 by the UN Refugee Agency. These data is carefully studied, and based on the results of this analysis various activities are organized to protect and assist the refugees. It is critical to be able to see the trends and changes over time when analyzing these huge amounts of information. Obviously, there is a strong need for tools which can support the exploration of these data and also help to increase the public's awareness of the situation with the refugees. Therefore, we decided to create an extensible flow map visualization tool which can be used as a platform for experimenting with different visualization techniques and to apply it for the analysis of the refugee dataset.

Flow maps are one of the most widely used representations of migrations. They usually do not accurately show the exact migrations paths, instead they are aimed to answer questions such as: Where on the map are the sources and the destinations of the flows? What is happening within a specific location? In which direction do the migrants go? Where are the largest and the smallest flows?

The refugee dataset has also a temporal dimension: the data is available for every year beginning from 1975. Hence, the tools for the exploration must be able to help finding answers to temporal questions, such as: How do the refugee flows change over time? What was happening in a specific time range? When did a specific flow reach its peak?

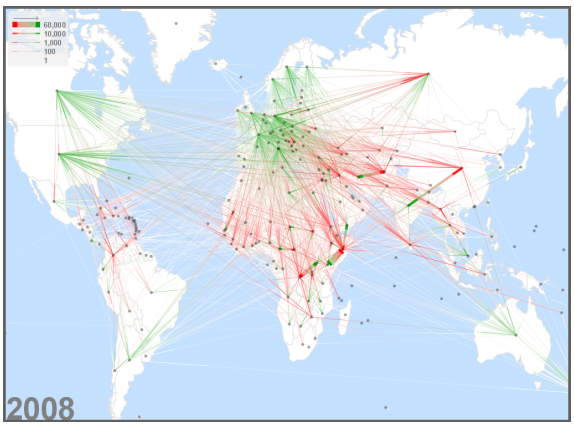

Figure 1: *World's Refugee Flows in 2008*

One of the early computer systems for the generation of flow maps was developed by Tobler in the late 1980s and was called FlowMapper [Tob87]. However, flow visualizations created using this system suffered from visual clutter. Since then there have been many attempts to improve flow map visualizations, and especially to reduce the cluttering [PXY*05, HvW09]. However, not much has been written on the exploration of temporal changes in migration flows. Marble et al. [MGLS97] note that the limitations of the data and the empirical difficulties encountered in their anal-

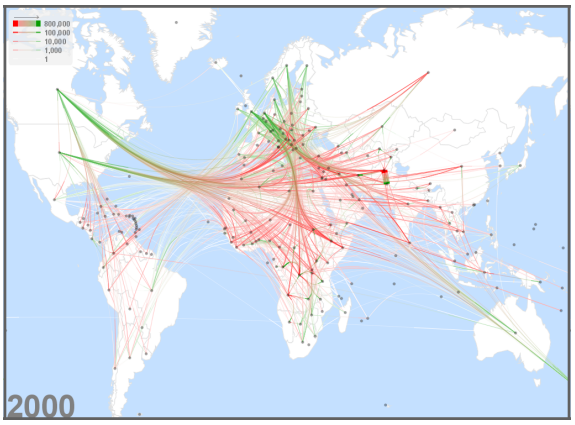

Figure 2: *World's Refugee Flows in 2000: Bundled Version*

ysis have restricted researchers to the examination of flows within a single time period.

We incorporated some of the techniques and ideas described in publications and built our prototype with two goals in mind: to find ways of effectively representing flow maps with large numbers of flows, and to facilitate the exploration of the temporal changes.

2. JFlowMap Visualizations

Currently, there are two separate views in JFlowMap: a *space-centric* which is a flow map representing the refugee flows of one specific year; and a *time-centric* view which is an aggregated overview of the whole dataset represented in a form of a timeline.

In the flow map the refugee flows are shown by straight lines and their directions are indicated by color markers (the markers of the outgoing flows are green and of the incoming ones - red) (Fig. 1). The quantities of the flows are mapped to two visual variables: the widths and the color saturations of the flow lines. The users can **highlight** or **select** flows and nodes, perform dynamic queries for **filtering** out flows by their quantities or their lengths and smoothly and continuously **zoom** into any subregion of the map to explore it in detail.

What is immediately apparent when looking at the Fig. 1 (and Fig. 2) is which countries have more in- or out-flows of refugees: the Western and "developed" countries are completely green, the others are mostly red. The largest flows of refugees are caused by wars or military actions: in 2000 these are the flows from Afganistan to Pakistan and Iran, in 2008 from Somalia to Kenya and from Congo to Uganda.

Our prototype supports node **clustering** with various distance metrics. The nodes inside each cluster can be merged by **aggregating** the flows between them. The idea behind that is that reducing the number of displayed flows can make

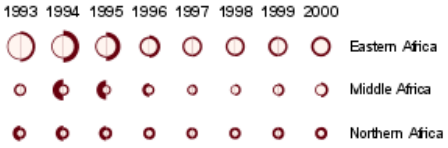

Figure 3: *A Fragment of the Time-Centric View*

the visualization more comprehensible. We also experiment with flow **bundling** which is another technique attempting to reduce visual clutter in graph visualizations and to make them more readable (Fig. 2). We implemented the bundling algorithm proposed by Holten [HvW09] in which the flows are visually bundled along their joint paths, similar to electrical wires or network cables, which are often strapped together in bundles. The resulting visualizations can reveal some high-level patterns, like the main "traffic roads" or highly connected regions. Note, for instance, the "highways" to Europe and Americas from Africa and Asia in Fig. 2.

In the time-centric visualization the summarized flow quantities are represented on a timeline as the sizes of the half-circles (Fig. 3). The sum quantities of the incoming flows are represented by the left half-circles and of the outgoing flows by the right ones. The light inner half-circles represent the summarized quantities of the intraregional flows, i.e. the numbers of refugees who found an asylum in a country of the same region. The view is hierarchical: the countries are joined into regions and the user can expand a region to see the values for the individual countries.

We are currently experimenting with different configurations for the time-centric view and on its linking to the flow map. The goal is to make the transition between the two representations as fluent as possible for the user, so that it feels like one view which takes the best of the two worlds: using maps for representing spatial information and timelines for temporal data.

In the near future, we plan to run a user evaluation to assess the effectiveness of the techniques and visualizations implemented in JFlowMap and find out which of them are the most effective for specific tasks.

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