Two Sides of the Same Cube:
Towards Immersive Dynamic Viusalization of Migration Data

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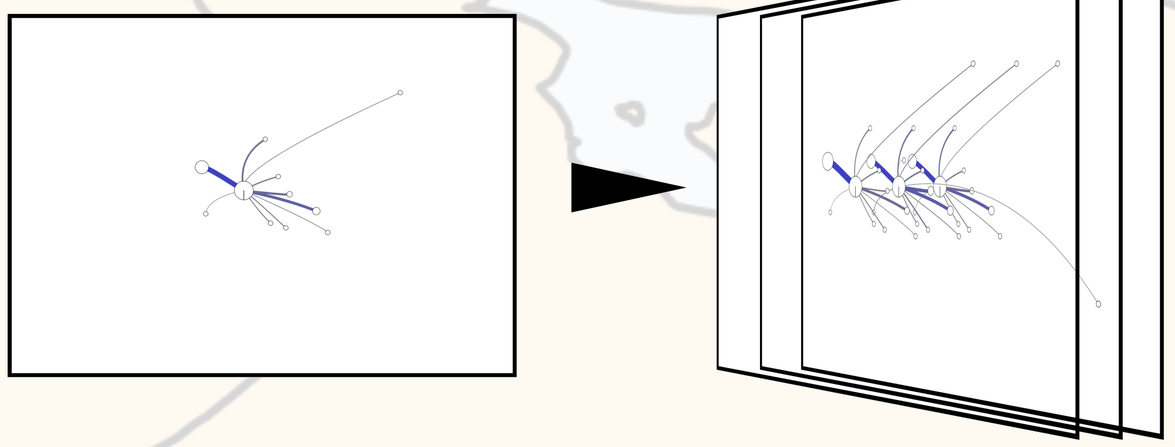
Visualizing Migration

When visualizing migration the task can be broken down into three distinct properties: **migration origin, migration destination, and the quantity**. Visualizing these properties can be done with origin-destination (OD) maps. OD maps only consider a specific point in time, whereas migration is a temporal phenomenon, heavily influenced by many geopolitical factors.

To accommodate the additional dimension of time, we introduce the **space-time cube** (STC). Which allows us to take multiple timeslices of the data which can be stacked along the z-axis. Our **contribution** to this topic are two different approaches for spatio-temporal migration visualization: an interactive **augmented reality** (AR) visualization for mobile phones and a data **physicalization** using printed OD maps on overhead transparencies.

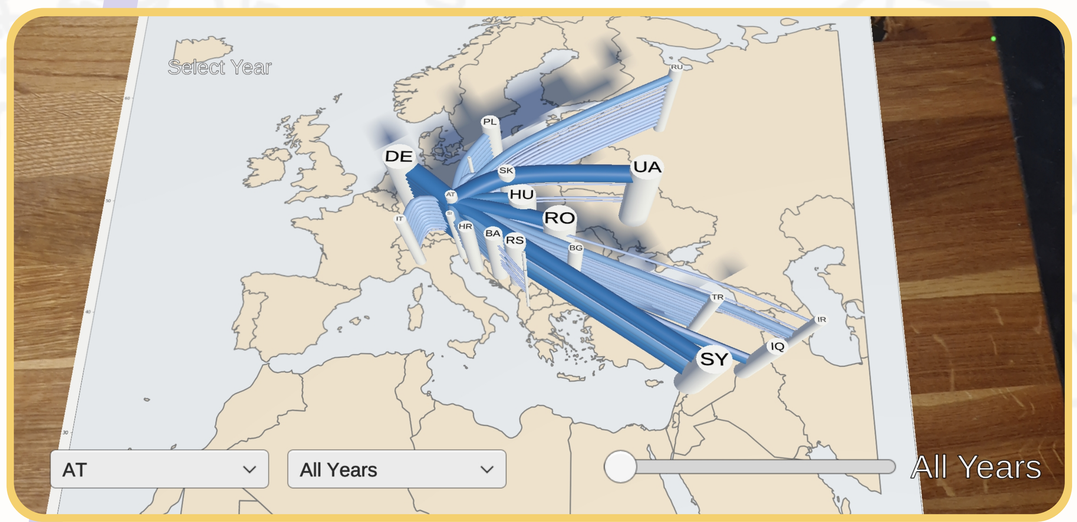


Migration Flow over Time

A major challenge when working with OD flow maps is producing a **clear layout**, especially for large datasets.
To address this, we use a **force-directed layout** (FDL) algorithm, as proposed by Jenny et al. This approach relies on weighted forces exerted by nodes and flows on one another to iteratively reach a stable and informative layout.
We create one layout per destination country, **consistent** across all years. This consistency allows us to **accurately stack** the OD flow **maps within** the **STC**. After these pre-processing steps we diverge into two different visualization approaches.

Augmented Reality

- **Pillars** indicate specific country
  - country code on top
  - each **tube** represents migration value per year
- Multiple-years view shows STC
  - **thickness** and **color** encodes movement amount
  - time is represented on the height-axis



- Possible to filter through all the given years
  - **selected year is saturated**
  - others are semi-transparent
- Select **specific origin countries**
- physically moving the camera changes the **viewing angle**

Physicalization

- 3D-printed apparatus based on Pahr et al.
- **Nodes** represent countries, country code within node
- Migration per year is shown by **lines**, thickness and saturation encode quantity
- Each Slice represents **one** year
- **Superimposition** results in a physicalization of an STC further showing migration over time

- Other operations possible, like **juxtaposition** or laying **single** / **multiple** slice/s on an Europe map
- **Saturation** of paths can be interpreted in different ways:
  - **more** saturated the color -> **ongoing** migration over the years
  - **less** saturation over time -> **single** / **less** migration values within specific years

Limitations

Our visualization approaches struggle for smaller nations with a lot of migration from their neighbouring countries such as the balkan states like Croatia. With the chosen scale visualizations for these countries become **cluttered and uninformative**.

In our visualizations and in the data we used, migration is **greatly simplified** and does not take the complex factors that affect routes people take into account.

Future Work

For the future, we want to examine how both approaches can affect user interaction and information gathering differently and similarly, by conducting a **user study**. This will examine ease of use, efficiency, and most importantly the **different emotional impacts** on the observer.

Expand the scope from Europe to a **global view on the data**. Need changes in the design approach to accompany such a large scale.
Compare **multiple destination countries** which would be an interesting addition to the visualizations.

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