# Spatio-Temporal Historical Event Visual Exploration Through Social Media-Based Models

## Vanessa P. Araya

Advisor: Bárbara Poblete Labra

Social media has become an important source of information.

Twitter is a very popular social media platform.

When a news event happens, people react quickly commenting on Twitter.

**BBC News (World)** ✔ @BBCWorld · Sep 28 ⌄

Tsunami hits Indonesia's Palu after strong earthquake

**Hundreds dead in Indonesia quake and tsunami**

More than 380 people die as a powerful quake sends three-metre tsunami waves through the city of Palu.

bbc.com

💬 33          ↻ **1.2K**          ♡ **556**          ✉

Researchers have extracted valuable information from Twitter. Some examples:

- Detect earthquakes
  (Sakaki 2013)

- Analyze news events
  (Liu et al. 2016)

- Analyze social movements
  (Scherman 2015)



BBC News (World) ✔ @BBCWorld · Sep 28

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bbc.com

💬 33    ↻ 1.2K    ♡ 556    ✉

3

Most news events have geographical features.

**Main research question:**

Can we extract information about the **interactions among countries** in social media?

**BBC News (World)** ✓ @BBCWorld · Sep 28

Tsunami hits Indonesia's Palu after strong earthquake

**Ganesh Prasad** @GPrasad87 · Sep 29

India on Saturday expressed deep sympathies to the people and government of Indonesia, and assured all help to the country hit by a tsunami triggered by a strong earthquake.

**The Statesman** ✓ @TheStatesmanLtd · Oct 3

Two Indian Air Force aircraft – C-130J and C-17 – landed in Indonesia today to help in the relief operations for the victims of the earthquake and tsunami that hit Central Sulawesi Province.

**UnitingWorld** 🌏 @UnitingWorld · Oct 4

Australia's aid agencies have joined the urgent call for help and donations after the devastating earthquake and tsunami in #Sulawesi. 1,500 people have lost their lives and 190,000 need urgent humanitarian assistance. Find out how you can help:

Sept 28 29 30 Oct 1 2 3 4 … Time

**BBC News (World)** ✔ @BBCWorld · Sep 28
Tsunami hits Indonesia's Palu after strong earthquake

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Sept    28    29    30    Oct 1    2    3    4    ...    Time

# Outline

- Problem statement
- Historical event exploration
  1. News event representation
  2. Galean
  3. Cartoglyphs
- Conclusion and future work

# Outline

- **Problem statement**
- Historical event exploration
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# Problem statement

➡️ Without proper high level representation is hard to extract valuable information about the **geopolitical entities involved in news events**

➡️ It is difficult to visualize multiple aspects of a news event at once. Hence, **visualizing geo-temporal change is not an easy task.**

# **Work hypotheses**

**H1**   The data published in social media platforms contains valuable information about what is happening in the real-world.

**H2**   Visual representation of news in their geopolitical context allows users to extract valuable knowledge about the real world.

# **Work hypotheses**

**H1** The data published in social media platforms contains valuable information about what is happening in the real-world.

By analyzing data from social media we can understand:

- **H1.1**: the **geopolitical interaction among countries** as consequence of news events.

- **H1.2**: **how people reacted to a news event** and to where it was propagated

- **H1.3**: **how events relate to each** other over time**.**
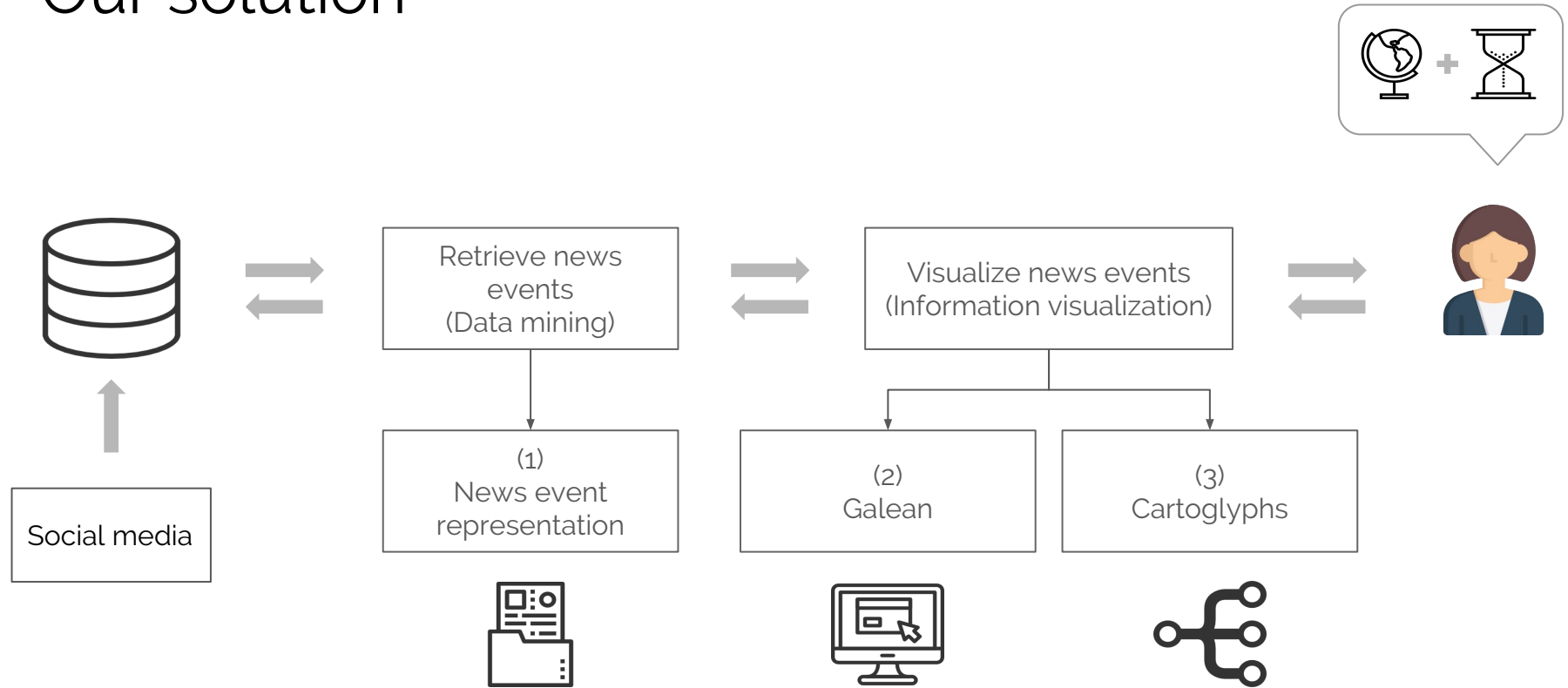
# Work hypotheses

**H2**   Visual representation of news in their geopolitical context allows users to extract valuable knowledge about the real world.

- **H2.1:** An expressive visual representation allows users to **visually identify and extract patterns**

- **H2.2:** An expressive visualization of the geopolitical context of a news event allows **users to extract relationships among events and participating entities.**

- **H2.3:** A simple visual representation of geographical data allows users to **extract knowledge from several points of view of a news event.**
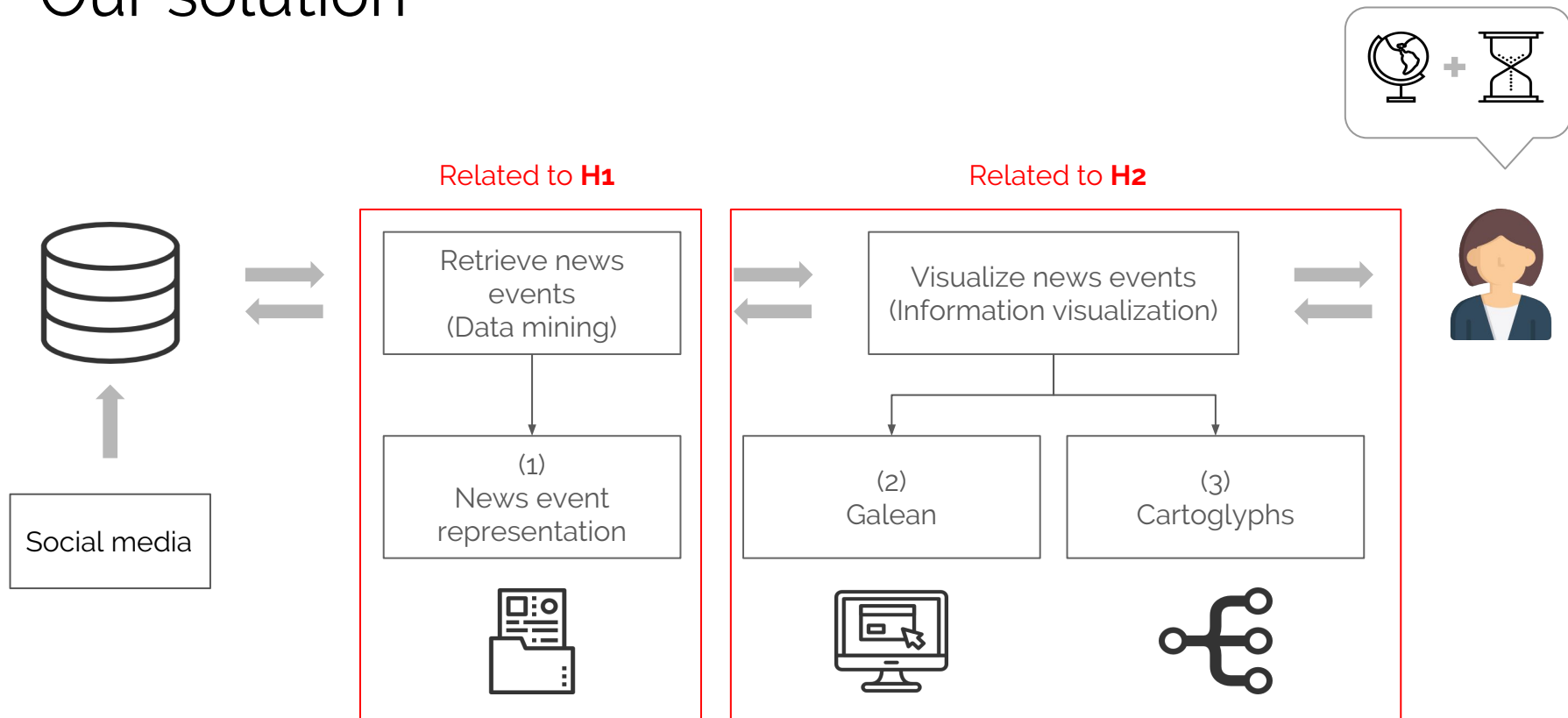
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- Problem statement
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  1. News event representation
  2. Galean
  3. Cartoglyphs
- Conclusion and future work

# Our solution

Social media

Retrieve news events
(Data mining)

(1)
News event representation

Visualize news events
(Information visualization)

(2)
Galean

(3)
Cartoglyphs

# Our solution



Related to **H1**

Related to **H2**

Social media

Retrieve news events
(Data mining)

(1)
News event representation

Visualize news events
(Information visualization)

(2)
Galean

(3)
Cartoglyphs

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# News event representation

## Goal:

Represent news events in their geopolitical and temporal context

## Current approaches:

- Propagation of documents
  (Kamath et al. 2013)
- Where an event happened
  (Sakaki et al. 2013)

# News event representation

**Our approach:**

locations **involved** in the event and locations to **where it was propagated.**

# News event representation



**BBC News (World)** ✓ @BBCWorld · Sep 28
Tsunami hits Indonesia's Palu after strong earthquake

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More than 380 people die as a powerful quake sends three-metre tsunami waves through the city of Palu.
bbc.com

💬 33    🔁 1.2K    ♡ 556    ✉

**Spatio-temporal context-aware representation for news events in social media**

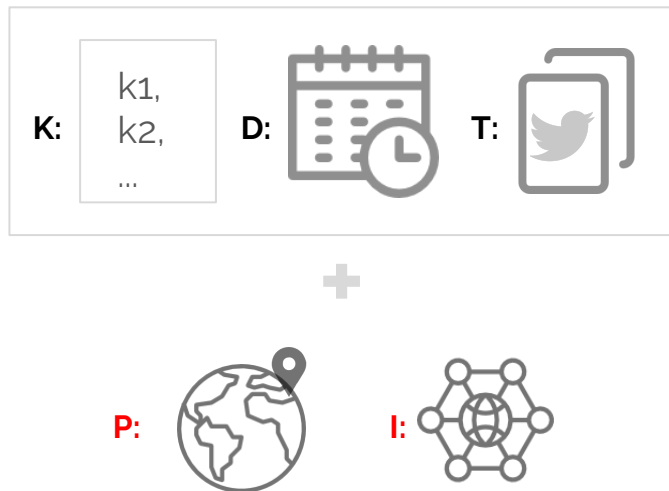**P** (protagonist location):

Indonesia

**I** (Interested locations):

India, United States. Chile, Mexico, etc..

# News event representation

## News event

K: k1, k2, …

D: (calendar/clock icon)

T: (Twitter icon)

+

P: (globe icon)

I: (network icon)

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**Spatio-temporal context-aware representation for news events in social media**

We define an event E as a tuple:

$$E = \langle K, D, T, P, I \rangle$$
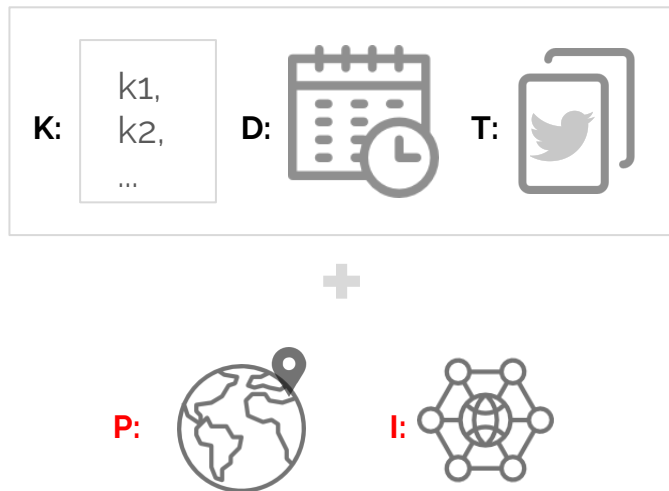
Given the set of possible locations as:

$$L = \{l_1, l_2, …, l_n\}$$

$P$ = protagonists locations  $\langle pl_1, pl_2, …, pl_n \rangle$

$I$ = Interested locations  $\langle il_1, il_2, …, il_n \rangle$

# News event representation

## News event

**K:** k1, k2, ...    **D:**    **T:**

**+**

**P:**    **I:**

---

**Spatio-temporal context-aware representation for news events in social media**

It allow us to define:

1) **Scope of events**:

   - **Provenance:** local, regional or global in terms of locations involved.
   - **Impact:** local, regional or global in terms of the locations interested

2) **Relationships among countries and events**
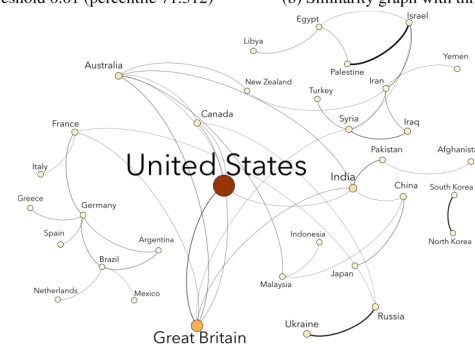
# Countries Relationships Analysis

Example: the distance among vectors informs the relationships among countries



(a) Similarity graph with threshold 0.01 (percentile 71.312)

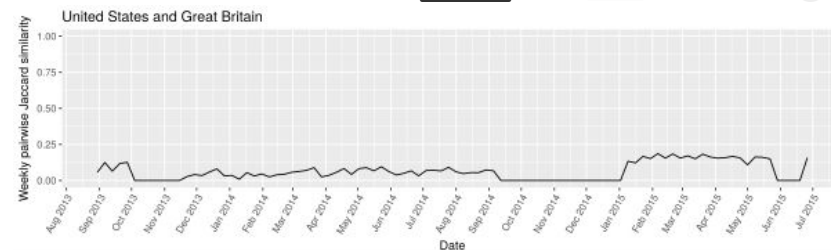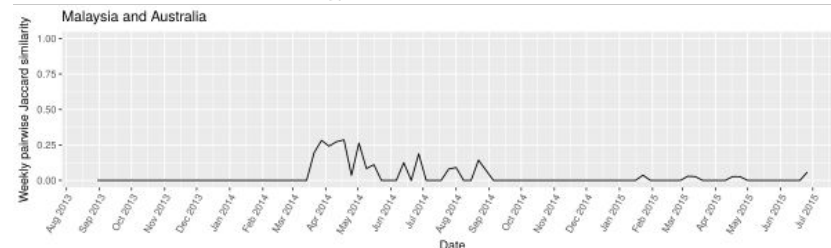(b) Similarity graph with threshold 0.032 (percentile 95.052)

(c) Similarity graph with threshold 0.06 (percentile 98.309)
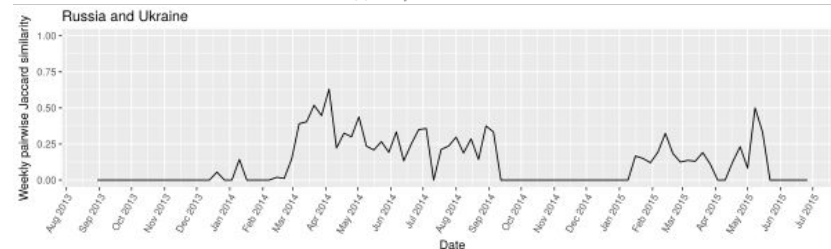
# News event Analysis

Example: the distance among vectors informs the relationships among countries over time



(a) United States and Great Britain.



(b) Malaysia and Australia



(c) Russia and Ukraine.

Collaboration with PhD student Mauricio Quezada     23

# Implications

It is possible to understand the **geopolitical development of news events** only by analyzing data from other data sources than traditional media

**Measure** relationships among locations

- Produce similar interest
- Have similar protagonism

It is the **first time** that this type of analysis is conducted

# Outline

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    2. Galean
    3. Cartoglyphs
- Conclusion and future work

# Visualize news events

## Goal:

Explore geopolitical relationships among countries, given the event representation
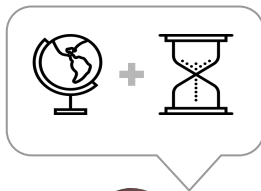
## Current approaches:

- Propagation of information
  (Cao et al. 2012, Ren at al. 2014)
- Event analysis
  (MacEachren et al. 2012, Bosch et al. 2012)
- Movement analysis
  (Krueger et al. 2016, Liu et al. 2014)

# Visualize news events



(a) Selected date: May 6, 2014

Filter by country: All

Filter by scope: All
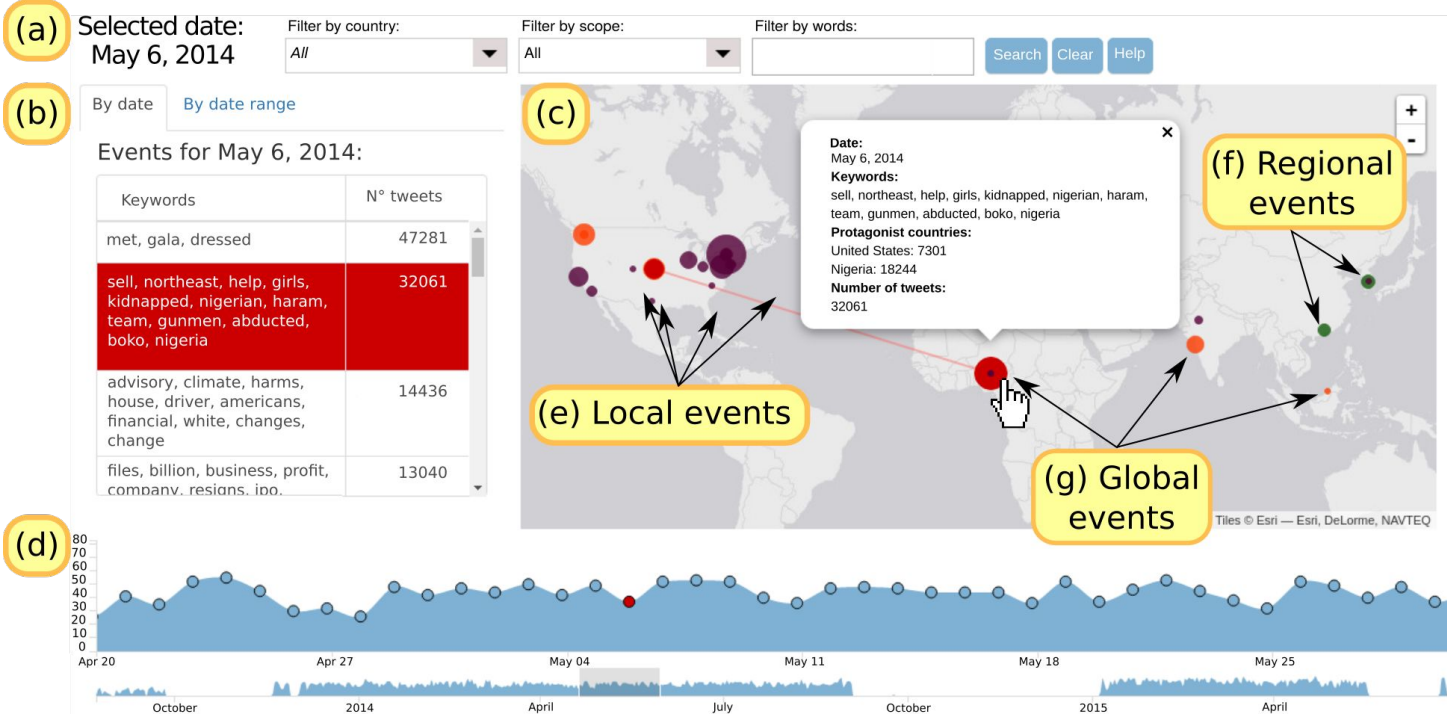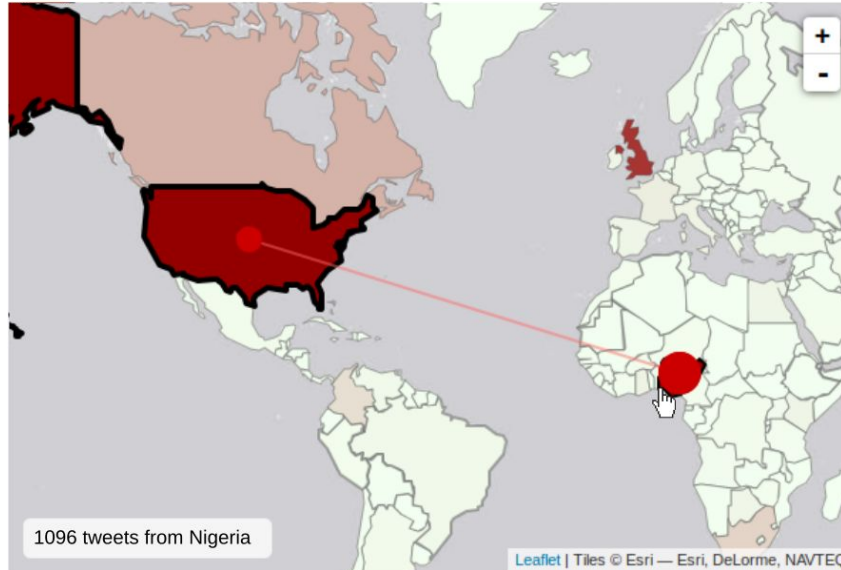
Filter by words:

Search  Clear  Help

(b) By date | By date range

Events for May 6, 2014:

| Keywords | N° tweets |
| --- | --- |
| met, gala, dressed | 47281 |
| sell, northeast, help, girls, kidnapped, nigerian, haram, team, gunmen, abducted, boko, nigeria | 32061 |
| advisory, climate, harms, house, driver, americans, financial, white, changes, change | 14436 |
| files, billion, business, profit, company, resigns, ipo, | 13040 |

(c)

Date:
May 6, 2014
Keywords:
sell, northeast, help, girls, kidnapped, nigerian, haram, team, gunmen, abducted, boko, nigeria
Protagonist countries:
United States: 7301
Nigeria: 18244
Number of tweets:
32061

(f) Regional events

(e) Local events

(g) Global events

Tiles © Esri — Esri, DeLorme, NAVTEQ

(d)

Apr 20   Apr 27   May 04   May 11   May 18   May 25

October   2014   April   July   October   2015   April

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# Visualize news events



(a)

(b)

Event Info

News Tweets

User Tweets

1096 tweets from Nigeria

Leaflet | Tiles © Esri — Esri, DeLorme, NAVTEQ

(c)

Tweets from all countries

@BreakingNews - 2014-05-06 17:04:10
State Department: US plans to send team to Nigeria in response to schoolgirls' kidnapping - @Reuters http://t.co/zERamNY6uj

@itvnews - 2014-05-06 17:05:50
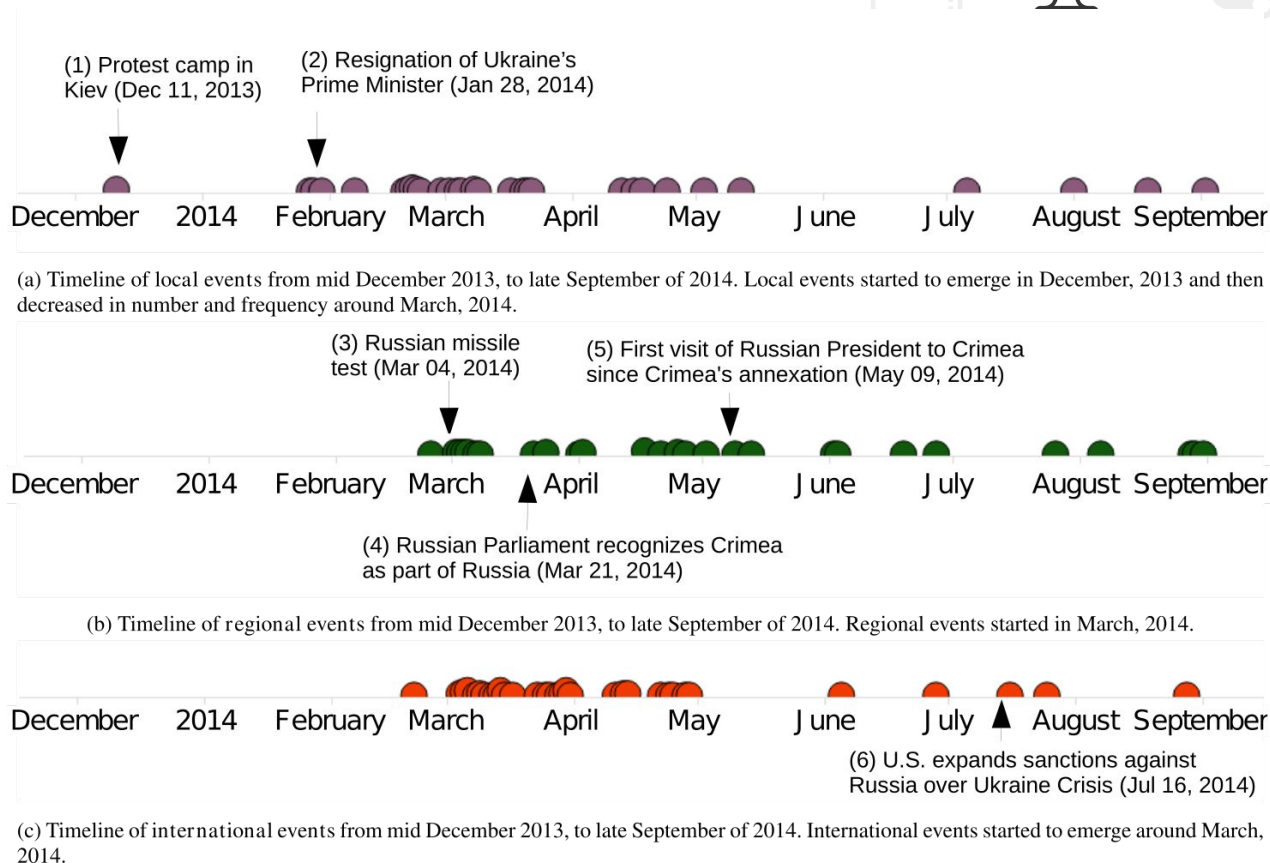Nigeria 'welcomes US help' in hunt for kidnapped schoolgirls http://t.co/UvOauW3iWn

@NewsHour -
RT @AP: White House says a U.S. team will head to Nigeria to help in the search for kidnapped schoolgirls: http://t.co/vNrI5ppiXT

2014-05-06 17:41:25

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# Case study

Analyzing the international relationships among relevant protagonist countries on the Crimea crisis.



(a) Timeline of local events from mid December 2013, to late September of 2014. Local events started to emerge in December, 2013 and then decreased in number and frequency around March, 2014.

(b) Timeline of regional events from mid December 2013, to late September of 2014. Regional events started in March, 2014.

(c) Timeline of international events from mid December 2013, to late September of 2014. International events started to emerge around March, 2014.

# Evaluations

## Qualitative

**Goal:**
Study usability and get expert feedback about its use in daily work.

**Design:**
6 domain experts, conduct analysis tasks

**Results:**

- Feedback about the interface design
- Patterns in the data

## Quantitative

**Goal:**
Study efficiency and effectiveness for retrieving international relationships of news reported on Twitter

**Design:**
30 participants, within-subjects, competitive baseline

**Results:**

- Galean was perceived as better than the baseline
- Objective and subjective metrics were more consistent in Galean than in the baseline

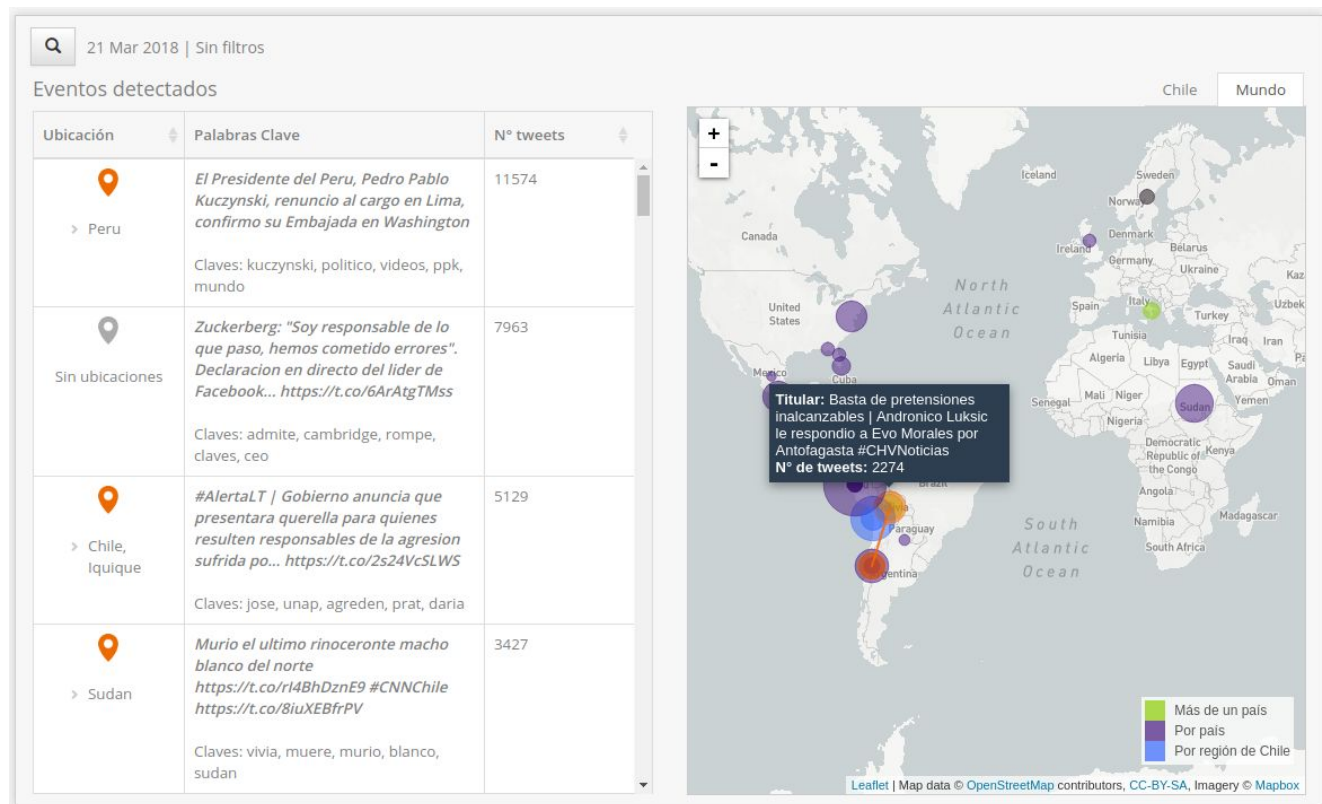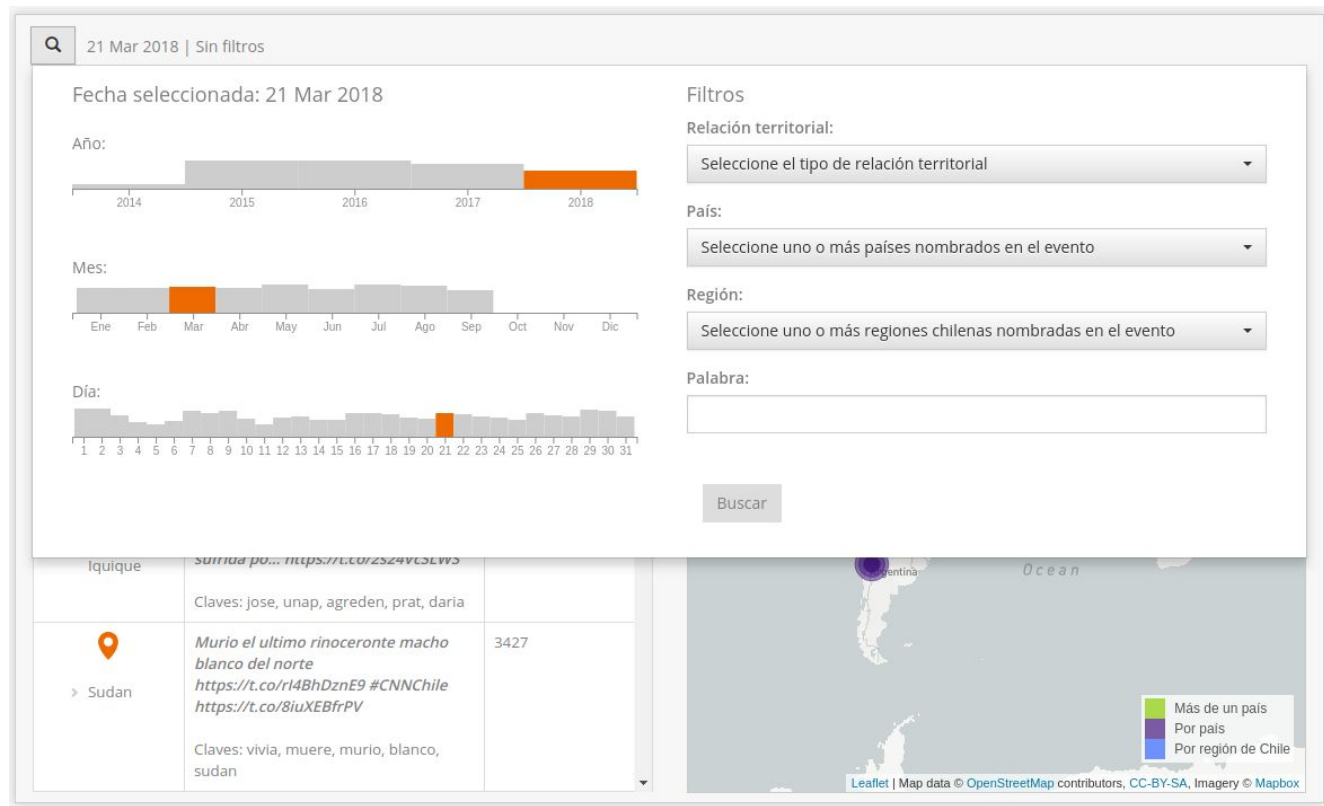# Baseline qualitative study

# Interface evolution

- Evaluations

- Expert feedback

- Users feedback

# Interface evolution

[www.galean.cl](www.galean.cl)

- Evaluations

- Expert feedback

- Users feedback



Q   21 Mar 2018 | Sin filtros

**Fecha seleccionada: 21 Mar 2018**

Año:

2014   2015   2016   2017   2018

Mes:

Ene  Feb  Mar  Abr  May  Jun  Jul  Ago  Sep  Oct  Nov  Dic

Día:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

**Filtros**

Relación territorial:

Seleccione el tipo de relación territorial ▾

País:

Seleccione uno o más países nombrados en el evento ▾

Región:

Seleccione uno o más regiones chilenas nombradas en el evento ▾

Palabra:

Buscar

Iquique   *surida po... https://t.co/zs24VcSLWS*

Claves: jose, unap, agreden, prat, daria

📍   *Murio el ultimo rinoceronte macho blanco del norte https://t.co/rI4BhDznE9 #CNNChile https://t.co/8iuXEBfrPV*   3427

> Sudan

Claves: vivia, muere, murio, blanco, sudan

Argentina   Ocean

Más de un país
Por país
Por región de Chile

Leaflet | Map data © OpenStreetMap contributors, CC-BY-SA, Imagery © Mapbox

# Interface evolution

[www.galean.cl](www.galean.cl)

- Evaluations

- Expert feedback

- Users feedback

# Implications

It allow users to:

- perform **historical analysis** of events over time from social media data;
- retrieve news event given **international relationships**,
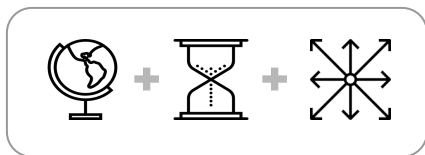- manually explore news events world-wide, as well as **their impact**.

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- Problem statement
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  2. Galean
  3. Cartoglyphs
- Conclusion and future work

# Cartoglyphs

## Goal:

Conduct geo-temporal analysis
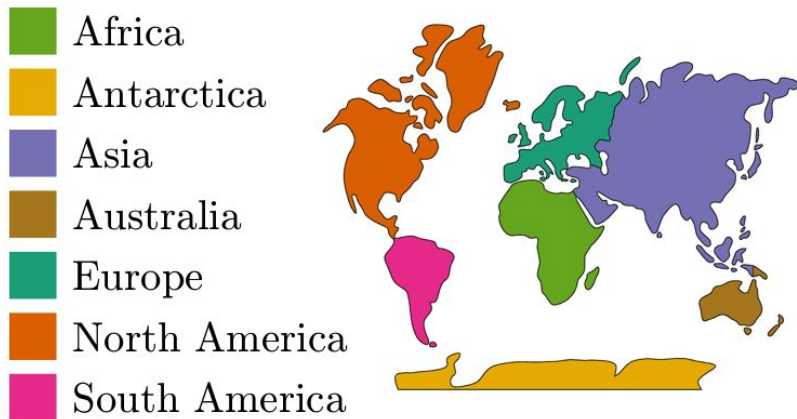of multivariate data

## Current approaches:

- Small multiples
  (Johnson et al. 2015)
- Animation
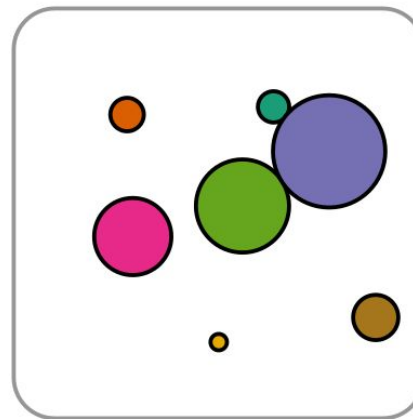  (Craig et al. 2014)
- Other
  (Kraak 2013)

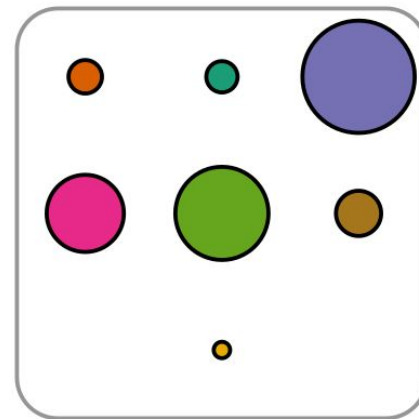# Cartoglyphs

Our solution: reduce the world to a glyph



(a) Legend

(b) Dorling cartoglyph with centroid layout

(c) Dorling cartoglyph with grid layout

Legend:
- Africa
- Antarctica
- Asia
- Australia
- Europe
- North America
- South America

# Cartoglyphs

Other designs, more than one dimension at a time



Color legend

- Africa
- Antarctica
- Asia
- Australia
- Europe
- North America
- South America

Width: female labor rate

Height: male labor rate

1993    2000    2007    2014
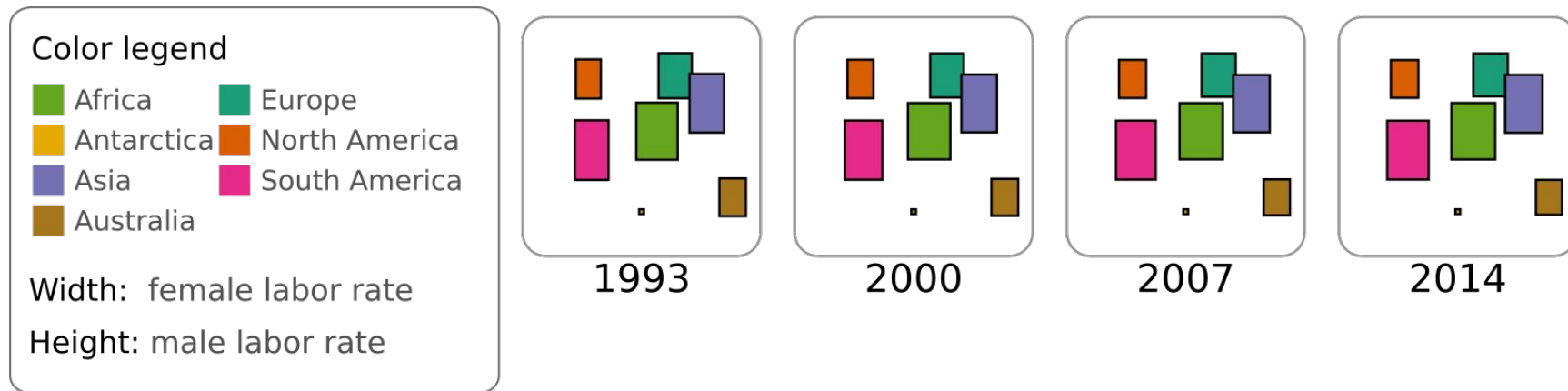
# Case study

Following the evolution of a news event

FBI to analyze thumbprints
from passengers who traveled
with stolen passports

It was discovered that
the aircraft deliberately flown
towards Andaman Islands

Officials say missing aircraft crashed
in the southern Indian Ocean.
Malaysia Airlines to provide cash,
caregivers for MH370 passengers'
familes

The US sends FBI
to assist investigation

Missing plane may have
been out of course

A Malaysia Airlines
plane carrying 239
people crashed

Mar 09 2014    Mar 10 2014    Mar 11 2014        Mar 14 2014              Mar 25 2014

Mar 08 2014                                                                                    (a)

Color legend

Africa          Europe
Antarctica      North America
Asia            South America
Australia

Dark border: countries from the
continent that are involved in the
physical world event

Size: average # tweets per
continent

Mar 12 2014        Mar 23 2014   Mar 24 2014   Mar 25 2014

(b)

Search area expanded
& several Asian countries
offered to help

Australian plane discovers
objects that could be from MH370

French satellite has
images of possible
debris of MH370

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# Cartoglyphs evaluation

*When using a glyph version of cartograms for geographical and geo-temporal analysis, which are the most important features for each task?*

Divided in **4** research questions:

**RQ1:** Does shape simplification impacts on the analysis of geographical data?

**RQ2:** Does abstraction of position impacts on the analysis of geographical data?

**RQ3:** Does shape and position impact on the analysis of geo-temporal data?

**RQ4:** Does the number of locations impact on the analysis?

# Cartoglyphs evaluation

Between subjects study, 60 participants in total.

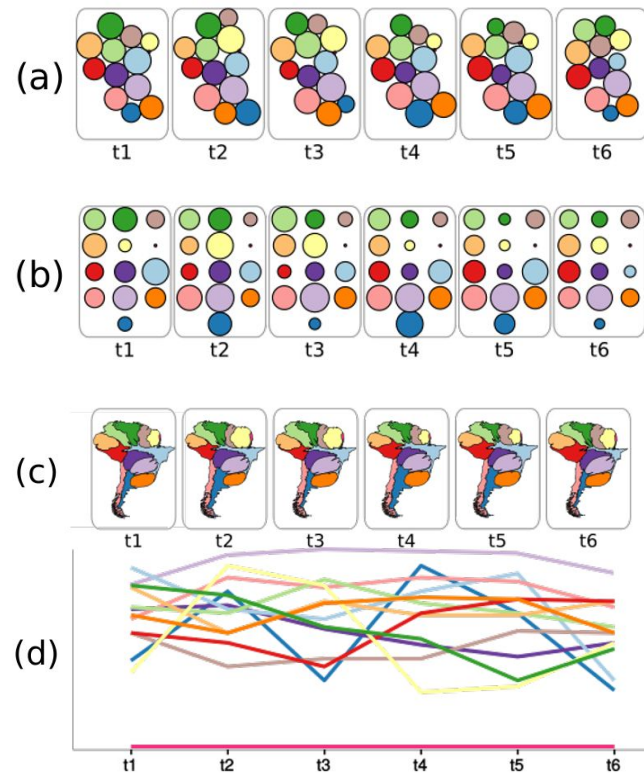Data analysis for continents and countries for the following tasks:
(from Nusrat et al. 2015, Roth 2013)

Geographical data:

- Locate
- Compare
- Find greatest
- Recognize
- Find adjacency

Geo-temporal data:

- Identify
- Compare
- Rank
- Associate
- Delineate

# Results

**RQ1:** Does shape simplification impacts on the analysis of geographical data?

**A1:** It depends of the task. Find greatest, contiguous had worst performance; find adjacency, better performance.

**RQ2:** Does abstraction of position impacts on the analysis of geographical data?

**A2:** For geographical related tasks

**RQ3:** Does shape and position impact on the analysis of geo-temporal data?

**A3:** Shape impact in some tasks, but not position

**RQ4:** Does the number of locations impact on the analysis?
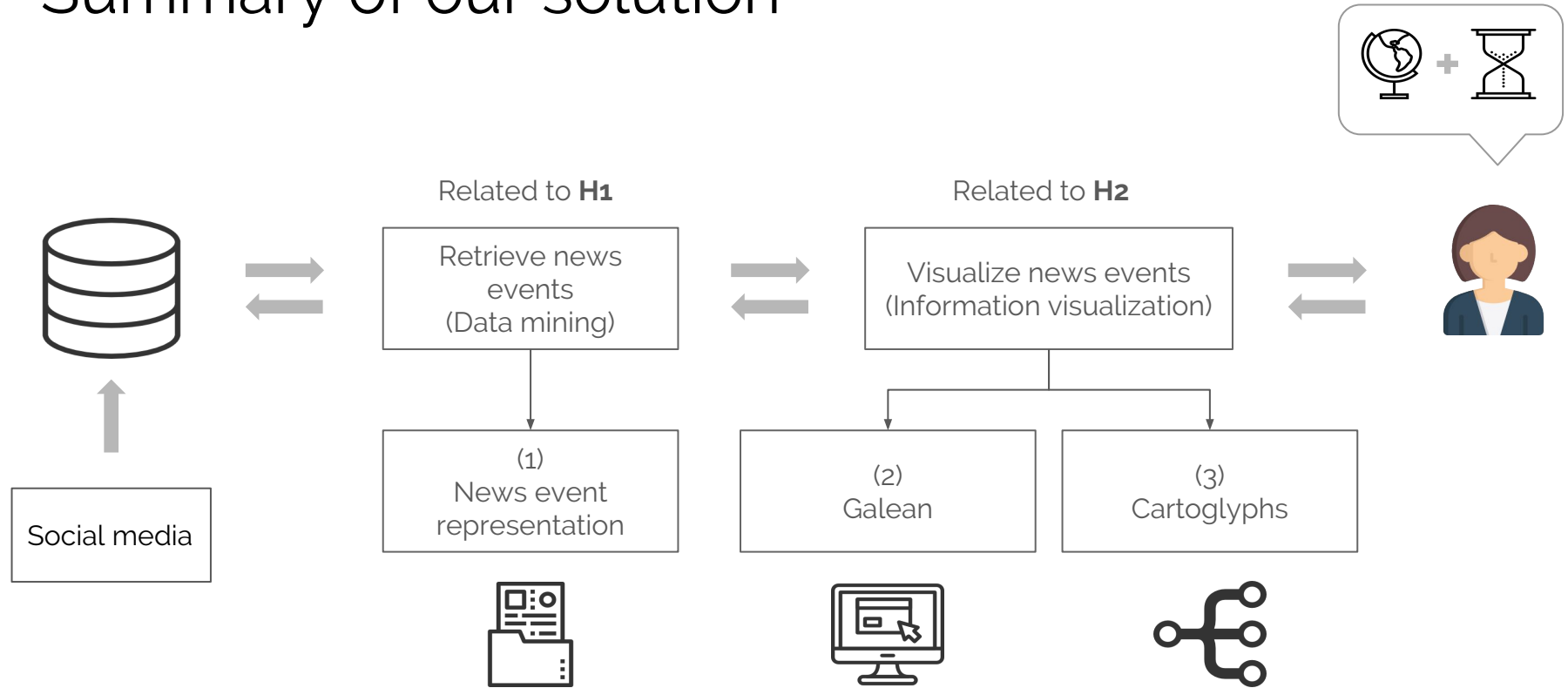
**A4:** Not necessarily

# Implications

- Cartograms can be used as glyphs for a **<span style="color:red">simplification of the world</span>**
- First insight on how to reach to an effective design of cartoglyphs
    - Depending on the task
    - Number of locations
    - Type of cartogram used

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# Summary of our solution

Related to **H1**

Related to **H2**

Retrieve news events
(Data mining)

Visualize news events
(Information visualization)

Social media

(1)
News event representation

(2)
Galean

(3)
Cartoglyphs

# Contributions                    Publications



(1)
News event
representation

- News event representation
  in their geopolitical and
  temporal context.
- Data insight.

EPJ Data Science, 2017
**Peña-Araya**, Quezada, Poblete and Parra
(Full paper)

SIGIR, 2015
**Peña-Araya**, Quezada and Poblete
(Demo paper)

(2)
Galean

- Visual interface for explore
  events using the
  representation.
- Users feedback and domain
  knowledge

SIGIR, 2015
Quezada, **Peña-Araya** and Poblete
(Short paper)

TAIA 2015 (SIGIR)
Madonado, **Peña-Araya** and Poblete
(workshop paper)

(3)
Cartoglyphs

- A new way of representing
  geographical data as glyphs.
- Initial designs and empirical
  study of their usefulness.

VAST, 2016
**Peña-Araya**, Bahamonde, Poblete and Bustos
(Poster paper)

Under preparation
**Peña-Araya**, Poblete and Bustos
(Full paper)

# Future work

### (1)
### News event
### representation

- Further analysis:
  *Did the impact of the event change after a particular country got involved?*
- Is it a conflict or an alliance?
- Increase time granularity

### (2)
### Galean

- Improve how tweets are displayed
- Show evolution of a news event -> cartoglyphs could be and option
- Include other features such as sentiment analysis or highlight influential locations/people

### (3)
### Cartoglyphs

Deepen the study...

# Future work

(3)
Cartoglyphs

Cartoglyphs for multivariate geographical data:
- How subjective metrics relate to objective ones
- Focus on **final users**!

Glyph alone:
- What happens when **their size is changed**?
- How much can we **simplify the world representation**?
- Will users still **recognize locations even without color**?
- Is it possible to include **more visual variables**?
- Which **interactions could improve** data analysis?

Several of them:
- Which layouts are effective to find **similar geographical patterns**?
- How to **include time** in order to preserve temporal linearity?

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# References

- Krueger R., Sun G., Beck F., Liang R., Ertl T.: Traveldiff: Visual comparison analytics for massive movement patterns derived from twitter. In Visualization Symposium (PacificVis), IEEE PacificVis (April 2016)
- Liu Y., Sui Z., Kang C., Gao Y.: Uncovering patterns of inter-urban trip and spatial interaction from social media check-in data. PLoS ONE 9, 1 (2014)
- Ren D., Zhang X., Wang Z., Li J., Yuan X.: Weiboevents: A crowd sourcing weibo visual analytic system. In Visualization Symposium (PacificVis), IEEE PacificVis Notes (2014)
- Bosch H., Thom D., Heimerl F., Püttmann E., Koch S., Krüger R., Wörner R M., Ertl T.: Scatterblogs2: Real-time monitoring of microblog messages through user-guided filtering. IEEE Transactions on Visualization and Computer Graphics 19 (2013)
- M. Walther and M. Kaisser. Geo-spatial event detection in the twitter stream. In ECIR, pages 356–367. Springer, 2013.
- T. Sakaki, M. Okazaki, and Y. Matsuo. Tweet analysis for real-time event detection and earthquake reporting system development. IEEE Trans. on Knowl. and Data Eng., 25(4):919–931, Apr. 2013.
- T. Johnson, C. Acedo, S. Kobourov, and S. Nusrat. Analyzing the evolution of the internet. In 17th IEEE Eurographics Conference on Visualization (EuroVis–short papers), volume 17, 2015.
- A. Scherman, A. Arriagada, and S. Valenzuela. Student and environmental protests in chile: The role of social media. Politics, 35(2):151–171, 2015.
-

# References

-   X. Liu, Q. Li, A. Nourbakhsh, R. Fang, M. Thomas, K. Anderson, R. Kociuba, M. Vedder, S. Pomerville, R. Wudali, R. Martin, J. Duprey, A. Vachher, W. Keenan, and S. Shah. Reuters tracer: A large scale system of detecting &#38; verifying real-time news events from twitter. In Proceedings of the 25th ACM International on Conference on Information and Knowledge Management, CIKM '16, pages 207–216, New York, NY, USA, 2016. ACM.
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