Structuring and exploring geographic iconographic heritage

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Geographic iconographic heritage?

- Aerial
- Terrestrial
- Photograph
- Painting
- Drawing
- etc
Why focusing on geographic iconographic heritage?

- It’s a rich spatio-temporal representation of our territory and its evolution

- Many domains impacted
  - Researches in SSH (historians, geographers, sociologists, etc.)
  - Environmental cartography
  - Urban planning
  - Tourism
  - Education
  - …

- Many hosting institutions: GLAMs, mapping agencies

- Open data policies make them more and more available
Why focusing on geographic iconographic heritage?

- **Main characteristics**
  - More and more digitally native, but a large part of them are not digitized
  - Large spatio-temporal coverage
    - Large territory coverage
    - Various acquisition dates (« multi-date » imagery)
  - Various contents
    - Heterogeneous: multi-view, multi-source, multi-date
    - Variable quality metadata, different standards
    - Very variable geolocation quality
  - Collections in silo in institutions, not interlinked
Outline of the talk

- How to bring **structure** to a collection, or between collections
  - Structure through **links** between contents
  - Structure through **spatialization**

- How to **access** and **visualize** the collections and their structure
  - Through **image retrieval**
  - Through spatialization **in 3D context**
A brief SOTA on GIH structuring and visualization

- Indexing, categorizing and querying with metadata
  - Metadata-based graphs (ex. Oronce Fine)
  - Metadata enriched with AI (ex. GallicaPix)

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Europeana

Metadata-based retrieval with GallicaPix (BnF)
A brief SOTA on GIH structuring and visualization

- Spatial turn: structuring and visualizing through **spatialization**
  - How to spatialize? (Blettery et al, 2021)
    - Manual: picking on a map (Gallicarte project), collaborative annotations (Smapshot)
    - Semi-automatic: guided localization (ALEGORIA, Geniet et al. 2022)
    - Automatic: image retrieval (Paul-Edouard Sarlin et al. 2021), pose regression (Moreau et al. 2022)
A brief SOTA on GIH structuring and visualization

- Content-based indexing, categorizing and querying
A brief SOTA on GIH structuring and visualization

- 3D (and 4D) integration and visualization platforms
  - Focused on topics, areas
  - 3D open platforms (iTowns, Cesium)

Images of Switzerland Online

Aioli

Smapshot

Hist4D

UD-Viz
Some of our contributions

- 3 observation scales

  Aerial, landscapes: **ALEGORIA** (2018-2021)

  Street-level, city-scale: **ON STAGE 3D** (2020-2023)

  Monument: **Notre-Dame de Paris** (ongoing)
Advanced Linking and Exploitation of diGitized geOgRaphic Iconographic heritAge

Collections of aerial old photographs

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Why old aerial oblique images

- Richness of the viewpoint: bird’s view
- Views spread all over the territory
- In the project: 90 000 views
  (42 000 digitized, 70 000 with harmonized metadata)

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Main objectives

- Development of tools and software architectures to facilitate access to and promotion of iconographic collections
  
  ✓ Digitization and harmonization of old iconographic collections
  ✓ A web-based multimodal search engine
  ✓ A web-based 3D navigation platform
  ✓ Several use cases with archivists, sociologists and historians
Multimodal search engine

- **Main user expectations**
  - Better document a photograph by finding similar documented views
  - Better geolocalize a photograph
  - Better structure the collections (redundancy, duplicates, etc.)
  - Discover new photographs
  - Propose alternative navigation paths in the collections according to different criteria

What would you gain from querying photographic collections, by visual content and/or metadata?

(38 participants)
Indexing and retrieval by content

- Description, indexing and retrieval \textit{by content} of the collections: \textbf{principles}

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Automatic extraction of visual characteristics

descriptor signature index fingerprint...

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Indexing and retrieval by content

- Description, indexing and retrieval **by content** of the collections: **principles**
  - Querying paradigm: query-by-example

(Gominski et al. 2019, 2021)
Indexing and retrieval by content

- Description and indexing by content of the collections: **challenges**
  
  - Image collections intra and inter-domains
    - Multi-source
    - Multi-date
    - Multi-view

- Lack of training datasets

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Indexing and retrieval by content

- Description and indexing by content of the collections: **which descriptor?**
Indexing and retrieval by content

- Description and indexing by content of the collections: *which descriptor?*

  - **Descriptors studied**
    - Global descriptor: **GeM + few-shot learning**
      (Gominski et al. 2022)
    - Local descriptor for instance retrieval:
      DELF + training benchmark ALEGORIA
      (Gominski et al. 2019, 2021)
    - Post-processings: **geometric verification**
      and **query expansion** (diffusion)
      (Gominski et al. 2021)

*When searching in the dataset, which metadata search criteria would you exploit first?*  
(48 participants)
Multimodal search engine

- Overview of the proposed web search engine (Geniet et al. 2022)
  - Distributed architecture
  - Several categories of image descriptors and post-processings
  - Retrieval by:
    - Metadata
    - Content
    - Multimodal
Retrieval examples

Retrieval by content between collections (local description)

<table>
<thead>
<tr>
<th>Image</th>
<th>Title</th>
<th>Date</th>
<th>Location</th>
<th>Collection</th>
<th>Institution</th>
<th>Comments</th>
<th>GeoRef</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vue aérienne de Caen, Les quatre ponts (titre factice)</td>
<td>1950</td>
<td>Caen</td>
<td>Combier</td>
<td>Musée Nicéphore Nalpope</td>
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<td>show</td>
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<tr>
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<td>Caen</td>
<td>MTRU</td>
<td>Archives nationales</td>
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<td>Caen</td>
<td>LAPIE 2</td>
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</table>
Retrieval examples

Retrieval by content between collections (local description)
Retrieval examples

External query by content (local description)
Use case for the French national Archives

- Identify views and share documentary information
- Date
- Follow the evolution of an area during the reconstruction period, here the old port of Marseille in the period 1930-1970
- Compare the modes of shooting on a site in time
Retrieval examples & 3D

Searching for metadata, by content (local description)
Retrieval examples & 3D

Then visualization in the 3D scene (French Geoportal), with the possibility to refine the geolocation
Search by content, to structure (local description)

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<td>Obliques</td>
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</table>
Retrieval examples & 3D

Then visualization in the 3D scene, here according to a fine geolocalization.
Immersive co-visualization of the contents

- Immersive navigation and interactions: iTowns, a 3D geospatial data visualization library for the web
  
  http://www.itowns-project.org/
Immersive co-visualization of the contents

- Interactive spatio-temporal navigation paradigms (Blettery et al. 2020)

  - Management of image collections at different scales: heat maps, pyramids, carousel
Immersive co-visualization of the contents

- Use case: Understanding the formation of the Parisian metropolis: Nanterre and its slums in the 1950s - a historical and sociological perspective
  
  (Blettery et al, 3DGeoInfo 2020) (Lecat et al, Humanités numériques 2021)

  ➢ Evaluation as a research and communication tool in urban visual sociology (LAVUE)

Photo-elicitation interview on the evolution of infrastructures and landmarks
(hotel/restaurant vs. highway interchange, 1960-1961 period)
Immersive co-visualization of the contents

- Use case: Understanding the formation of the Parisian metropolis: Nanterre and its slums in the 1950s - a historical and sociological perspective

  (Blettery et al, 3DGeoInfo 2020) (Lecat et al, Humanités numériques 2021)

  - History of metropolization phenomena in the Parisian agglomeration Paris in the middle of the 20th century (Archival City / Grand Paris)
ON STAGE 3D: cONtent-based STructuring of pAris photoGraphic hEritage in 3D

► Focus on street-level Parisian architecture

► Objectives
  o Visual-based linking for structuring
  o Structure visualization and refinement

► Diverse depictions of 10k visual contents
  o 1915-2015
  o Streets, monuments, churches or regular buildings
  o Coming from different institutions and departments, with various types of metadata
ON STAGE 3D: cONtent-based STructuring of pAris photoGraphic hEritage in 3D

► Focus on street-level Parisian architecture: not easy!
ON STAGE 3D: cONTent-based STructuring of pAris photoGraphic hEritage in 3D

- Visual-based Linking for structuring
  - Best image descriptors related to landmarks:
    How + AMSK (Tolias et al. 2016, 2020)
ON STAGE 3D: cONTent-based STructuring of pAris photoGraphic hEritage in 3D

- Visual-based Linking for structuring
  - Exploiting the geometry of the scene during a posteriori reranking

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ON STAGE 3D: cONTent-based STructuring of pAris photoGraphic hEritage in 3D

- Visual-based Linking for structuring
  - **Best image descriptors** related to landmarks: How + AMSK (Tolias et al. 2016, 2020)
  - Exploiting the **geometry** of the scene during a posteriori **reranking**
  - **4 strategies** (Blettery et al. 2023)
    - 2D-3D matching: exploitation of the 3D of the scene (Structure from Motion)
    - 2D approximation of 2D-3D matching
    - Exploitation of the location available
    - **Diffusion**: GNN-R from (Zhang et al, 2020)
ON STAGE 3D: cONtent-based STructuring of pAris photoGraphic hEritage in 3D

Combination of re-ranking strategies: evaluation (mAP)

<table>
<thead>
<tr>
<th>Re-ranking step</th>
<th>Diffusion after previous re-ranking</th>
<th>Mean time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No GNN-R</td>
<td>GNN-R × 1</td>
</tr>
<tr>
<td>How-A</td>
<td>41.0</td>
<td>57.2</td>
</tr>
<tr>
<td>How-A + RANSAC-SG</td>
<td>41.6</td>
<td>57.2</td>
</tr>
<tr>
<td>How-A + RANSAC-LG</td>
<td>41.9</td>
<td>61.2</td>
</tr>
<tr>
<td>How-A + R3D-SG</td>
<td>44.4</td>
<td>61.9</td>
</tr>
<tr>
<td>How-A + R3D-LG</td>
<td>43.2</td>
<td>61.1</td>
</tr>
<tr>
<td>How-A + R2D-SG</td>
<td>36.2</td>
<td>59.6</td>
</tr>
<tr>
<td>How-A + R2D-LG</td>
<td>41.9</td>
<td>61.0</td>
</tr>
<tr>
<td>How-A + location weighting (Sp)</td>
<td>42.0</td>
<td>58.9</td>
</tr>
<tr>
<td>How-A + location weighting (No dist)</td>
<td>40.5</td>
<td>57.8</td>
</tr>
<tr>
<td>How-A + location weighting (All)</td>
<td>42.5</td>
<td>60.2</td>
</tr>
<tr>
<td>How-A + RANSAC-SG +R3D-SG</td>
<td>44.9</td>
<td>62.9</td>
</tr>
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<tr>
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<td>41.9</td>
<td>61.1</td>
</tr>
</tbody>
</table>

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ON STAGE 3D: cONtent-based STructuring of pARis photoGraphic hEritage in 3D

Combination of re-ranking strategies: visual inspection
ON STAGE 3D: cONTent-based STructuring of pAris photoGraphic hEritage in 3D

- Visual-based Linking for structuring
  - **Best image descriptors** related to landmarks: How + AMSK (Tolias et al. 2016, 2020)
  - Exploiting the **geometry** of the scene during a posteriori reranking
  - **4 strategies** (Blettery et al. 2023)
    - 2D-3D matching: exploitation of the 3D of the scene (COLMAP)
    - 2D approximation of 2D-3D matching
    - Exploitation of the location available
    - Diffusion: GNN-R from (Zhang et al, 2020)

How to make it even better?
ON STAGE 3D: cONTent-based STructuring of pAris photoGraphic hEritage in 3D

- Structure visualization and refinement
  - A 3D representation of the graph-based representation of links between images, based on:
    - Visual similarities (auto)
    - Spatial similarities (auto)
    - expert similarities (manual)
ON STAGE 3D: cONtent-based STructuring of pAris photoGraphic hEritage in 3D

- Structure visualization and refinement

  ✓ Refinement of the global structuring through iterations between automatic linking and manual annotations

<table>
<thead>
<tr>
<th>Combination of retrieval and re-ranking approaches</th>
<th>k-re-ranked images per query</th>
<th>Re-ranking computation time (hours)</th>
<th>mAP after diffusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>How-A</td>
<td>-</td>
<td>-</td>
<td>59.3</td>
</tr>
<tr>
<td>Automatic re-ranking approaches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How-A + Location weighting (Sp)</td>
<td>135</td>
<td>1/60</td>
<td>61.8</td>
</tr>
<tr>
<td>How-A + RANSAC-SG + R3D-SG</td>
<td>135</td>
<td>150</td>
<td>65.8</td>
</tr>
<tr>
<td>How-A + RANSAC-LG</td>
<td>135</td>
<td>45</td>
<td>65.5</td>
</tr>
<tr>
<td>How-A + RANSAC-SG/RANSAC-LG</td>
<td>5</td>
<td>1.5</td>
<td>59.3</td>
</tr>
<tr>
<td>Iterative semi-automatic process building on an automatic location weighting step</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>How-A + Location weighting (Sp)</td>
<td>135</td>
<td>1/60</td>
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</tr>
<tr>
<td>+ Automatic location propagation</td>
<td>-</td>
<td>-</td>
<td>62.2</td>
</tr>
<tr>
<td>+ Manual interventions on the first 5 links</td>
<td>-</td>
<td>1</td>
<td>62.6</td>
</tr>
<tr>
<td>+ Manual interventions on the 5-10 links</td>
<td>-</td>
<td>1</td>
<td>64.2</td>
</tr>
<tr>
<td>Iterative semi-automatic process building on an automatic RANSAC-SG + R3D-SG step</td>
<td></td>
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<tr>
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</tr>
<tr>
<td>+ Manual interventions on the 5-10 links</td>
<td>-</td>
<td>1</td>
<td>66.4</td>
</tr>
<tr>
<td>+ Manual interventions on the 10-15 links</td>
<td>-</td>
<td>1</td>
<td>66.9</td>
</tr>
</tbody>
</table>
Visual documentation at the scale of a monument

- Integration of heterogeneous data in a digital ecosystem dedicated to restauration sites
  - Case study: Notre-Dame de Paris
  - Structuring of various visual contents collected:
    - before, during and after the fire
    - inside and outside

A digital ecosystem for linking physical features of a heritage object with collective knowledge

Notre-Dame Scientific action

n-Dame_Heritage
n-Dimensional analysis and memorisation ecosystem for building cathedrals of knowledge in Heritage Science
Documentation at the scale of a monument

- Structuring of various visual contents collected before, during and after the fire, inside and outside
  
  ➢ Difficult, specific contents!

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Documentation at the scale of a monument

- Structuring of various visual contents collected before, during and after the fire, inside and outside
- How: considering the multimodal information available
  - Structuring by integrating together visual, spatio-temporal and semantic information (Willot et al, 2023)
Documentation at the scale of a monument

- Structuring of various visual contents collected before, during and after the fire, inside and outside

- How: considering the multimodal information available
  
  - Exploiting the geometrical structure of the scene (e.g. point clouds)
Some conclusions

- Geographic iconographic heritage: a very rich heritage, still under exploited!

- Open data policies → more and more data made available

- Challenging research in Computer Vision, AI, Multimedia and HCI
  - Ex: exploitation of multimodal data (text, 3D point clouds, etc.) to help
  - Ex: reproducible, replicable and sustainable architectures

- A large panel of application domains
  - Including generative AI: GIH can serve as reference!
Last publications, datasets & event

Publications

- All ALEGORIA publications: [https://www.alegoria-project.fr/en/papers](https://www.alegoria-project.fr/en/papers)


- (Blettery et al, 2023) E. Blettery and V. Gouet-Brunet, Re-ranking Image Retrieval in Challenging Geographical Iconographic Heritage Collections, 20th International Conference on Content-Based Multimedia Indexing, Sep 2023, Orléans, France


Datasets


Event

- SUMAC’24: 6th Intl. workshop on the analySis, Understanding and proMotion of heritAge Contents @ ACM Multimedia 2024
  [https://sumac-workshops.github.io/2023/](https://sumac-workshops.github.io/2023/)
Thank you!

Contact: valerie.gouet@ign.fr