

Structuring and exploring geographic iconographic heritage

Valérie Gouet-Brunet

LaSTIG, IGN-ENSG, Gustave Eiffel University, France



Geographic iconographic heritage?



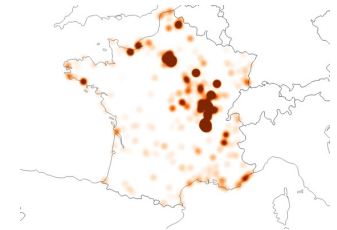
- ✓ Aerial
- ✓ Terrestrial
- ✓ Photograph
- ✓ Painting
- ✓ Drawing
- ✓ etc

Why focusing on geographic iconographic heritage?

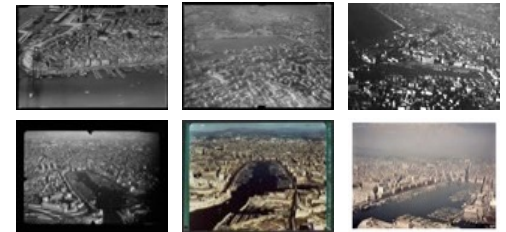
- It's a rich **spatio-temporal** representation of our **territory** and its **evolution**
- Many **domains impacted**
 - Researches in SSH (historians, geographers, sociologists, etc.)
 - Environmental cartography
 - Urban planning
 - Tourism
 - Education
 - ...
- Many **hosting institutions**: GLAMs, 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**



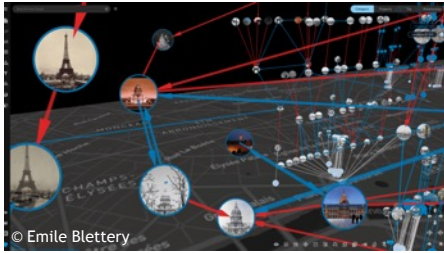
© ALEGORIA



Marseille harbor evolution between 1930 and 1970
© IGN, Archives nationales, Niépce Museum

Outline of the talk

- How to bring **structure** to a collection, or between collections



- Structure through **links** between contents
- Structure through **spatialization**

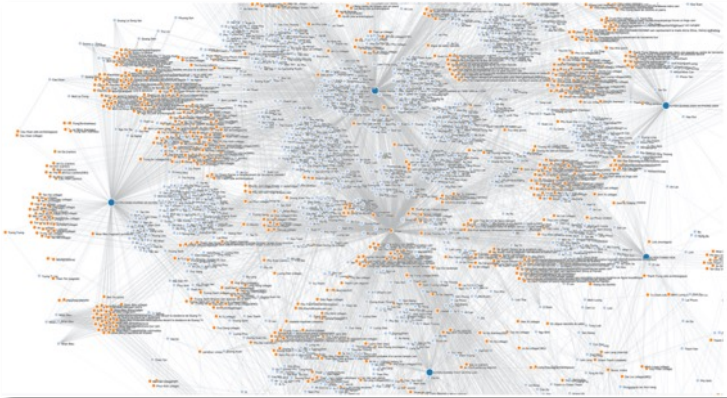
- How to **access** and **visualize** the collections and their structure



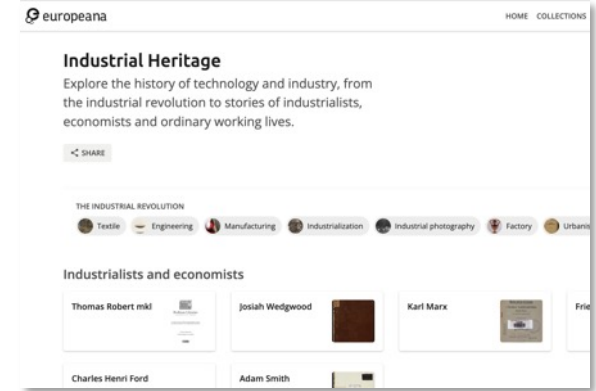
- Through **image retrieval**
- Through spatialization **in 3D context**

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)



Oronce Fine



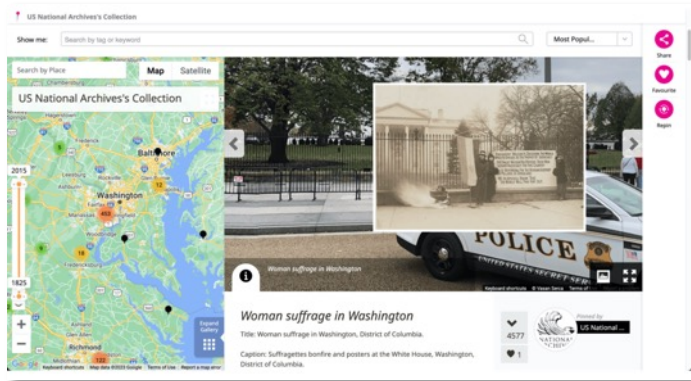
Europeana



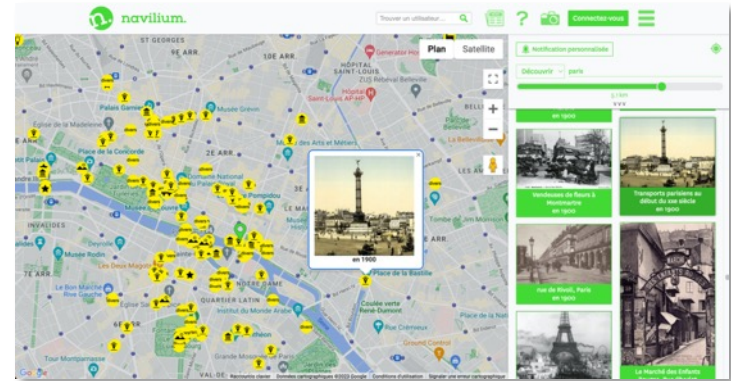
Metadata-based retrieval with GallicaPix (BnF)

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)



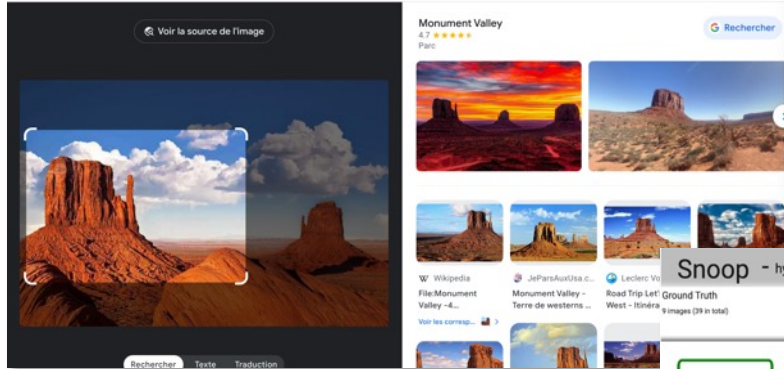
HistoryPin



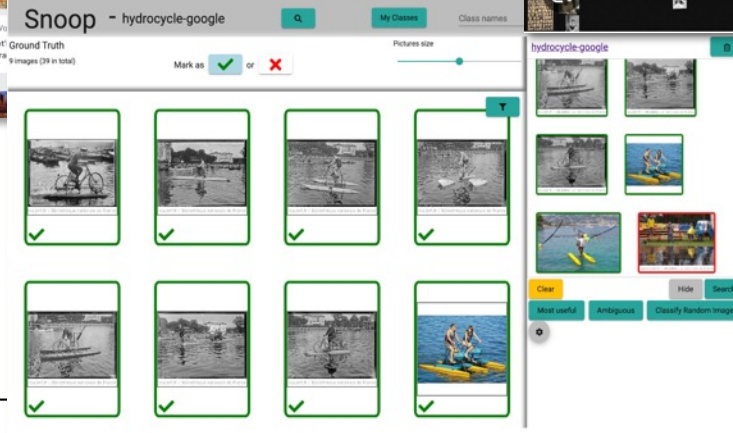
Navilium

A brief SOTA on GIH structuring and visualization

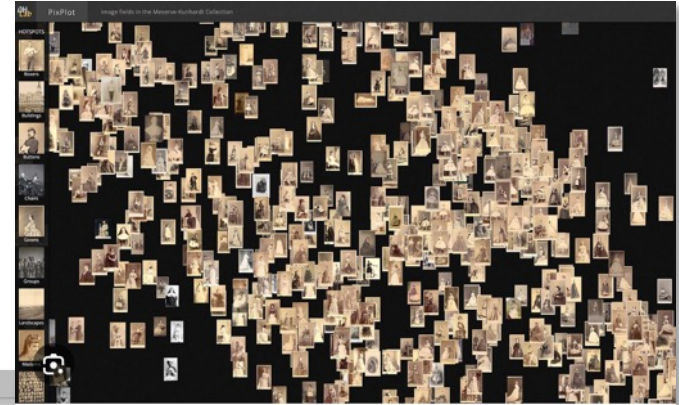
- Content-based indexing, categorizing and querying



Google Images



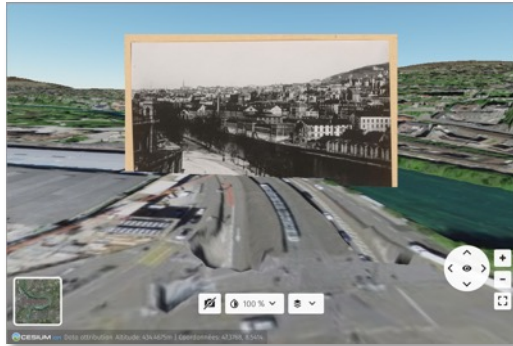
GallicaSnoop



PixPlot

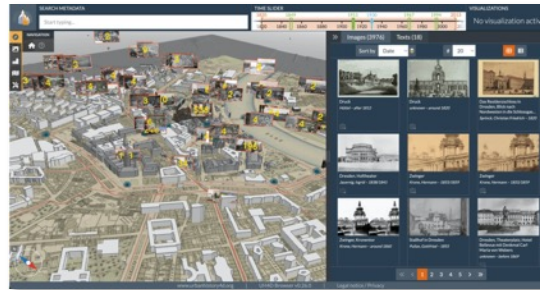
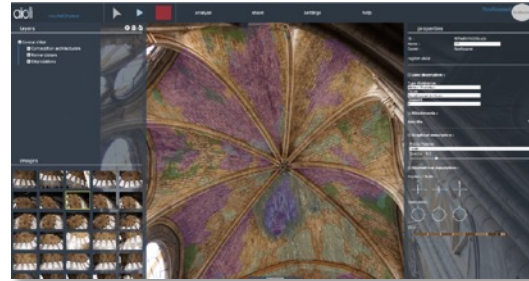
A brief SOTA on GIH structuring and visualization

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

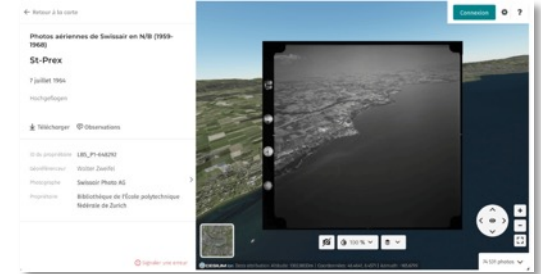


Images of Switzerland Online

Aioli



Hist4D



Snapshot



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)

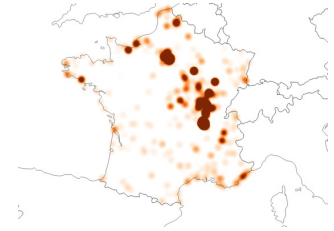
Advanced Linking and Exploitation of diGitized geOgRaphic Iconographic heritAge



Collections of
aerial old
photographs

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**)



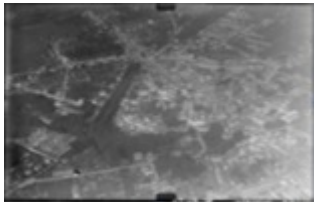
MRU collection
Archives nationales



LAPIE collection
Archives nationales



BD IGN Compagnie
Aérienne Française



Médiathèque Terra MTES



Combiér collection
Nicéphore Niépce Museum

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



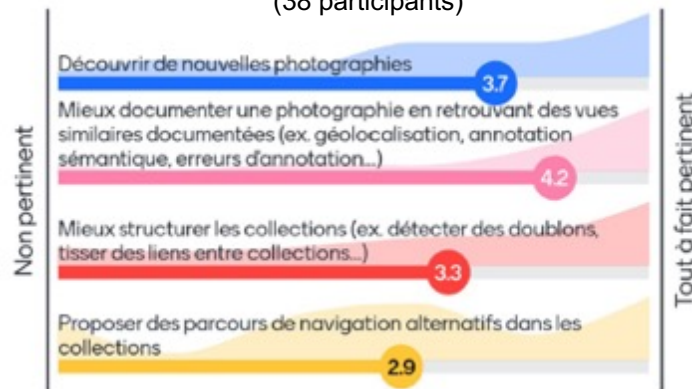
Multimodal search engine

○ 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)*

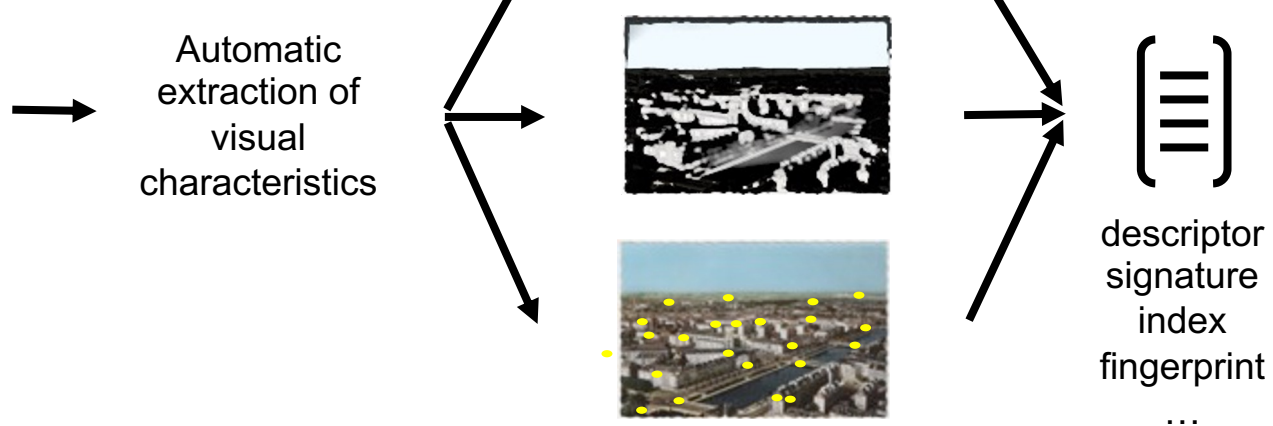


Indexing and retrieval by content

- Description, indexing and retrieval **by content** of the collections: **principles**

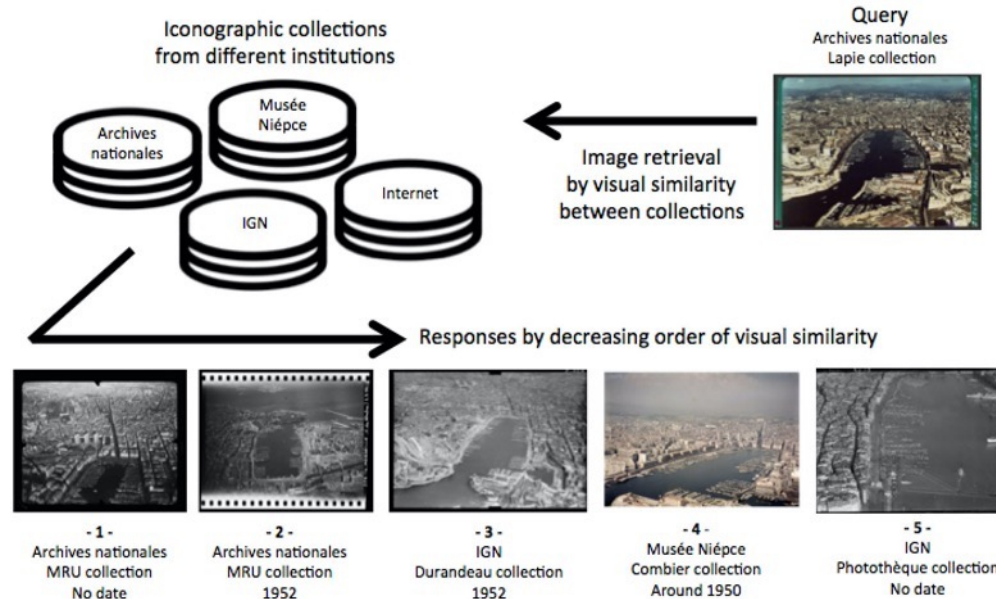


© Niépce Museum / Combier



Indexing and retrieval by content

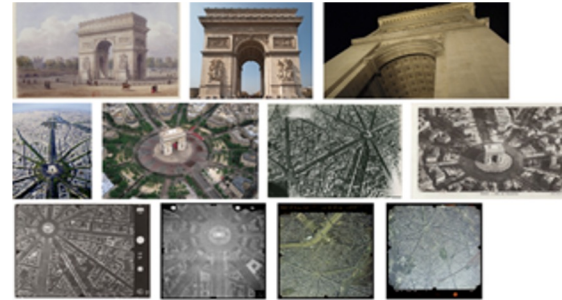
- Description, indexing and retrieval **by content** of the collections: **principles**
 - Querying paradigm : query-by-example



(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



« Arc de Triomphe » class



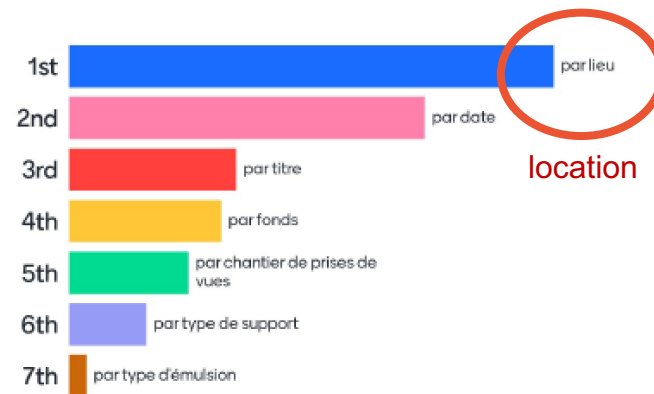
Indexing and retrieval by content

- 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

ALEGORIA Search Engine

Select an image FRAN_0242_00664_L.jpg

Image 

Collection

Descriptor type

Post-processing Planear

Post-processing Diffusion

Number of answers

Weight

Weight

Weight

Weight

Weight

Weight

Title



Place

Date

Support Type

Total processing time: 8.564 seconds







Results (by decreasing order of similarity)

Image	Title	Date	Location	Collection	Institution	Comments	Geolocation	Go To
	"G.T.143", trage numbré "43C"	-	-	LAPIE 2	Archives nationales (France) ; 1790-...	Mention obligatoire : cliché Archives nationales/Fonds LAPIE. Toute réutilisation est interdite sans l'accord des ayants droit.	<input type="button" value="show"/>	<input type="button" value="show"/>
	Marseille (trouée du Phénix)	sans date	-	MPJ	Archives nationales (France) ; 1790-...	Reproduction libre, dans le respect des dispositions contenues dans le règlement de la salle de lecture.	<input type="button" value="show"/>	<input type="button" value="show"/>

Retrieval examples

Retrieval by content
between collections
(local description)






Results (by decreasing order of similarity)

Image	Titre	Date	Location	Collection	Institution	Comments	GeoRef
	Vue aérienne de Caen, Les quatre ponts (titre factice)	1950	Caen	Combier	Musée Nicéphore Niépce	-	show
	Vue aérienne de Caen (titre factice)	Créat. Vers 1950	Caen	Combier	Musée Nicéphore Niépce	-	show
	Vue aérienne de Caen, Les quatre ponts (titre factice)	Créat. Vers 1950	Caen	Combier	Musée Nicéphore Niépce	-	show
	Mission n° 884 : Caen (Calvados)	1956-03-14	Caen	MRU	Archives nationales (France ; 1790-....)	Reproduction libre, dans le respect des dispositions contenues dans le règlement de la salle de lecture.	show
	Vue aérienne de Caen, Les quatre ponts (titre factice)	1950	Caen	Combier	Musée Nicéphore Niépce	-	show
	"B.N.30", tirage numéroté "20K"	-	Caen	LAPIE 2	Archives nationales (France ; 1790-....)	Mention obligatoire : cliché Archives nationales/Fonds LAPIE. Toute réutilisation est interdite sans l'accord des ayants droit.	show

Retrieval examples

Retrieval by content
between collections
(local description)

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	Vue aérienne de Caen, Les quatre ponts (titre factice)	1950	Caen	Combiar	Musée Nicéphore Niépce	-	show
	Vue aérienne de Caen (titre factice)	Créat. Vers 1950	Caen	Combiar	Musée Nicéphore Niépce	-	show
	Vue aérienne de Caen, Les quatre ponts (titre factice)	Créat. Vers 1950	Caen	Combiar	Musée Nicéphore Niépce	-	show
	Mission n° 884 : Caen (Calvados)	1956-03-14	Caen	MRU	Archives nationales (France ; 1790-....)	Reproduction libre, dans le respect des dispositions contenues dans le règlement de la salle de lecture.	show
	Vue aérienne de Caen, Les quatre ponts (titre factice)	1950	Caen	Combiar	Musée Nicéphore Niépce	-	show
	"B.N.30", tirage numéroté "20K"	-	Caen	LAPIE 2	Archives nationales (France ; 1790-....)	Mention obligatoire : cliché Archives nationales/Fonds LAPIE. Toute réutilisation est interdite sans l'accord des ayants droit.	show







Retrieval examples

External query
by content
(local description)



Query

Results (by decreasing order of similarity)

Image	Title	Date	Location	Collection	Institution	Comments	GeoRef
 1975.19.69105.12.3P01H	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show
 1975.19.69105.12.2P01RH	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show
 1975.19.69105.12.1P01RH	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	Créat. Vers 1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show
 1975.19.69105.12.2P01H	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show
 1975.19.69105.12.1P01H	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show
	LACENAS (Rhône) - / 3 - L'Eglise, la Place du Monument (titre factice)	1950	Lacenas	Combiar	Musée Nicéphore Niépce	-	show

Use case for the French national Archives

- Identify views and share documentary information
- Date
- Follow the evolution of an area
- Compare the modes of shooting on a site in time

Follow the evolution of an area during the reconstruction period, here the old port of Marseille in the period 1930-1970



1931 (IGN - CAF)



1947 (IGN - Durandea)



1950 (AN - MRU)



After 1950 (AN - MRU)



After 1950 (AN - LAPIE)








After 1955-1975 (Niépce - Combier)

Retrieval examples & 3D

Searching for
metadata, by content
(local description)

Total processing time: 7.731 seconds

Results (by decreasing order of similarity)

Image	Title	Date	Location	Collection	Institution	Comments	GeoRef
	-	-	-	-	-	-	show
 1975.19.52093.8.2P01H	CHALINDREY (52. Hte-Marne) Ac 382-6 A - Vue aérienne - Le Stade (titre inscrit)	1963-06-12	Chalindrey	Combiér	Musée Nicéphore Niépce	-	show
 1975.19.52093.7.1P01RH	CHALINDREY (52. Hte-Marne) Ac 382-6 A - Vue aérienne - Le Stade (titre inscrit)	1963-06-12	Chalindrey	Combiér	Musée Nicéphore Niépce	-	show
 1975.19.52093.5.1P01RH	CHALINDREY (52. Hte-Marne) (titre inscrit)	1960	Chalindrey	Combiér	Musée Nicéphore Niépce	-	show
 FRAN_0242_00224_L	"B.K.153", tirage numéroté "2K"	-	Neuilly-Saint-Front	LAPIE 2	Archives nationales (France ; 1790-....)	Mention obligatoire : cliché Archives nationales/Fonds LAPIE. Toute réutilisation est interdite sans l'accord des ayants droit.	show

Retrieval examples & 3D

Then visualization in the 3D scene (French Geoportal), with the possibility to refine the geolocation






© IGN



Retrieval examples & 3D

Search by content,
to **structure**
(local description)

Results (by decreasing order of similarity)

Image	Title	Date	Location	Collection	Institution	Comments	GeoRef
	BEZONS - MAISONS-LAFITTE	1947-04-15	Carrières-sur-Seine	Obliques	IGN	-	show
	BEZONS - MAISONS-LAFITTE	1947-04-15	Carrières-sur-Seine	Obliques	IGN	-	show
	BEZONS - MAISONS-LAFITTE	1947-04-15	Carrières-sur-Seine	Obliques	IGN	-	show
	BEZONS - MAISONS-LAFITTE	1947-04-15	Carrières-sur-Seine	Obliques	IGN	-	show
	BEZONS - ACHERES - MANTES-LA JOLIE	1948-03-26	Carrières-sur-Seine	Obliques	IGN	-	show

Retrieval examples & 3D

Then visualization in the 3D scene, here according to a fine geolocalization



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iTowns

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/>



© IGN



© IGN



© IGN

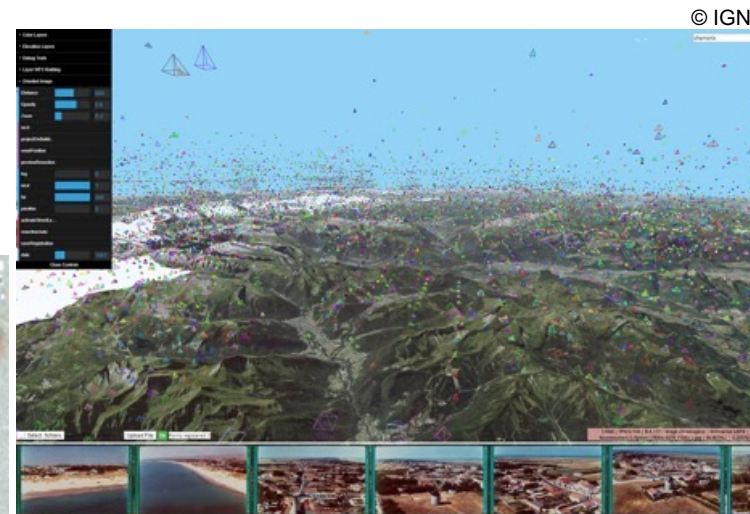
Immersive co-visualization of the contents

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



© IGN

- Management of image collections at different scales: heat maps, pyramids, carousel



© IGN

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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)**

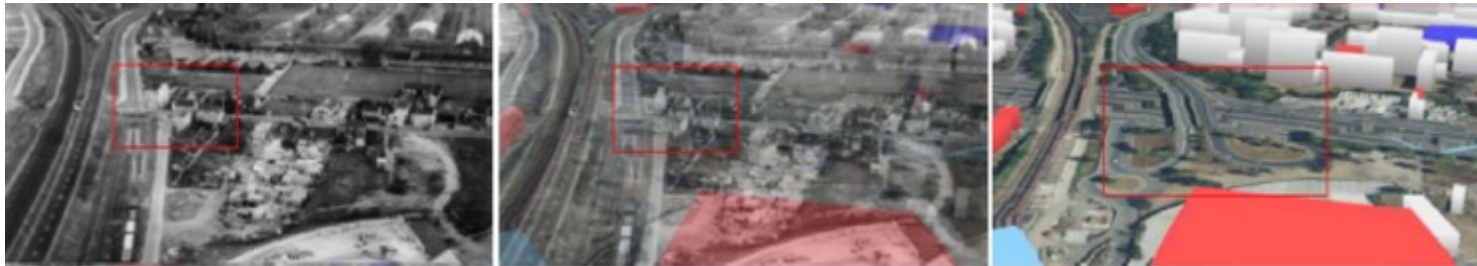


Photo-elicitation interview on the evolution of infrastructures and landmarks
(hotel/restaurant vs. highway interchange, 1960-1961 period)

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)**



• 1954 census as statistical data



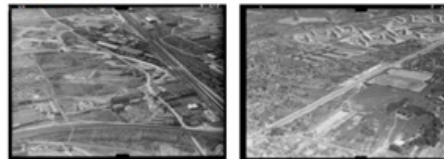
• Visual data:

- Vertical orthoimages:



- Oblique images:

© IGN

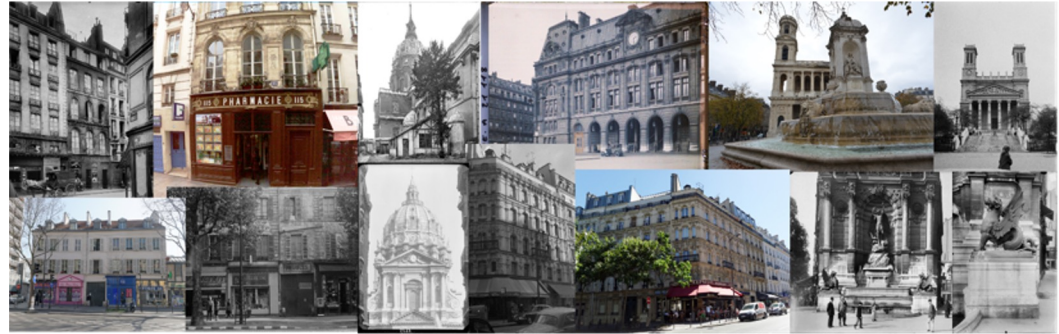


ON STAGE 3D: cONTent-based STructuring of pARis photoGraphic hEritage in 3D

► Focus on **street-level Parisian architecture**

► Objectives

- Visual-based **linking** for structuring
- Structure **visualization** and refinement



► Diverse depictions of 10k visual contents

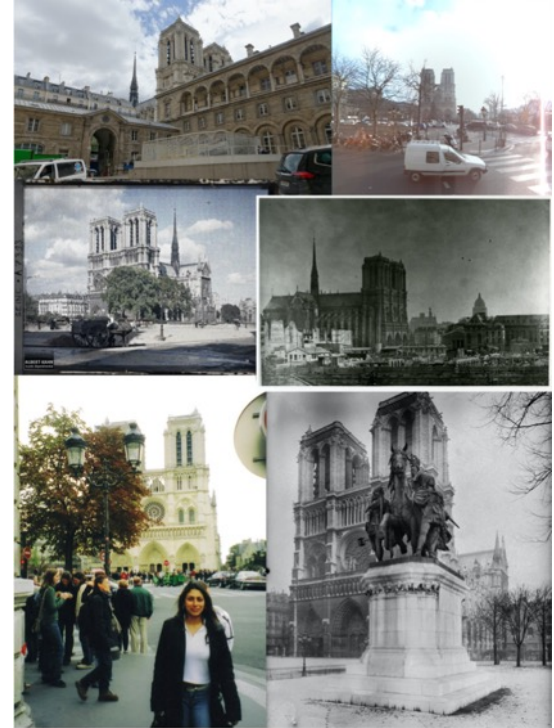
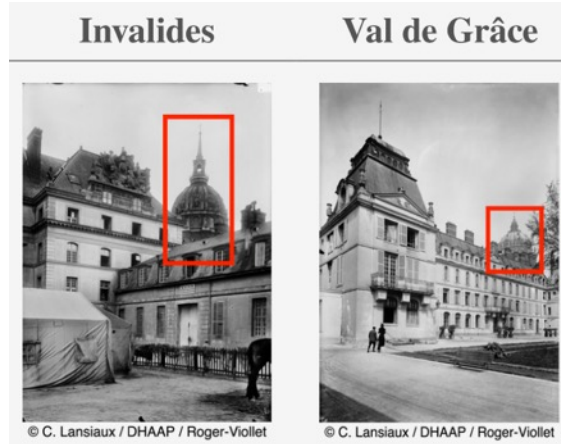
- 1915-2015
- Streets, monuments, churches or regular buildings
- Coming from different institutions and departments, with various types of metadata

© Commission du Vieux Paris / DHAAP / Roger-Viollet
© IGN

© Collection Archives de la Planète - Musée Albert-Kahn

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

- Focus on street-level Parisian architecture: **not easy!**



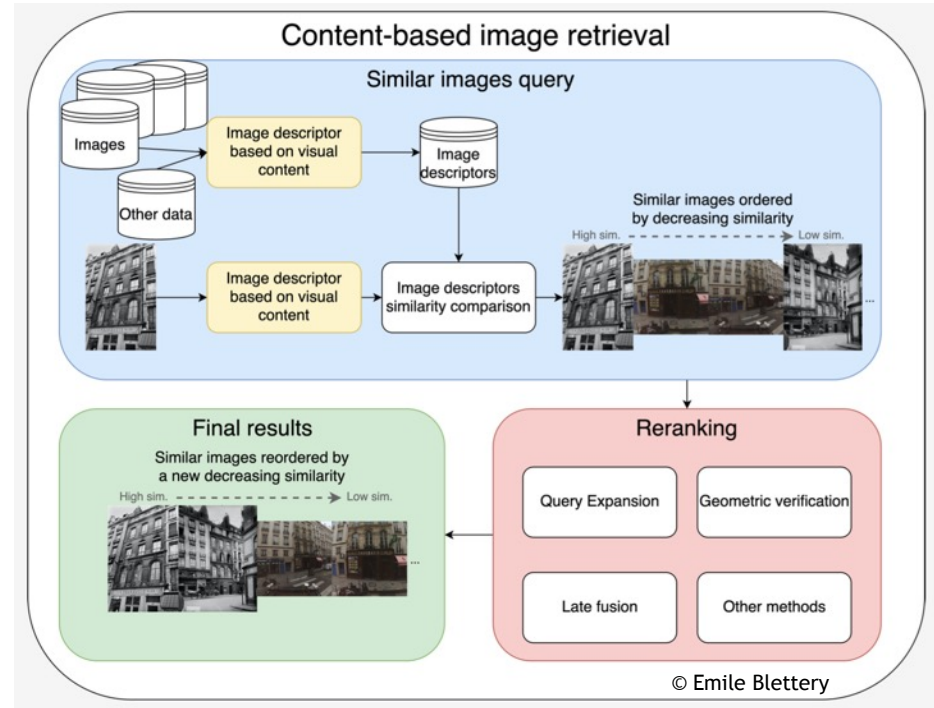
© DHAAP / CVP, © Flickr, © Musée Albert Kahn,
© MAP, © IGN, © C. Lansiaux / DHAAP / Roger-Viollet

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

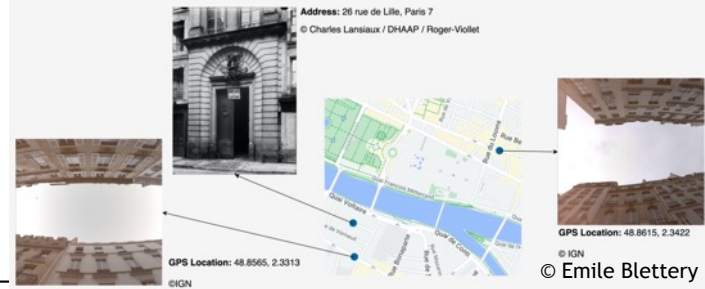
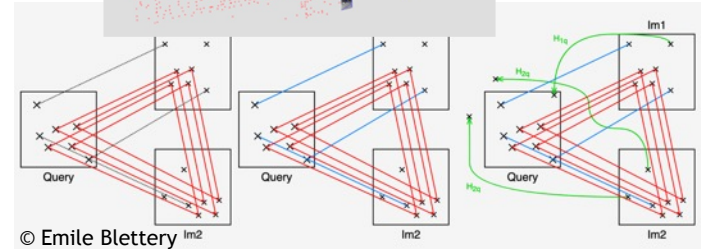
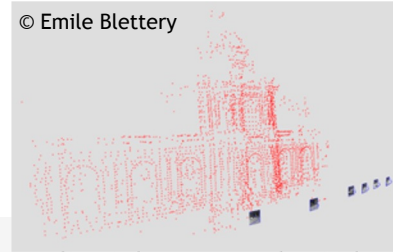
- Visual-based Linking for structuring
 - ✓ **Best image descriptors** related to landmarks: How + AMSK (Tolias et al. 2016, 2020)
 - ✓ Exploiting the **geometry** of the scene during a posteriori **reranking**



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)

© Emile Blettery



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

Combination of
re-ranking
strategies:
evaluation (mAP)

Descriptor + Re-ranking step	Diffusion after previous re-ranking				Mean time
	No GNN-R	GNN-R × 1	GNN-R × 2	GNN-R × 3	
How-A	41.0	57.2	59.3	57.0	
How-A + RANSAC-SG	41.5	57.2	59.3	57.0	+120s
How-A + RANSAC-LG	41.9	61.2	65.5	63.3	+100s
How-A + R3D-SG	44.4	61.9	64.2	61.9	+220s
How-A + R3D-LG	43.2	61.1	63.2	60.7	+210s
How-A + R2D-SG	36.2	59.6	62.9	60.5	+150s
How-A + R2D-LG	41.9	61.0	64.4	62.1	+140s
How-A + location weighting (Sp)	42.0	58.9	61.8	59.5	+1/30s
How-A + location weighting (No dist)	40.5	57.8	61.1	59.0	+1/30s
How-A + location weighting (All)	42.5	60.2	63.1	61.8	+1/30s
How-A + RANSAC-SG +R3D-SG	44.9	62.9	65.8	63.3	+340s
How-A + RANSAC-LG +R3D-LG	43.0	61.8	64.1	61.9	+300s
How-A + RANSAC-SG +R2D-SG	36.9	60.1	63.0	60.5	+270s
How-A + RANSAC-LG +R2D-LG	41.7	61.2	64.3	62.2	+240s
How-A + location weighting (Sp) + R3D-SG	44.7	62.4	64.9	62.4	+220s
How-A + location weighting (Sp) + R2D-LG	41.9	61.1	64.7	62.1	+140s

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ON STAGE 3D: cONTent-based STructuring of pARis photoGRaphic hERitage in 3D

Query



Combination of re-ranking strategies: visual inspection



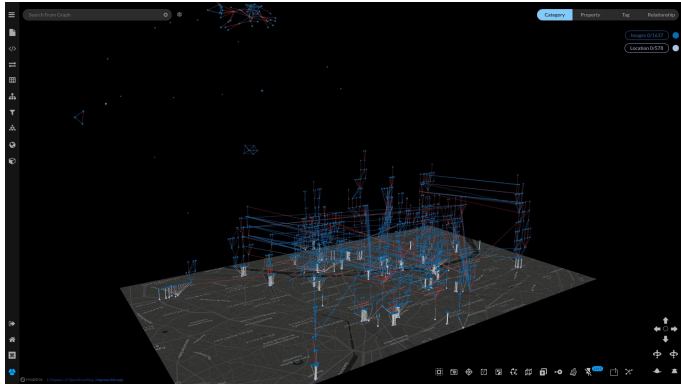
ON STAGE 3D: cONTent-based STructuring of pARis photoGraphic hEritage in 3D

- Visual-based Linking for structuring
 - ✓ **Best image descriptors** related to landmarks:
How + AMASK (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)

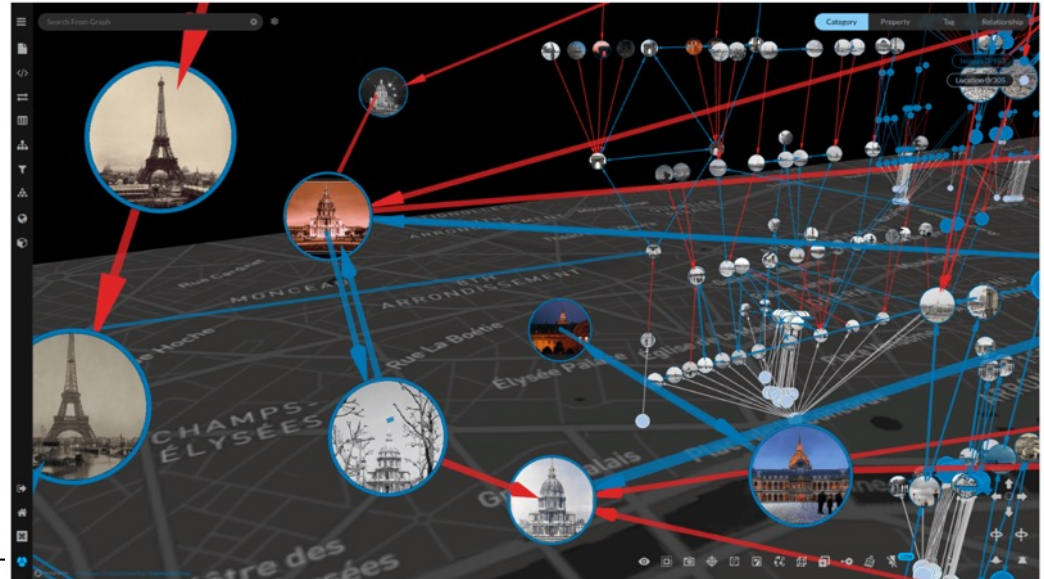
How to make it even better?

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**)



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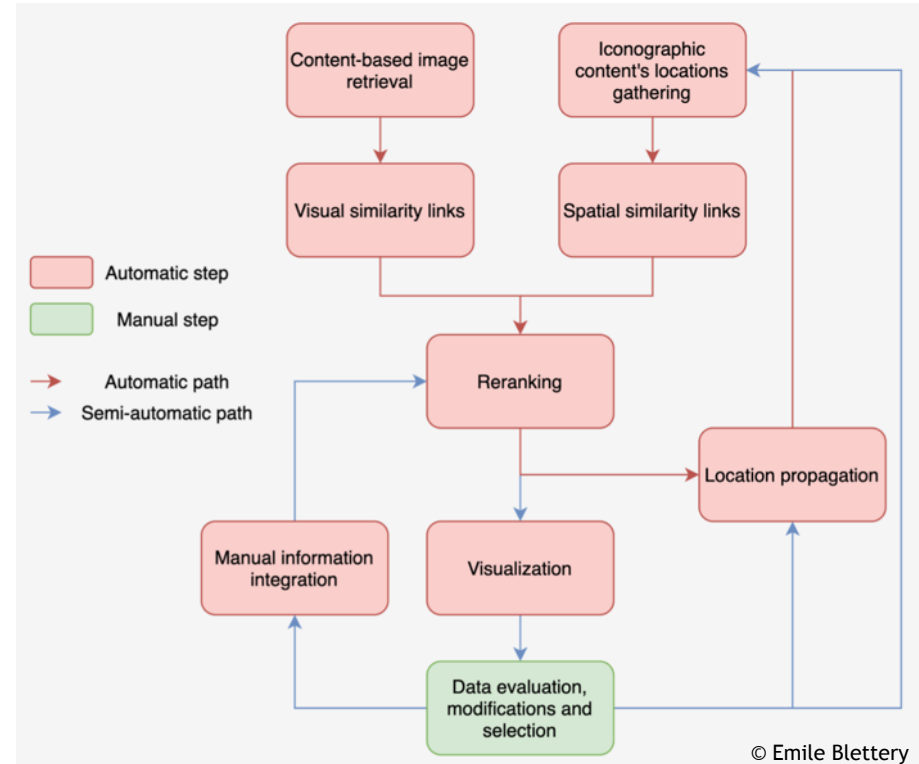


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ON STAGE 3D: cONtEnt-based STructuring of pARis photoGRaphic hERitage in 3D

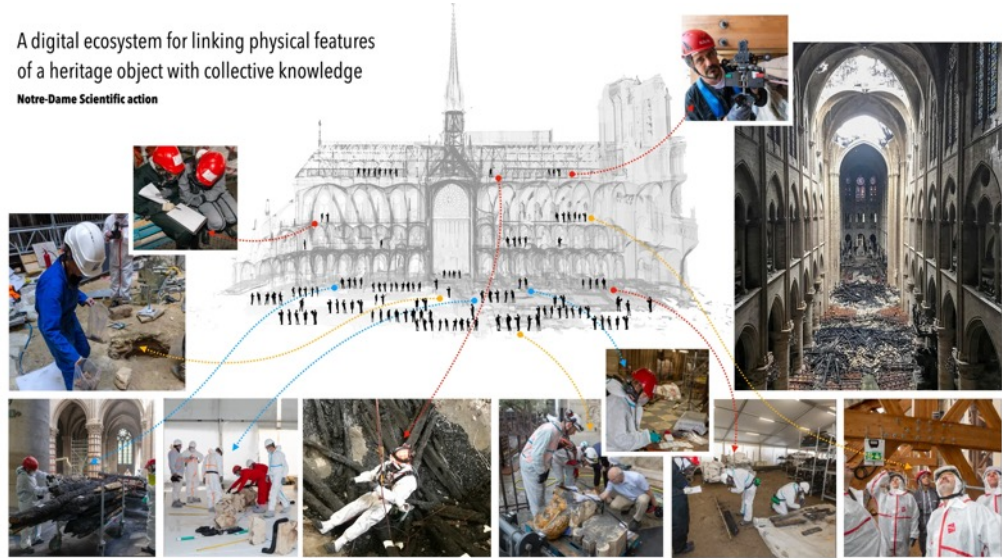
- Structure visualization and **refinement**
 - ✓ Refinement of the global structuring **through iterations between automatic linking and manual annotations**

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



Visual documentation at the scale of a monument

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

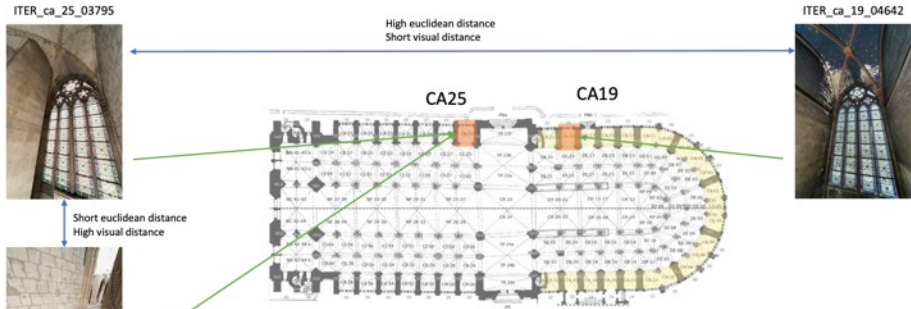


n-Dame_Heritage | n-Dimensional analysis and memorisation ecosystem for building cathedrals of knowledge in Heritage Science

Documentation at the scale of a monument

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

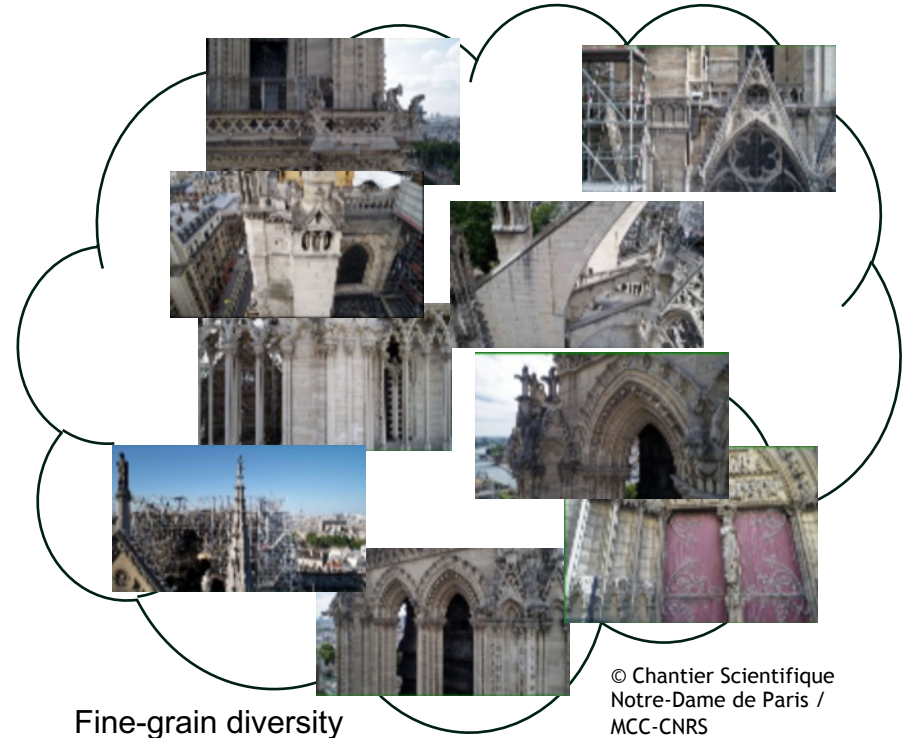
➤ Difficult, specific contents!



Distance in the taxonomy:
 - CA25 belongs to the nave chapels
 - CA19 belongs to the choir chapels
 But both are chapels

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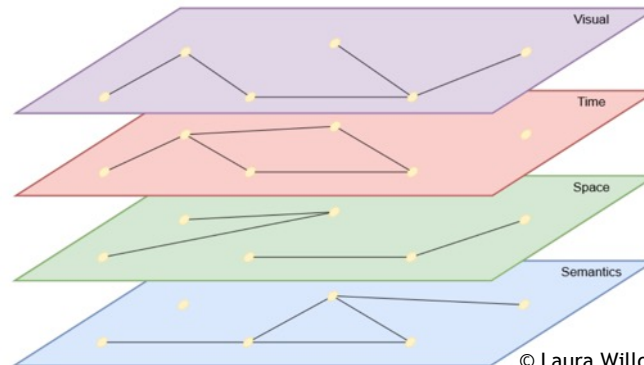
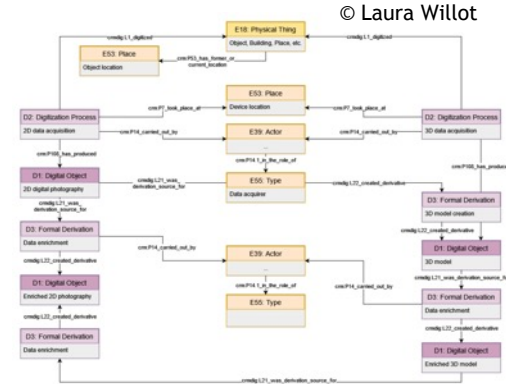
26



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Documentation at the scale of a monument

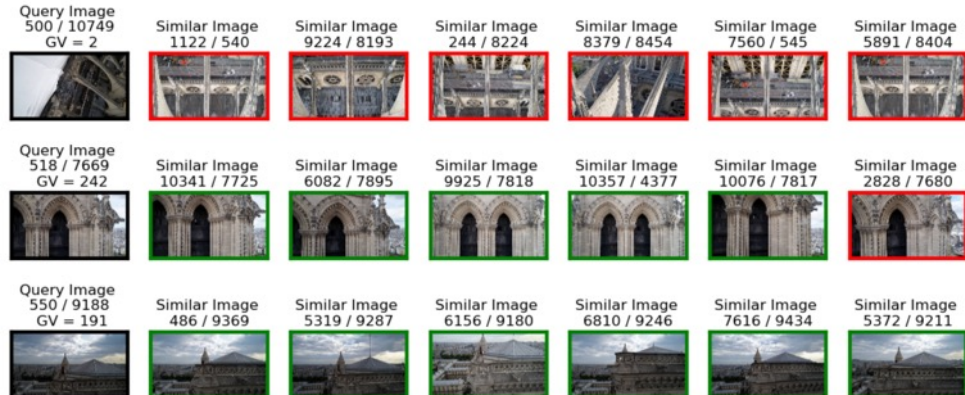
- Structuring of various visual contents collected before, during and after the fire, inside and outside
- How: considering the multimodal information available
- Structuring by integrating together visual, spatio-temporal and semantic information (Willot et al, 2023)



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)

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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>
- (Blettery et al, 2024) E. Blettery and V. Gouet-Brunet, Heritage Iconographic Content Structuring: from Automatic Linking to Visual Validation, Journal on Computing and Cultural Heritage, 2024 – To appear
- (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
- (Willet et al, 2023) L. Willot, D. Vodislav, V. Gouet-Brunet, L. De Luca and A. Manuel, Clustering for the Analysis and Enrichment of Corpus of Images for the Spatio-temporal Monitoring of Restoration Sites, 5th Workshop on AnalySis, Understanding and ProMotion of HeritAge Contents (SUMAC '23), ACM Multimedia 2023, Nov 2023, Ottawa, Canada. pp.39-47

Datasets

- **ALEGORIA datasets (images & metadata):** <https://www.alegoria-project.fr/en/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/>



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FRANÇAISE

*Liberté
Égalité
Fraternité*

Thank you!

Contact: valerie.gouet@ign.fr