Linking Past to Present: Discovering Style in Two Centuries of Architecture

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The Big Picture

– Over 2.8 zettabytes of information created or duplicated in 2012 alone
– Much of the data we produce is visual
  – 285+ billion photos uploaded to Facebook, Instagram, & Flickr
  – 5+ million miles of panoramas on Google Street View
  – 300 hours of video uploaded to YouTube a minute

Social sciences and the humanities will need to build on computational foundations to condense and interpret this data.
Recent high-profile work focuses on text analysis

– Studying social media information to predict and track disease

– Examining historical law record
  (Klingenstein et al., *Proceedings of the National Academy of Sciences* 2014)

– Mapping the rise and fall of word use in large digital book collections
  (Michel et al., *Science* 2011)
Some visual analysis has been applied in these domains

– Finding similarities in large collections of art
  (Kim et al., *Scientific Reports*, 2014)
– Aligning 3D architectural models to paintings
  (Aubry et al., *ACM Transactions on Graphics*, 2014)

More closely related to this work:

– Discovering city-scale architectural differences
  (Doersch et al., *ACM Transactions on Graphics*, 2012)
– Finding stylistic shifts in discriminative elements
  (Lee et al., *ICCV*, 2013)
Our Problem | Evolution of Architecture

- Automatically generate a large temporally labeled building facade dataset
- Identify visual elements specific to certain time periods
- Track stylistic changes in functionally identical elements
Dataset | Combining Street View and fine-grained cadastral maps

120,000 Parisian Buildings
- Fine-grained 2D building geometry
- Labeled with construction period (10 periods from -1800 to 2000+)

145,000 ...
- Precise location and heading
- 360° panorama images

70,000 Building Facade Crops
- Labeled with construction period
- Rectified so that building face is nearly planar
Dataset | Automatically generating facade images

1. Cast 30m rays to the sides of each Street View capture location at 1° intervals

2. Compute intersections with facades and select the widest view

3. Project onto the panoramas then crop and warp the facade images

Filter buildings that are far skewed or too narrow in view, resulting in approximately 70,000 facades.
Method | What are we looking for?

**Period-Discriminative Elements:**
- Visual elements that occur frequently in one period but not in others

[Diagrams showing period-specific elements and agnostic elements]
Method: Mining Period-Discriminative Elements

1. Seed Images
2. Candidate Patches

w \cdot x_1 + b

3. 

4. 

Precision Recall

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**Results** | **Period-Discriminative Elements**

-1800
Results | Period-Discriminative Elements

1801-1850
Results | Period-Discriminative Elements

1851-1914
Results | Period-Discriminative Elements

1915-1939
Results | Period-Discriminative Elements

1940-1967
Results | Period-Discriminative Elements

1968-1975
Results | Period-Discriminative Elements

1976-1981
Results | Period-Discriminative Elements

1982-1989
Results | Period-Discriminative Elements

1990-1999

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Results | Period-Discriminative Elements

2000+
Results | Using the Discovered Patches

Mining fine-grained importance

Visualizing period influences at the facade level
How do we define style in architecture?

- Changes in visual appearance through time for functionally identical elements

Each element of a style chain should

- be somewhat distinctive to its own period and
- coarsely visually similar to its neighbors in the chain
Method | Tracking style over time

Source

-1800
1801
1851
1915
-1850
-1914
-1939

Sink

Straightforward shortest path algorithms produce chains from the graph by starting from a source at its sink.
Results | Style
Take-homes

Social sciences and the humanities will need to build on computational foundations to condense and interpret this data.

Large automatically labeled datasets for social science research can be created by combining open data sources and fine-grained metadata.

Architecturally interesting elements and evolutions can be automatically discovered using straight-forward data mining techniques.

Visit the project page at vision.soic.indiana.edu for more info and full browsable results

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