



Jane Jacobs in the Sky

Predicting (*and Showing*) Urban Vitality
with Open Satellite Data

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Team:

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CSCW 2021

An aerial satellite image of a city, likely New York City, showing a dense urban grid and surrounding green spaces. A prominent river, the Hudson River, is highlighted with a thick purple line that follows its course from the top right towards the bottom right. The text "image as data" is overlaid in the center of the image in a white, bold, sans-serif font.

image as data

We use image data to...

- ① test theories with empirical studies at scale
- ② develop new data visualization methods

We use image data to...

- ① test theories with empirical studies at scale
- ② develop new data visualization methods

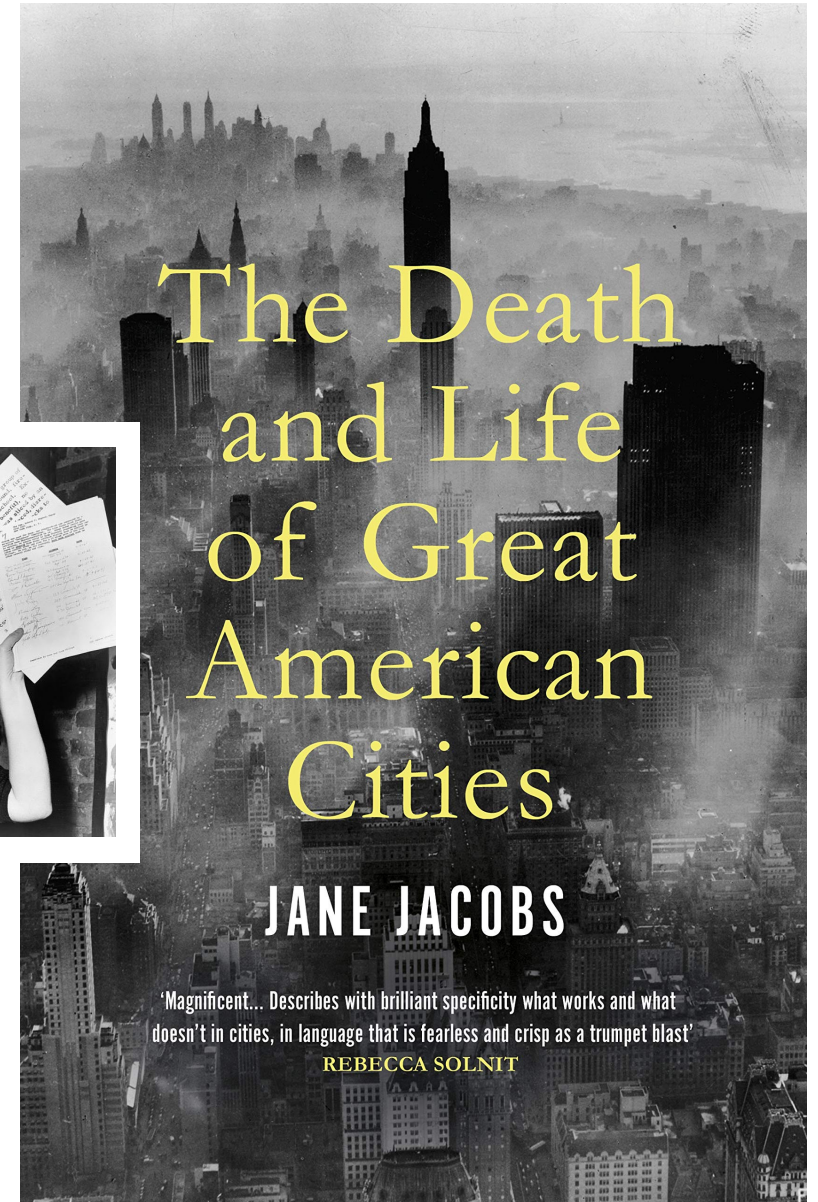
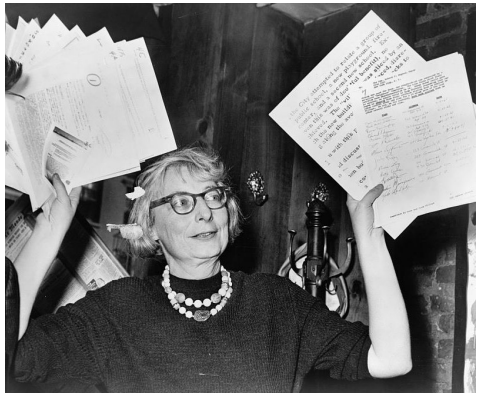
Jane Jacobs Urban Vitality Theory

Visual storytelling from above

Jane Jacobs Urban Vitality Theory

Four conditions for the promotion of life in cities:

- ① diversity of land use
- ② small block sizes
- ③ concentration of people
- ④ mix of economic activities



Jane Jacobs Urban Vitality Theory

Four conditions for the promotion of life in cities:

- 1 **diversity of land use**
- 2 **small block sizes**
- 3 concentration of people
- 4 mix of economic activities





① Florence



② Milan



③ Palermo



④ Bologna



⑤ Turin



⑥ Rome

Testing the theory with data

Satellite images
→ proxy for diversity of land use and small block sizes



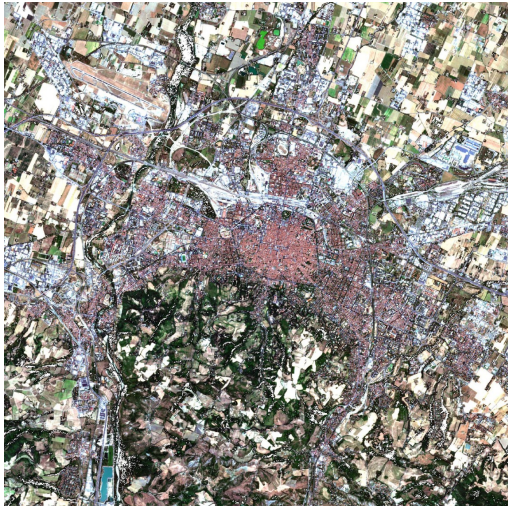
① Florence



② Milan



③ Palermo



④ Bologna



⑤ Turin



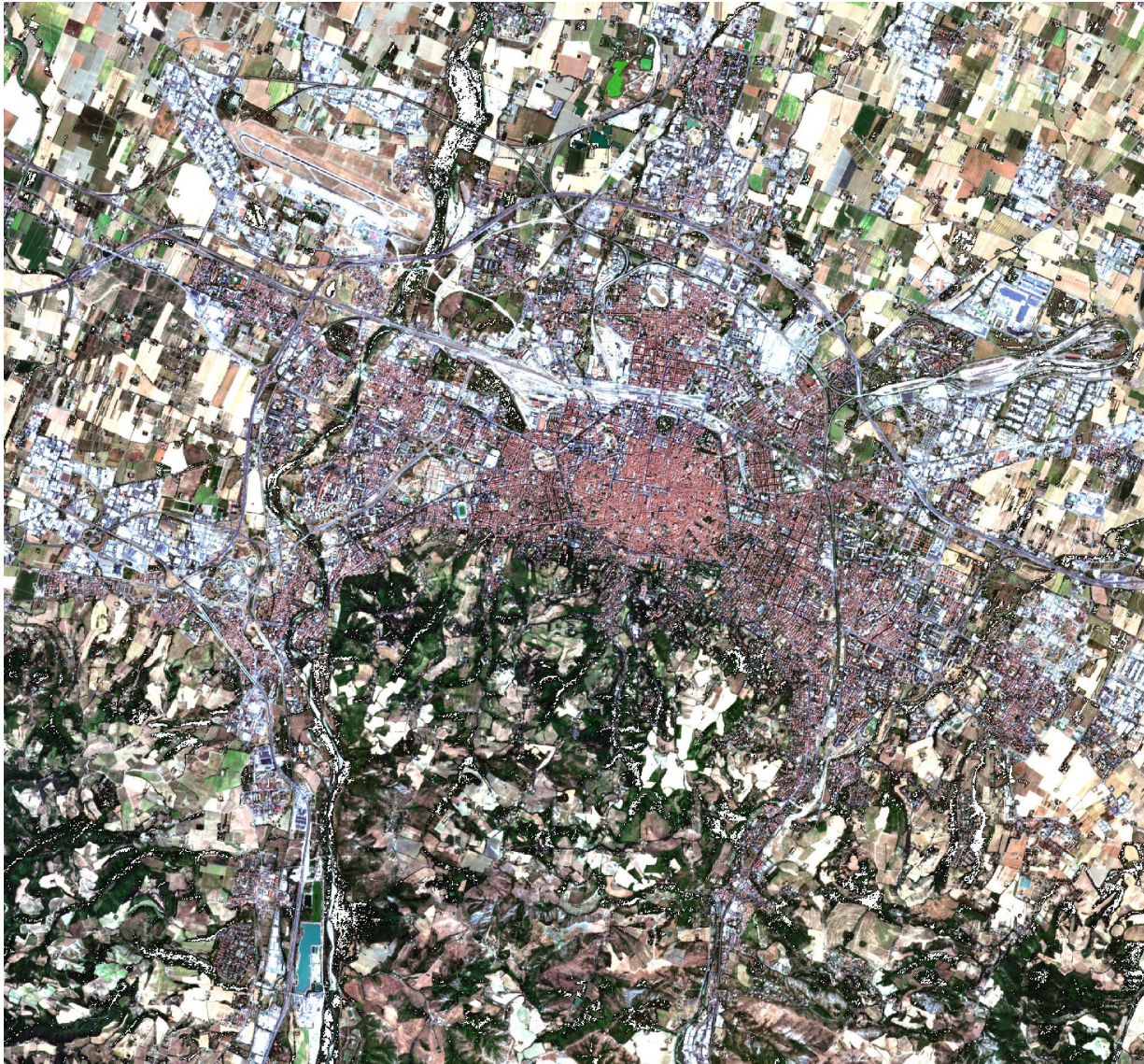
⑥ Rome

Testing the theory with data

Satellite images
→ proxy for diversity of land use and small block sizes

Mobile phone internet density
→ proxy for vitality

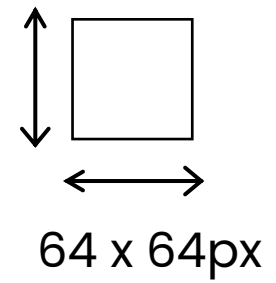
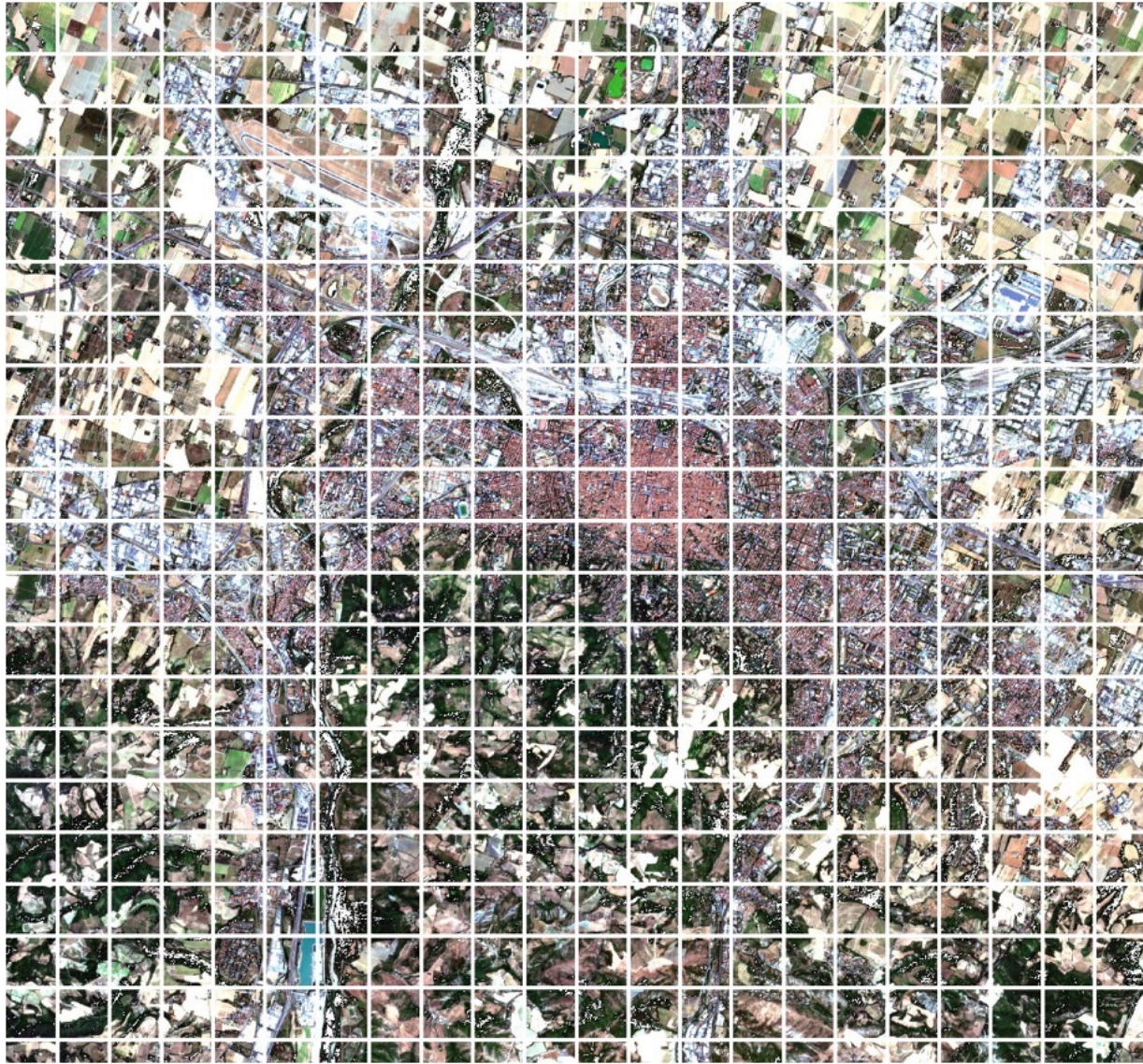
Empirical framework



□
1px → 10m

- ① Download a Sentinel-2 satellite image

Empirical framework



② Crop it into small images (imagelets)

Empirical framework



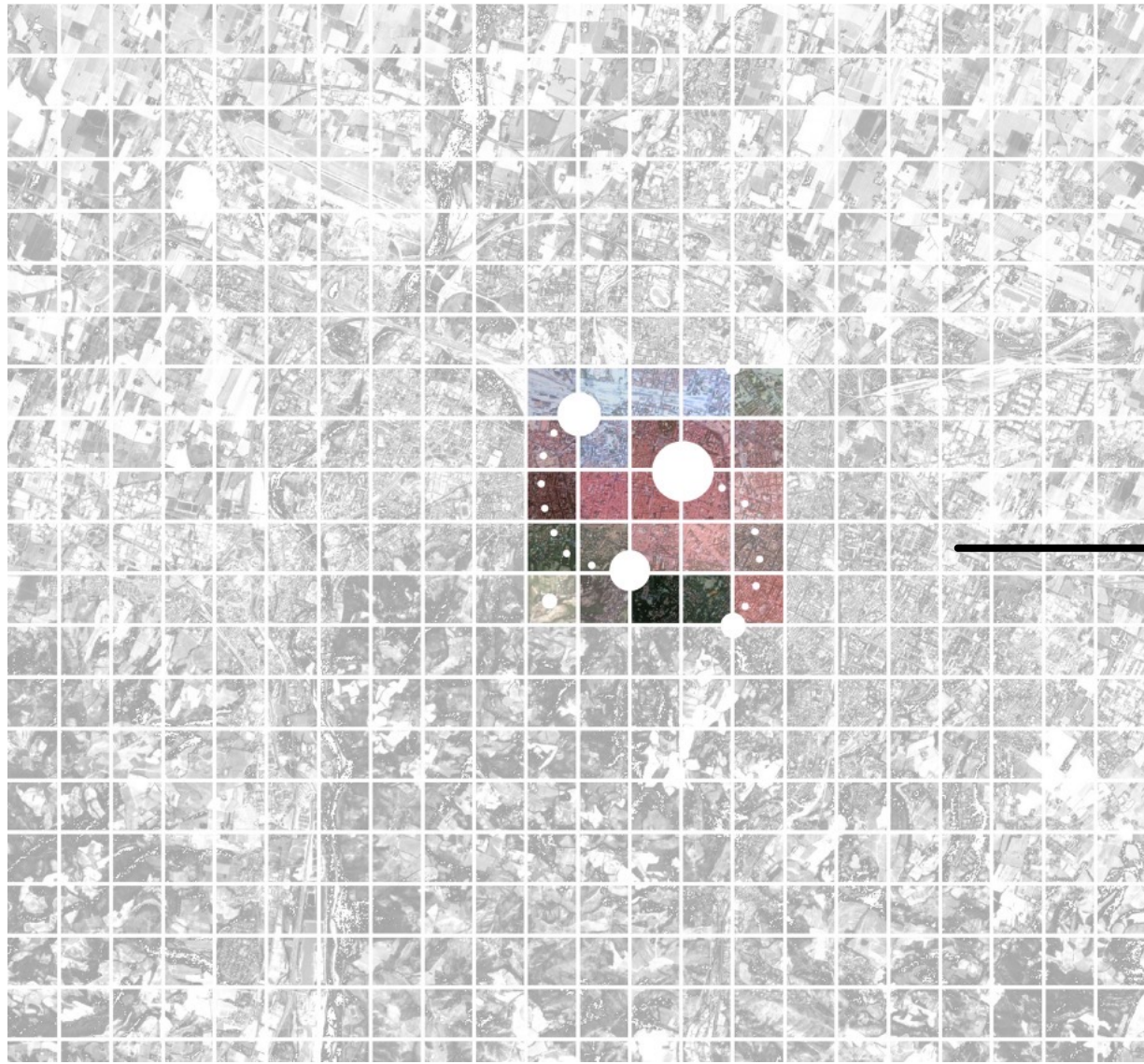
Feature
Extractor



PCA

- 3 Extract visual features from these imagelets with deep learning methods

Empirical framework



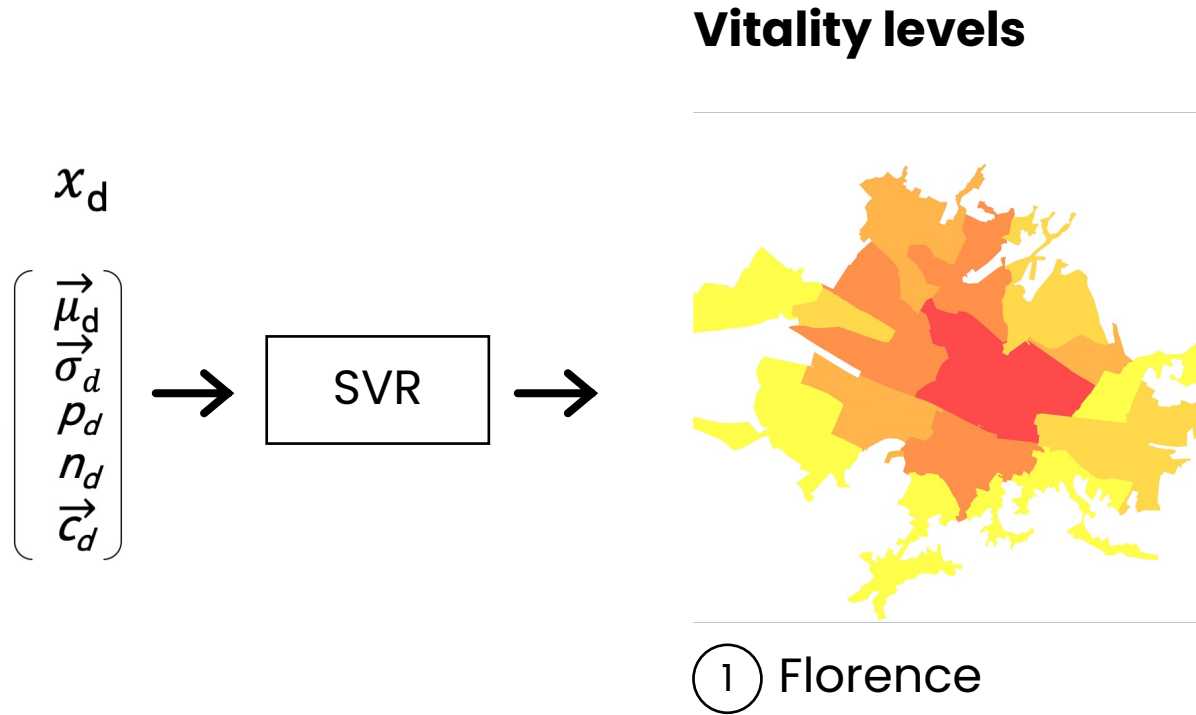
$$\begin{pmatrix} v_{i1} \\ v_{i2} \\ \vdots \\ v_{in_d} \end{pmatrix}$$



$$x_d \begin{pmatrix} \mu_d \\ \sigma_d \\ p_d \\ n_d \\ c_d \end{pmatrix}$$

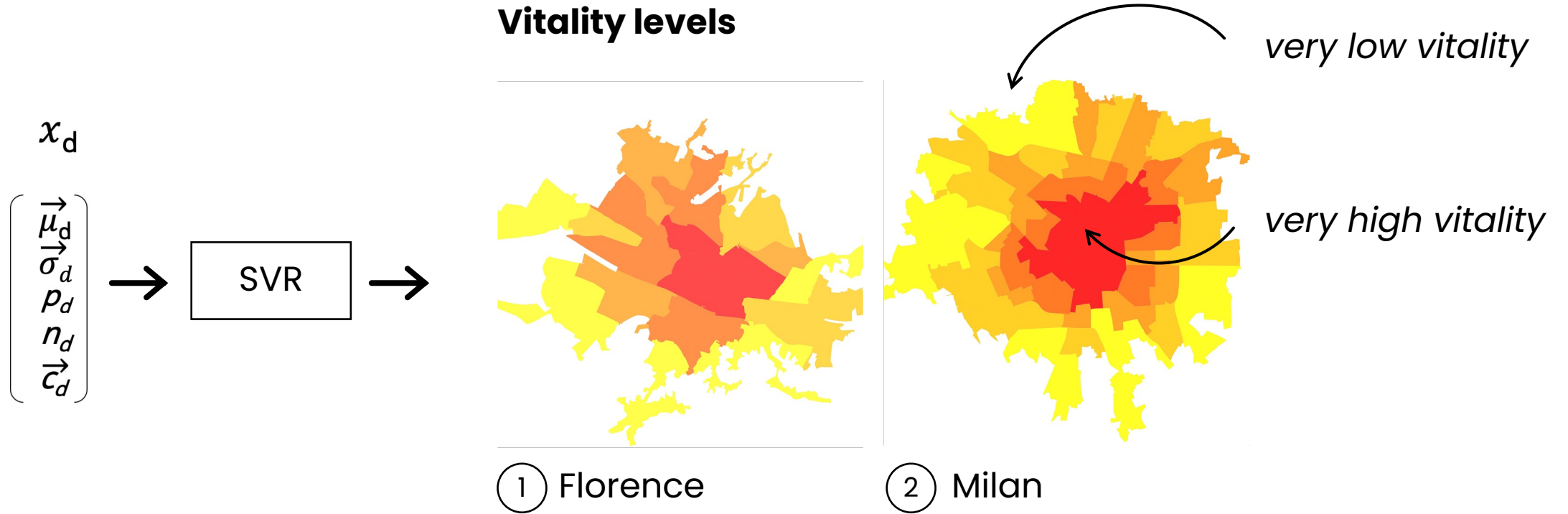
④ Combine visual features into district-level feature vectors

Empirical framework



- ⑤ Predict vitality levels as proxied by mobile phone internet density

Empirical framework



- ⑤ Predict vitality levels as proxied by mobile phone internet density

Navigating design constraints



I have six satellite images and six vector choropleth maps



...but the images are pixelated.

Navigating design constraints



I have six satellite images and six vector choropleth maps

I cannot increase their resolution

...but you can hide them behind other visualization and show on demand.



...but the images are pixelated.

Navigating design constraints



I have six satellite images and six vector choropleth maps

I cannot increase their resolution

I should show how vitality levels vary across one city



...but the images are pixelated.

...but you can hide them behind other visualization and show on demand.

...but it would be great to compare the vitality levels between the cities.

Visualizing Satellite Data

Design choices inspired by cartography...

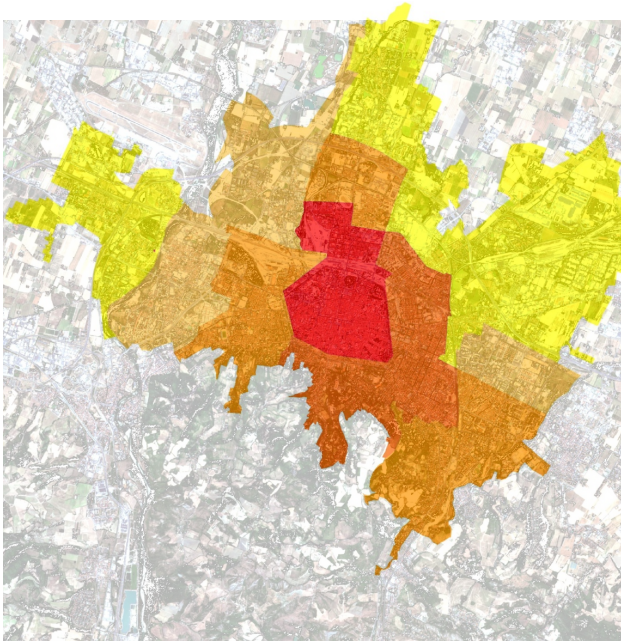


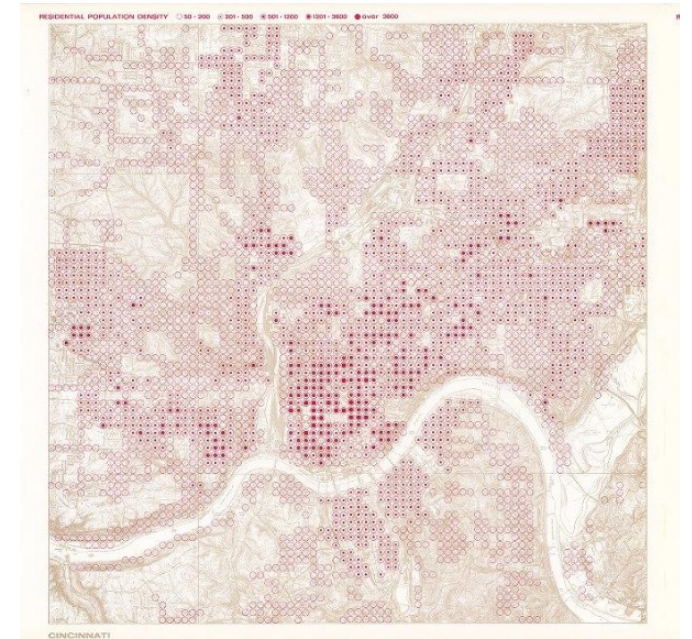
Image maps

Christian Murphy, 2014



Dot grid map

Jacques Bertin, 1967



Dot grid map

Richard Saul Wurman,
Joseph R. Passonneau, 1966

...and art...



Solar Diary, Needle Park

Gene Davis, 1972

Jacob Marrel, c. 1637 - 1645



Color DNAs

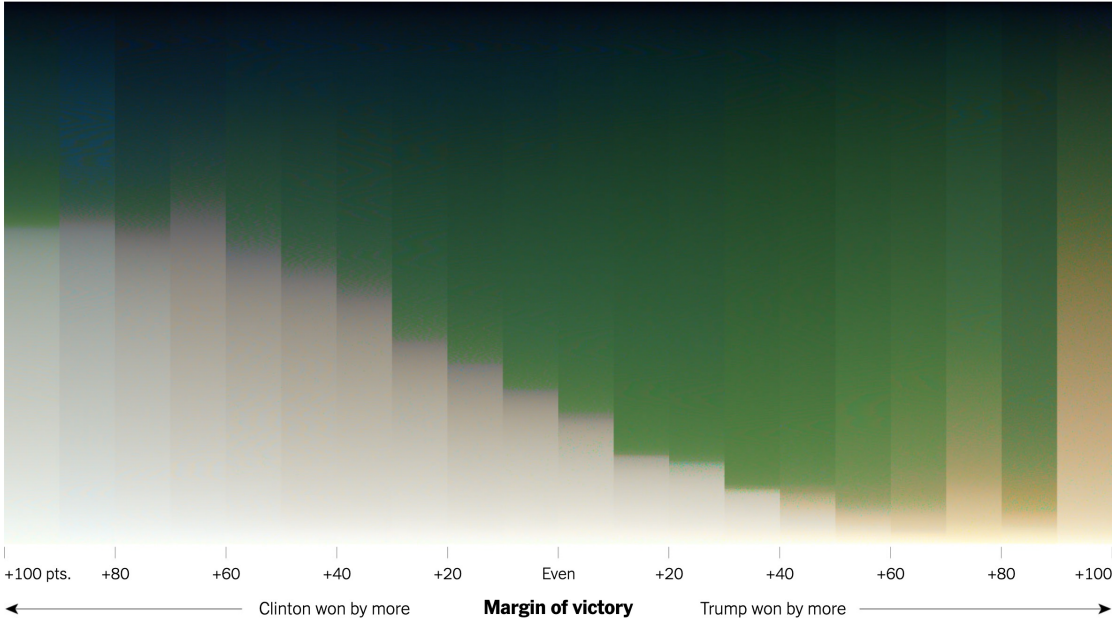
Irma Boom, 2004

Jacob Marrel, c. 1637 - 1645

...and journalism



The Colors of Clinton and Trump Precincts



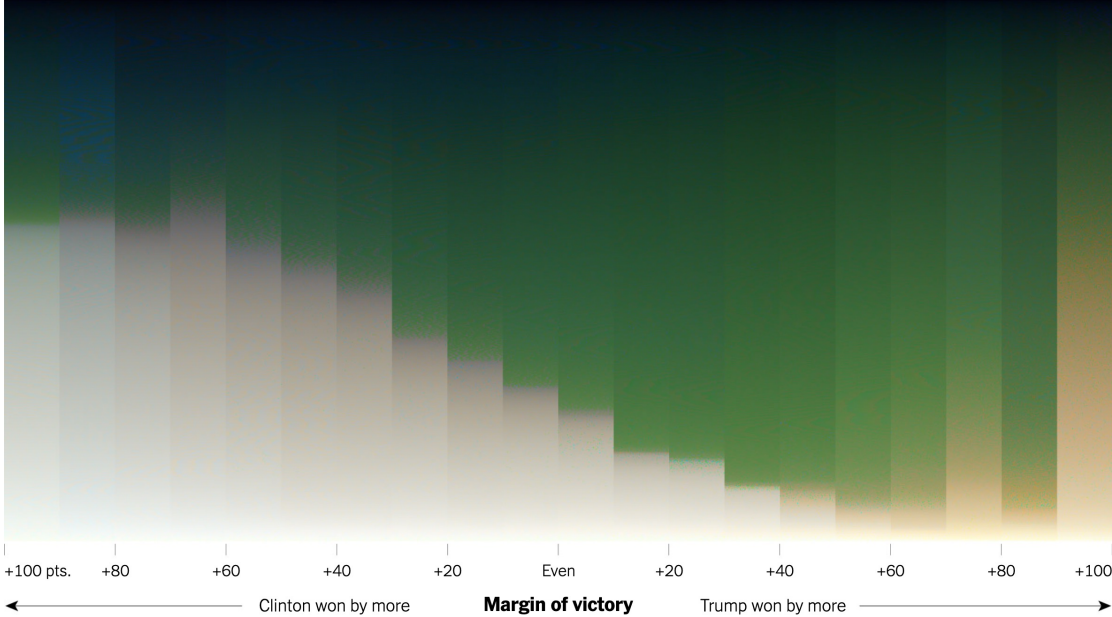
The True Colors of America's Political Spectrum Are Gray and Green

Tim Wallace, Krishna Karra, 2020

...and journalism



The Colors of Clinton and Trump Precincts



The True Colors of America's Political Spectrum Are Gray and Green

Tim Wallace, Krishna Karra, 2020

• The most frequent 100,000 colors for each voter margin class were sorted by luminance, from least to most bright.

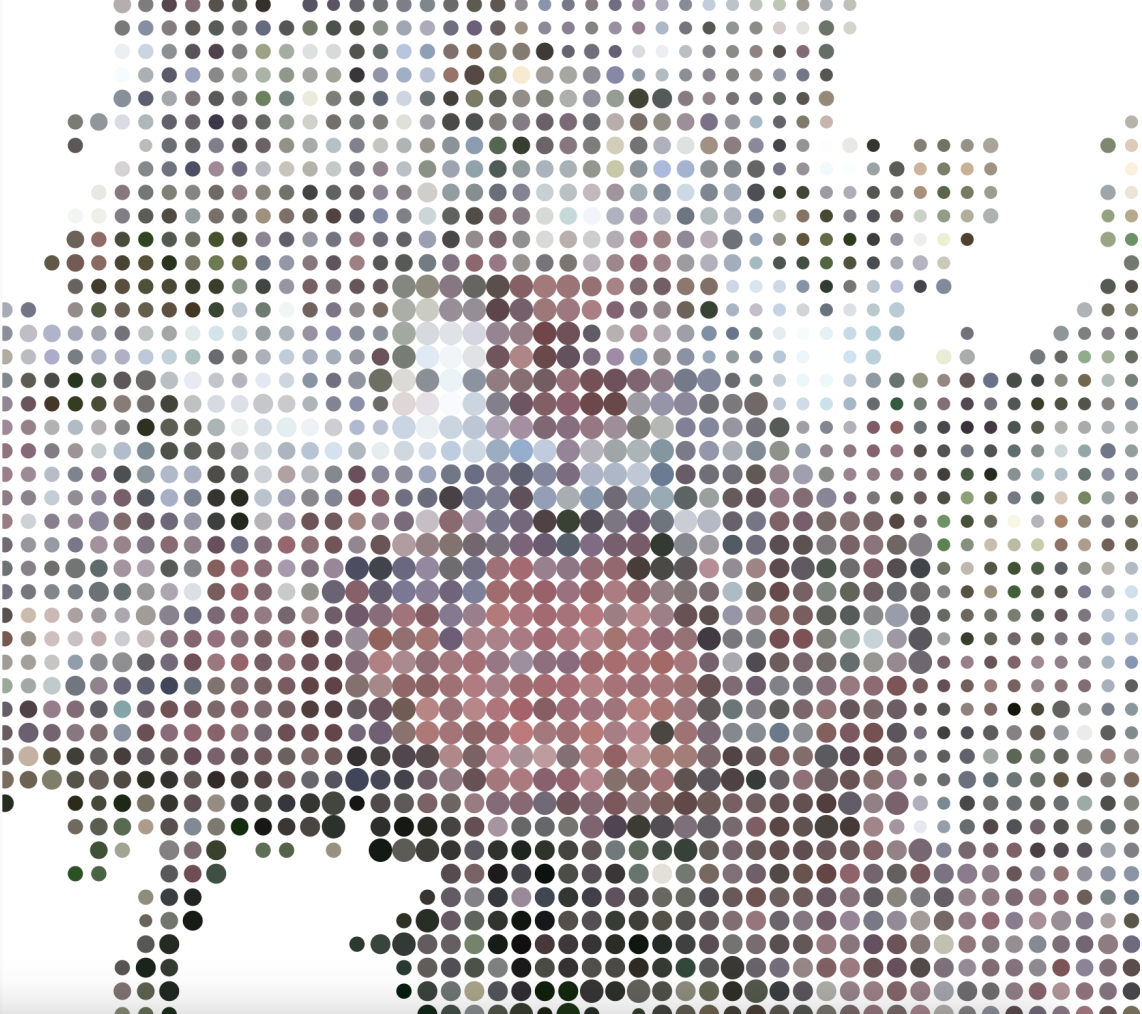
Prototype in p5.js

p5* File Edit Sketch Help English Log in or Sign up

Auto-refresh Color palette generator - pointilism by e.p.bogucka

```
sketch.js
1 /* Export SVG - this code extension will export an SVG file from canvas to your download folder.
2 It is required to add the p5.svg.js in project folder and in index.html
3 Documentation: see https://github.com/zenozeng/p5.js-svg
4 */
5
6 let img; // initialize variable for image
7 let table;
8
9 function preload() {
10   img = loadImage('bologna-background-square-pixelate.jpg');
11   var1 = loadImage('bologna-vitality-square.jpg'); // preload the image - variable name of your image
12 }
13
14 function setup() {
15   createCanvas(img.width, img.height, SVG); // set SVG canvas size the same as image size
16   //image(img,0,0); // draw an image to the p5.js canvas
17   //filter(GRAY);
18   imageMode(CENTER);
19   noStroke();
20   img.loadPixels(); // loads the pixel data for the display window into the pixels [] array
21   var1.loadPixels();
22   table = new p5.Table();
23   table.addColumn('id');
24   table.addColumn('size');
25   table.addColumn('color_R');
26   table.addColumn('color_G');
27   table.addColumn('color_B');
28   table.addColumn('color_A');
29 }
30
31 function draw(){
32   fill(255,255,255);
33   rect(0,0,img.width, img.height)
34   let iterateSize = 24;
35   let spacing = 2;
36
37   // we are increasing x - position, but at a particular y level.
38   for(var y = 0; y < img.height; y += iterateSize) { // y's will be our outer for loop
39     for(var x = 0; x < img.width; x += iterateSize) { // x's are our inner loop
40       var vitalityClass;
41       let vitalityScore = var1.get(x, y)
42       let pixelSize = iterateSize;
43
44       //print(vitalityScore)
45       pixelColor = img.get(x, y) // fetch pixel color in the the row
46       fill(pixelColor); // apply fill from the fetched pixel color
47     }
48   }
49 }
50
```

Preview



Console

Saved svg color palette

Prototype in p5.js

p5* File Edit Sketch Help English Log in or Sign up

Auto-refresh Color palette generator - pointilism by e.p.bogucka

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sketch.js
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```

Preview

color management

improve contrast

improve lightness

Console Clear

Saved svg color palette

Roof color swatches



Bologna



Florence



Palermo



Rome



Milano



Torino

Residential areas



Bologna



Milano



Torino



Florence



Palermo



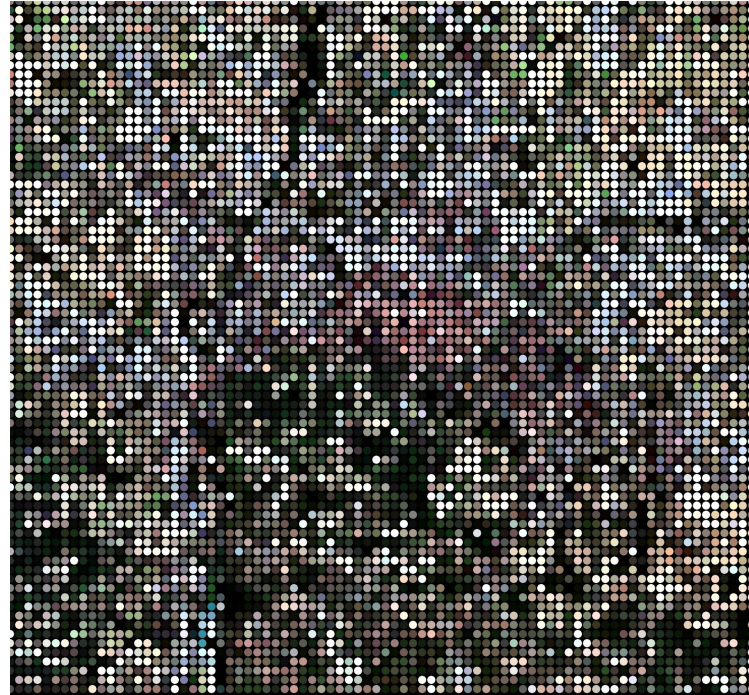
Rome

Industrial zones

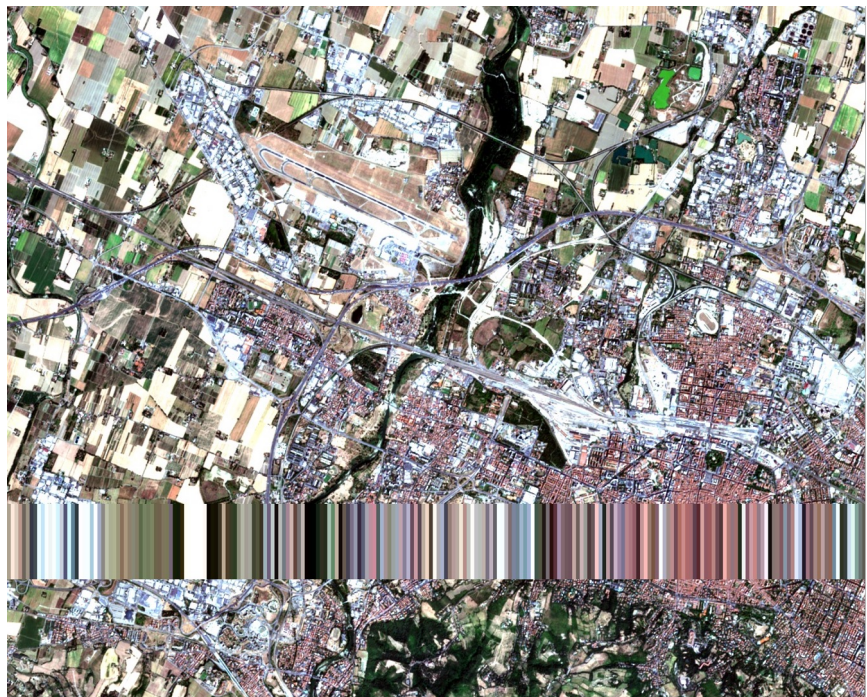
Dot grid map



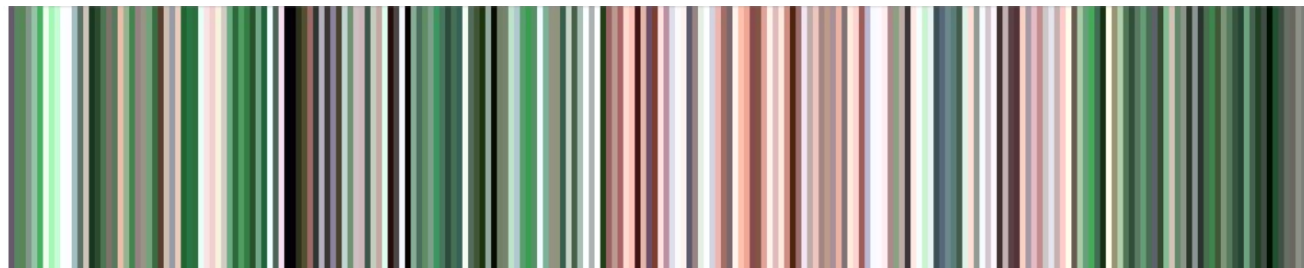
Bologna



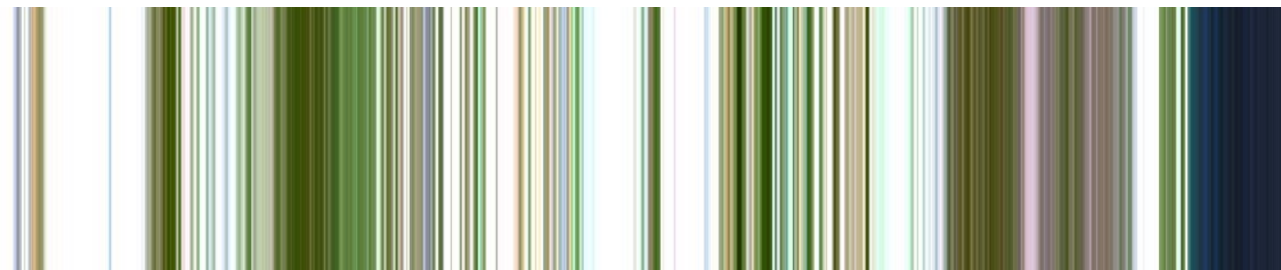
Color DNA



Bologna

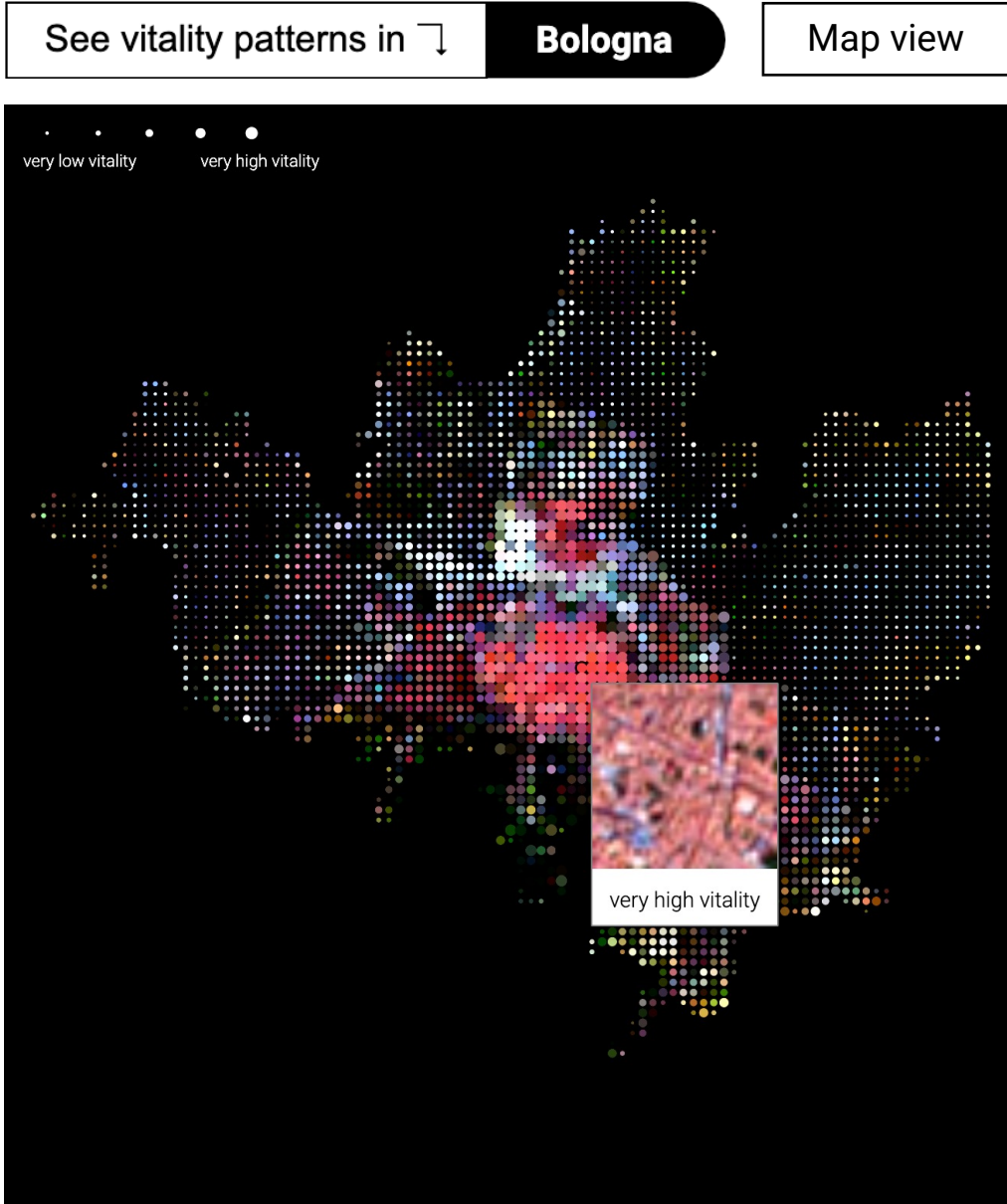


Florence



Palermo

Dot grid maps ●●●

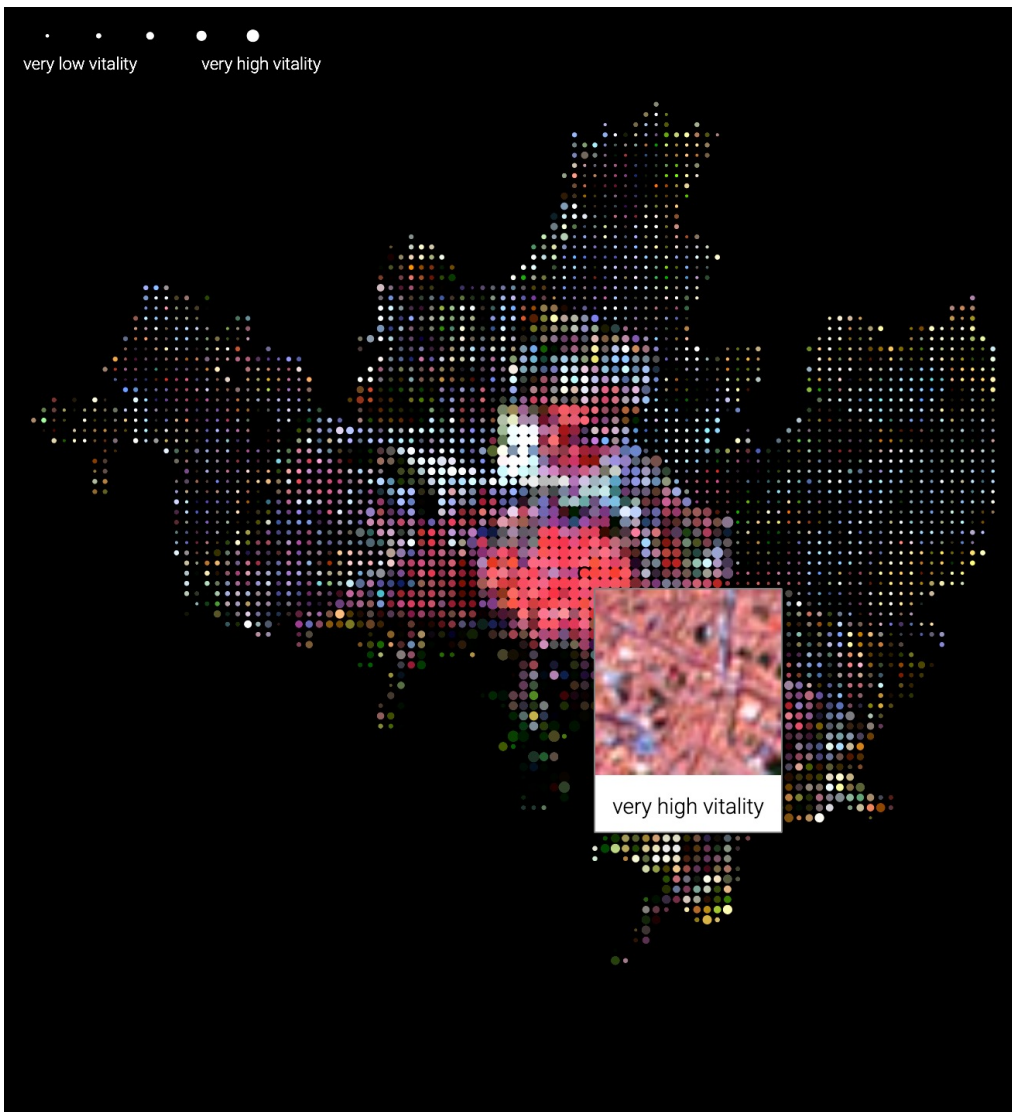


Dot grid maps ●●●

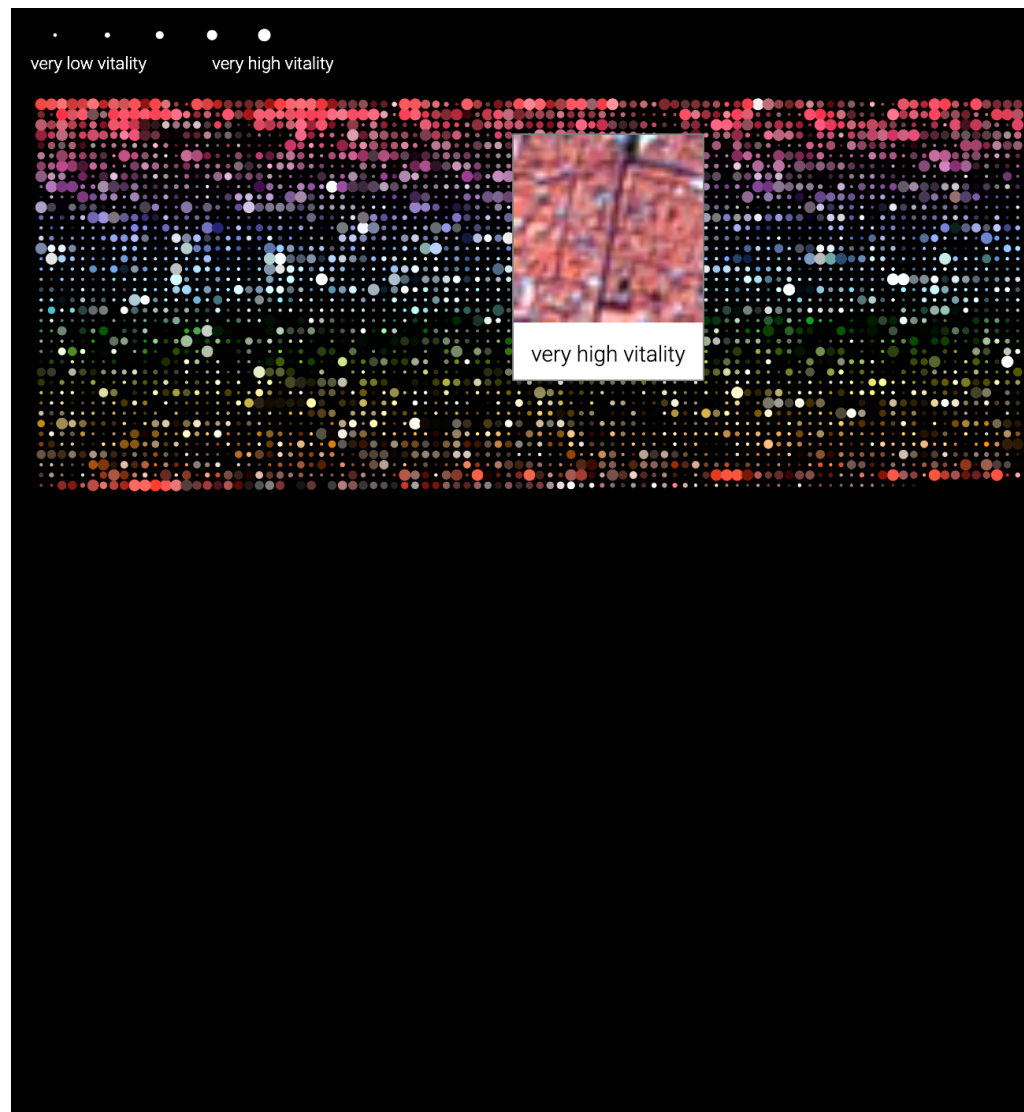
See vitality patterns in ↴

Bologna

Map view



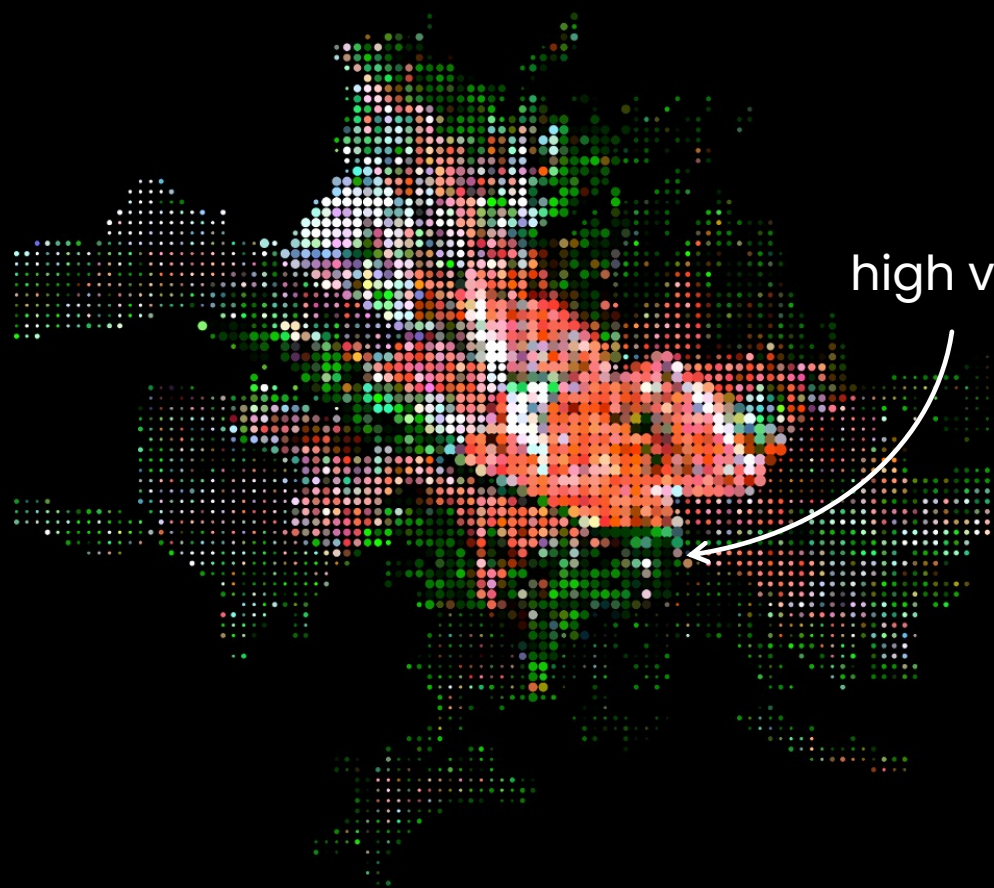
Color grid view



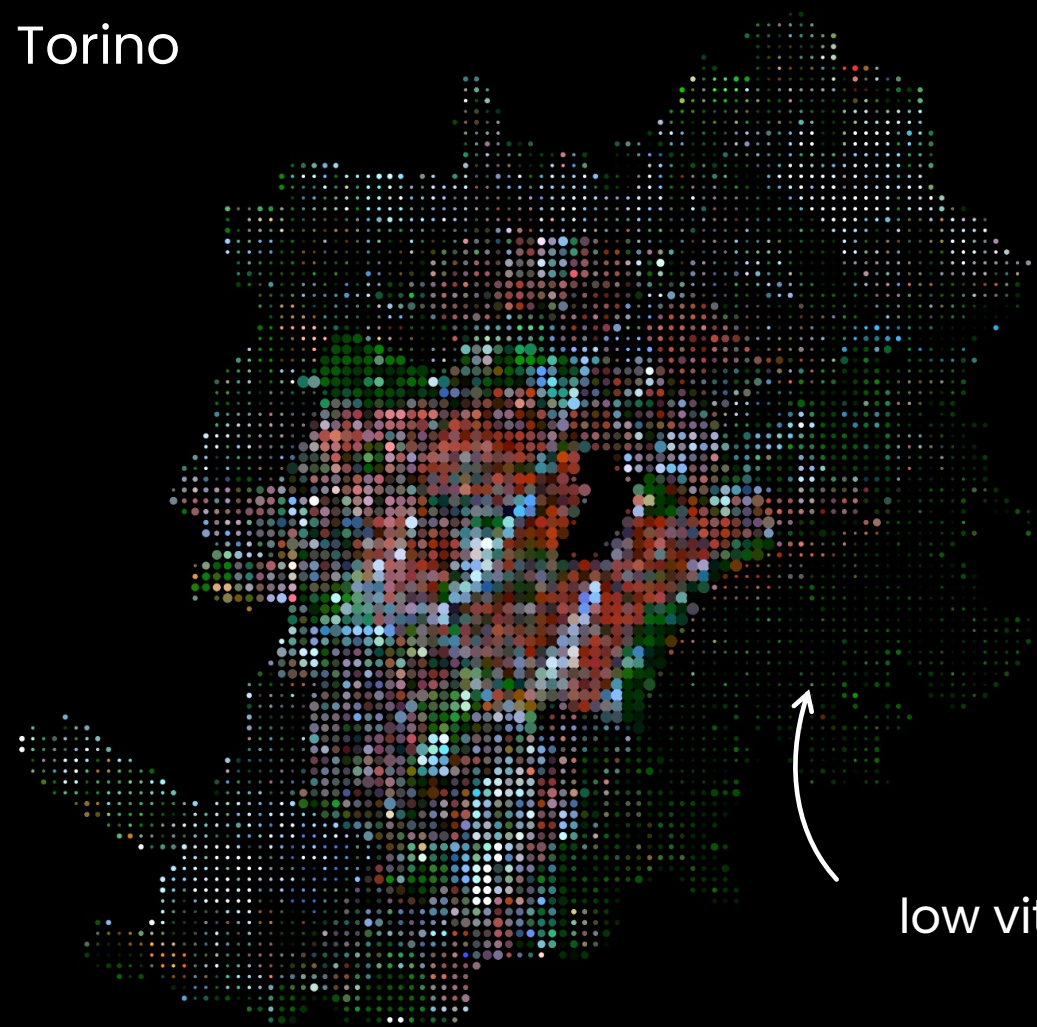
Roofs versus greenery

Florence

Torino

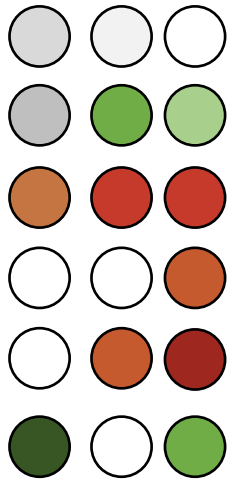


high vitality



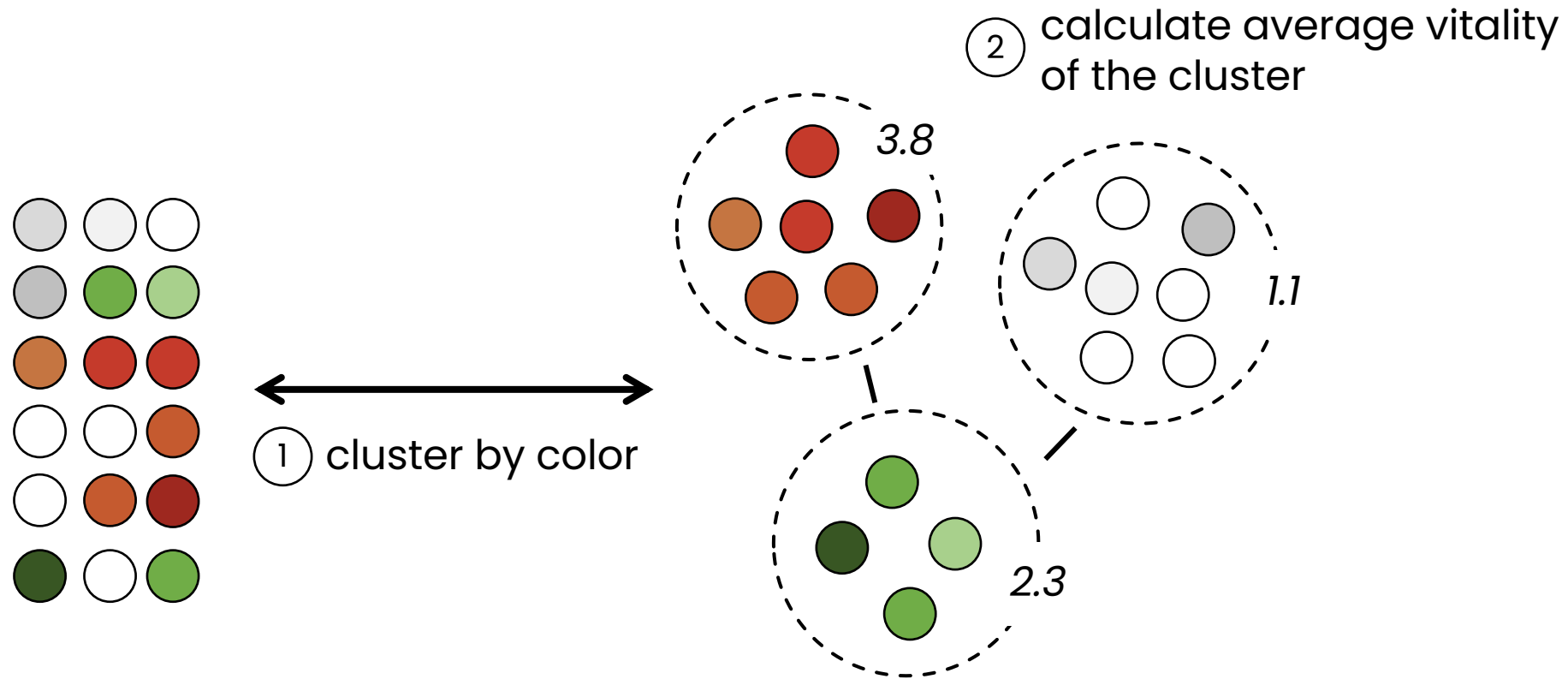
low vitality

From points to color DNAs

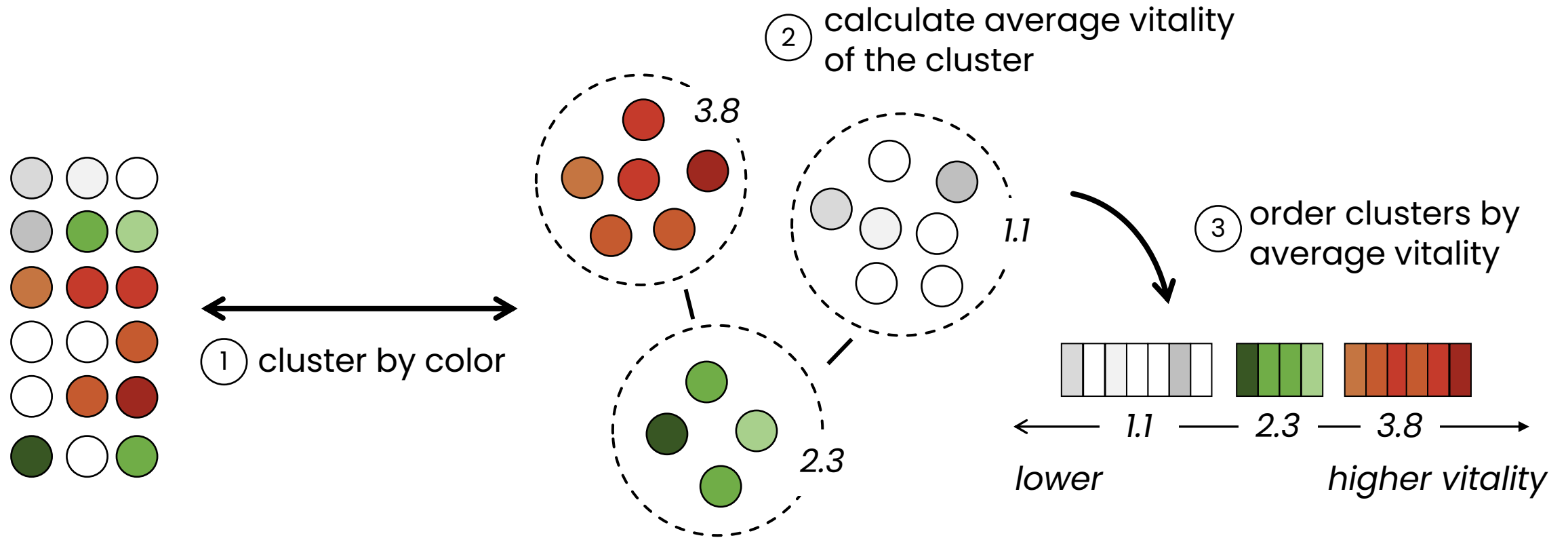


① cluster by color

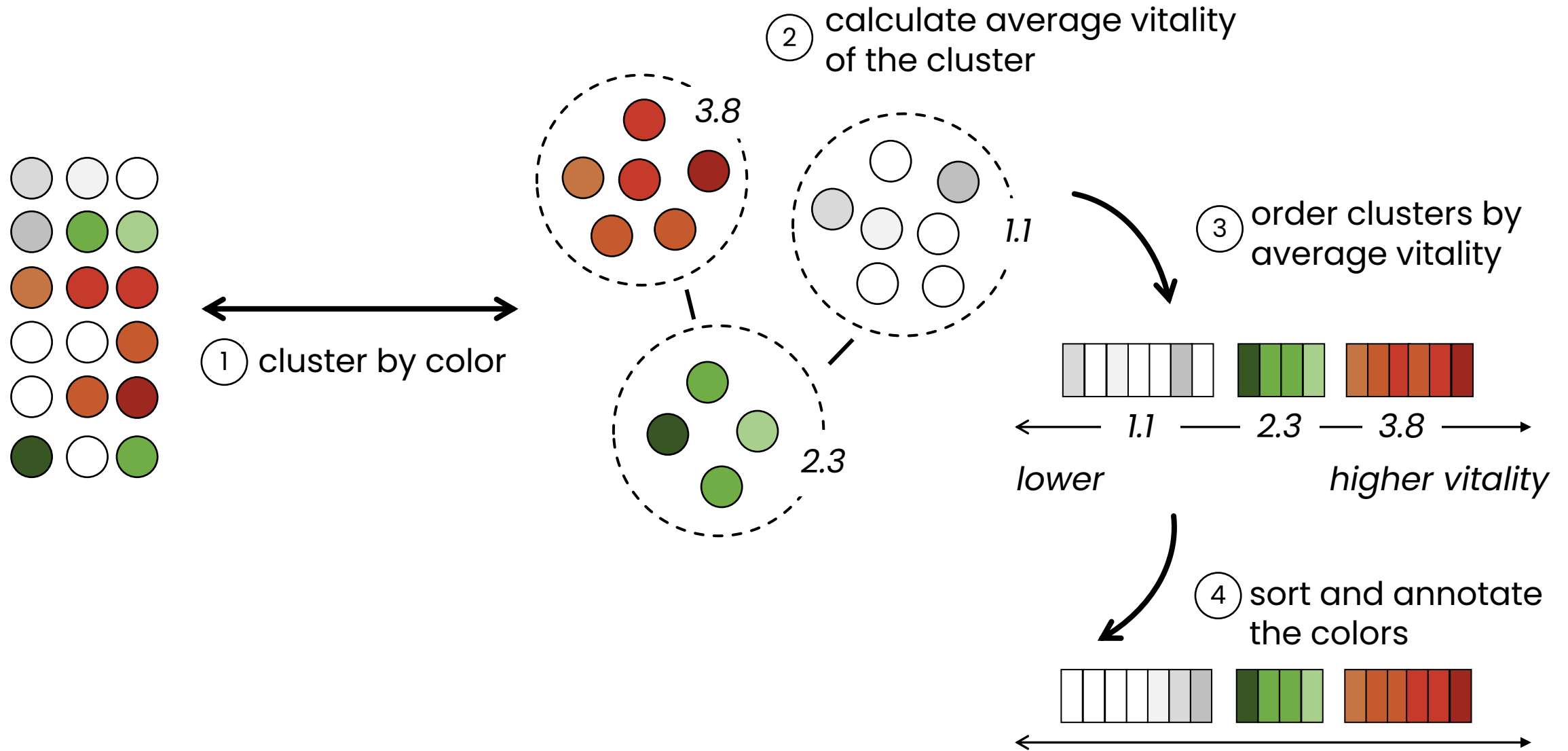
From points to color DNAs



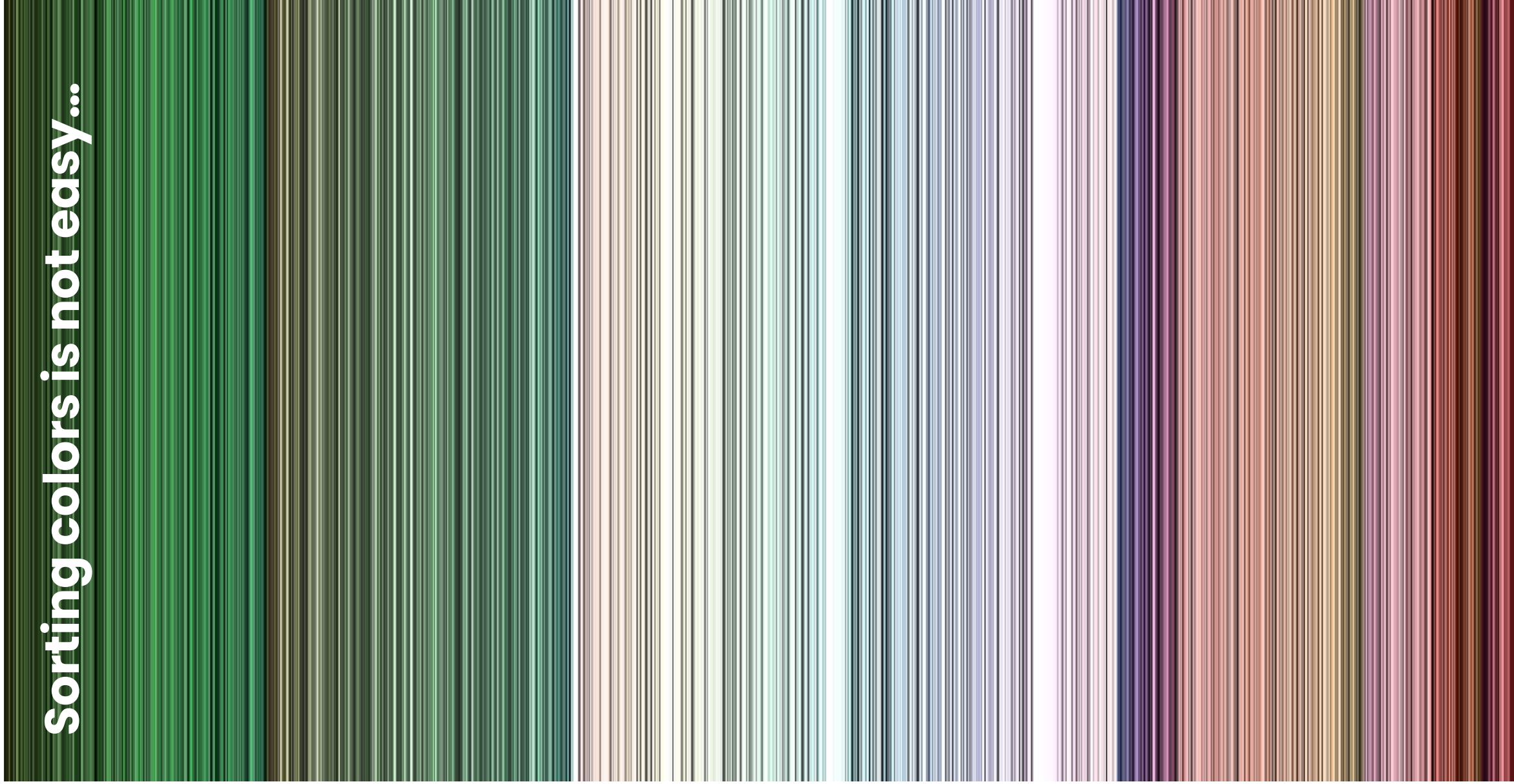
From points to color DNAs



From points to color DNAs



Sorting colors is not easy...





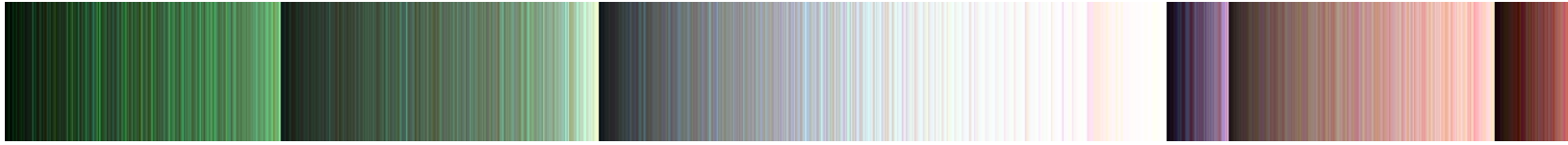
raw data



Florence



raw data



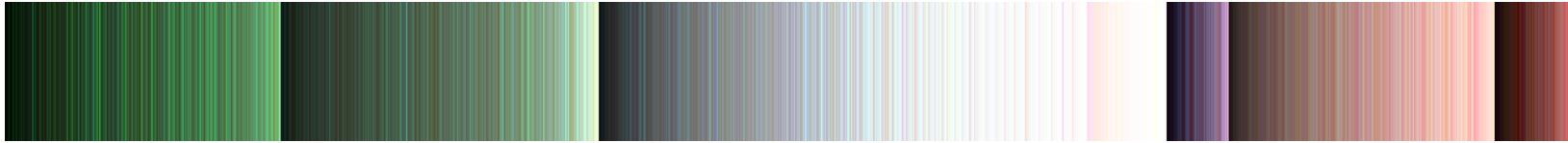
simple sort by hue



Florence



raw data



simple sort by hue



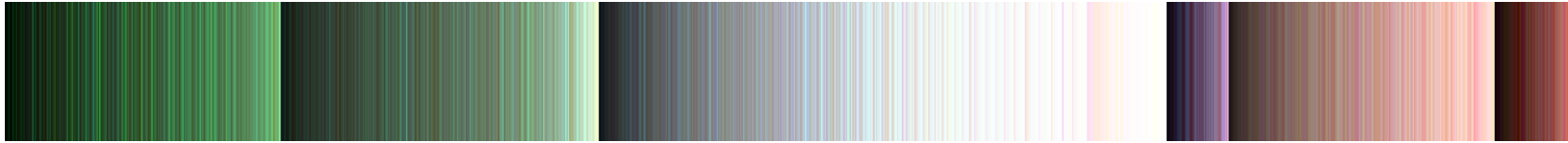
sort by luminosity



Florence



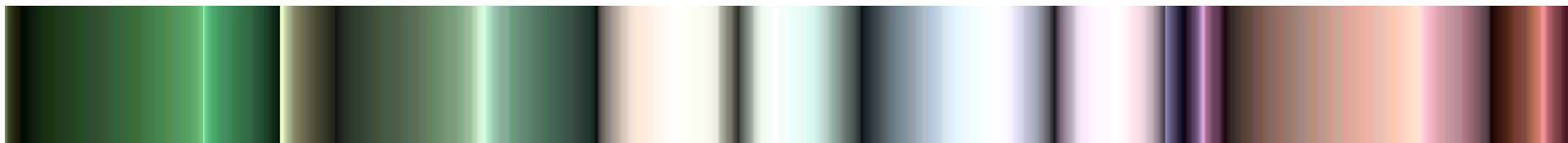
raw data



simple sort by hue



sort by luminosity



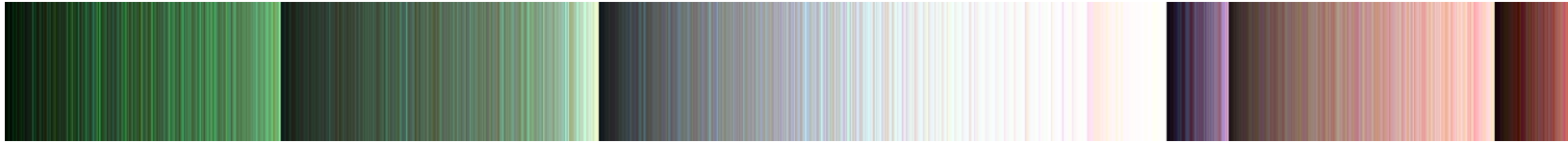
sort by hue and luminosity



Florence



raw data



simple sort by hue



sort by luminosity



sort by hue and luminosity



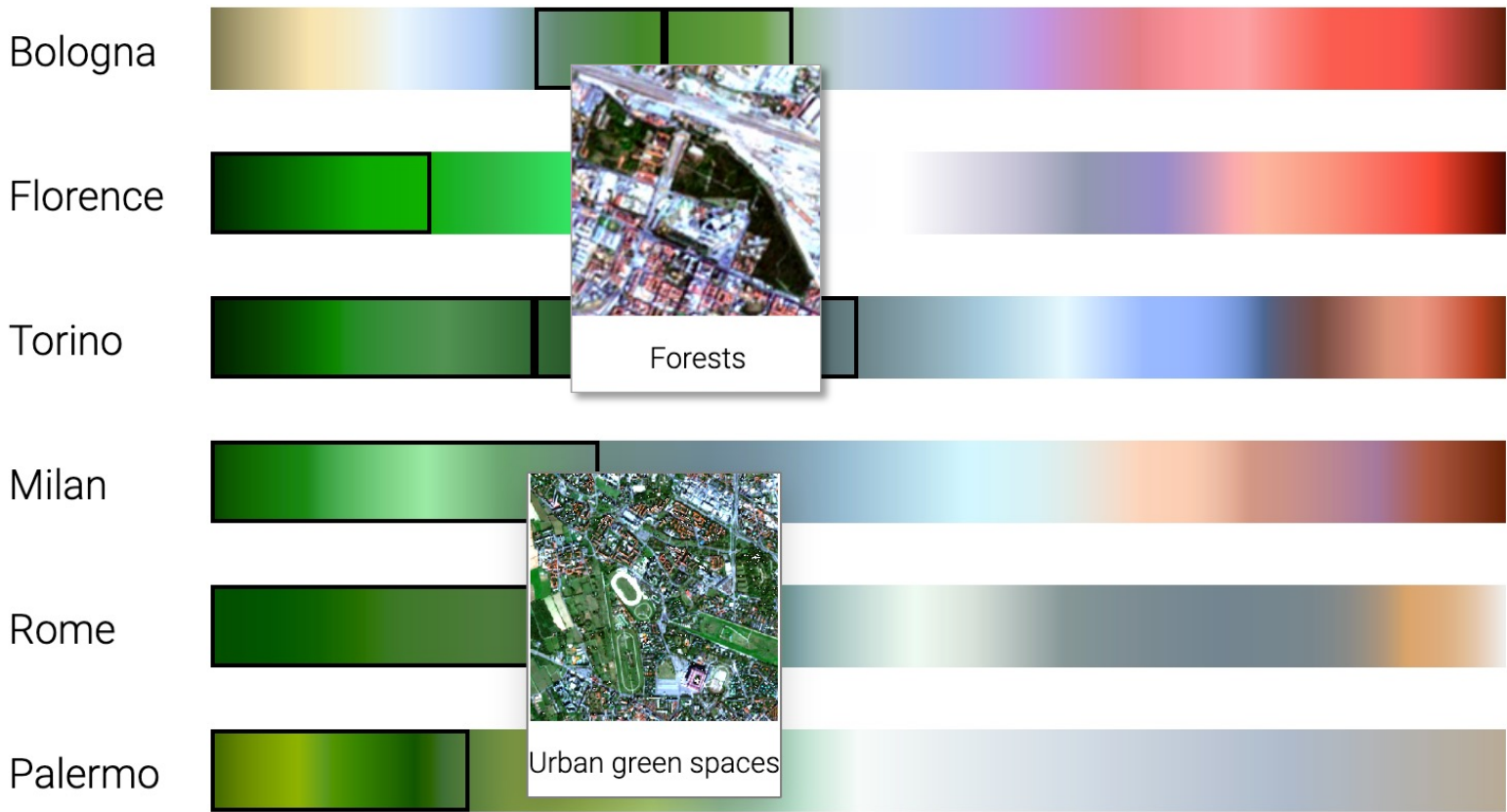
interpolate gradients, raise contrast



Florence

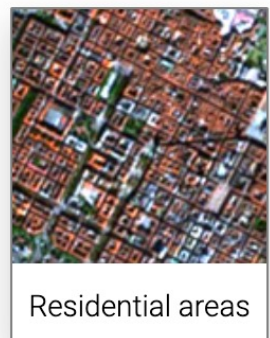
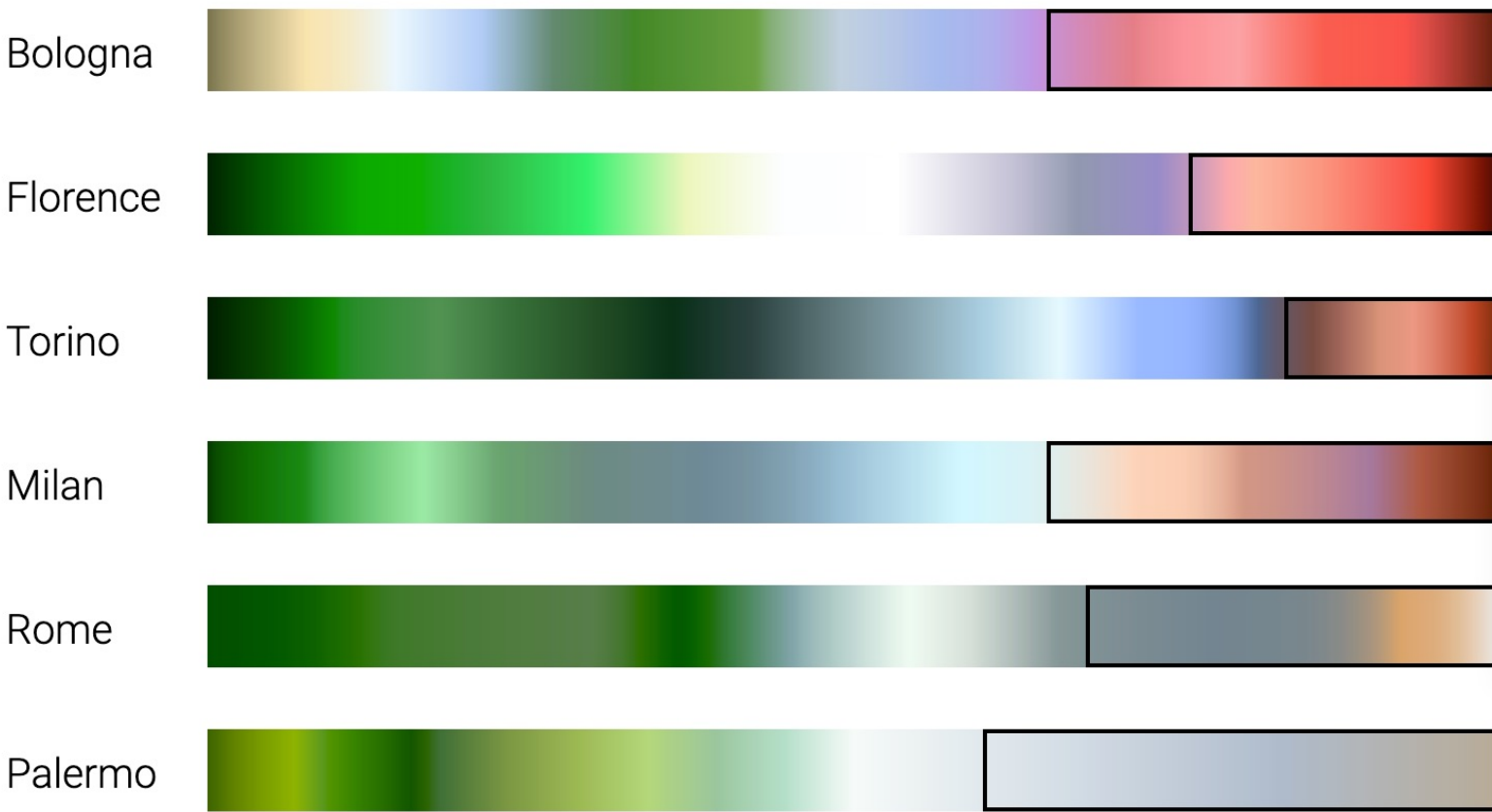
Color DNAs

- Residential areas
- Industrial zones
- Roads and transport
- Urban green spaces
- Forests
- Orchards
- Farmland



Color DNAs

- Residential areas
- Industrial zones
- Roads and transport
- Urban green spaces
- Forests
- Orchards
- Farmland



Survey with 27 Earth Observation Experts from 11 countries

96%

of Earth Observation experts could not name similar visualizations in their field

Eliciting trust and transparency

The connection to real satellite images is constantly given.

Crafting delightful metaphors

The DNA concept serving as the "signature" for a place is neat.

I loved the multiple interactive methods used. I want to combine scrolly-telling with other non-scrolling animated visualizations in my future projects.

We use image data to...

- ① test theories with empirical studies at scale

If scaled across the world, our method could help to uncover subtleties in how vitality is expressed across different natural and cultural environments and extend the theory

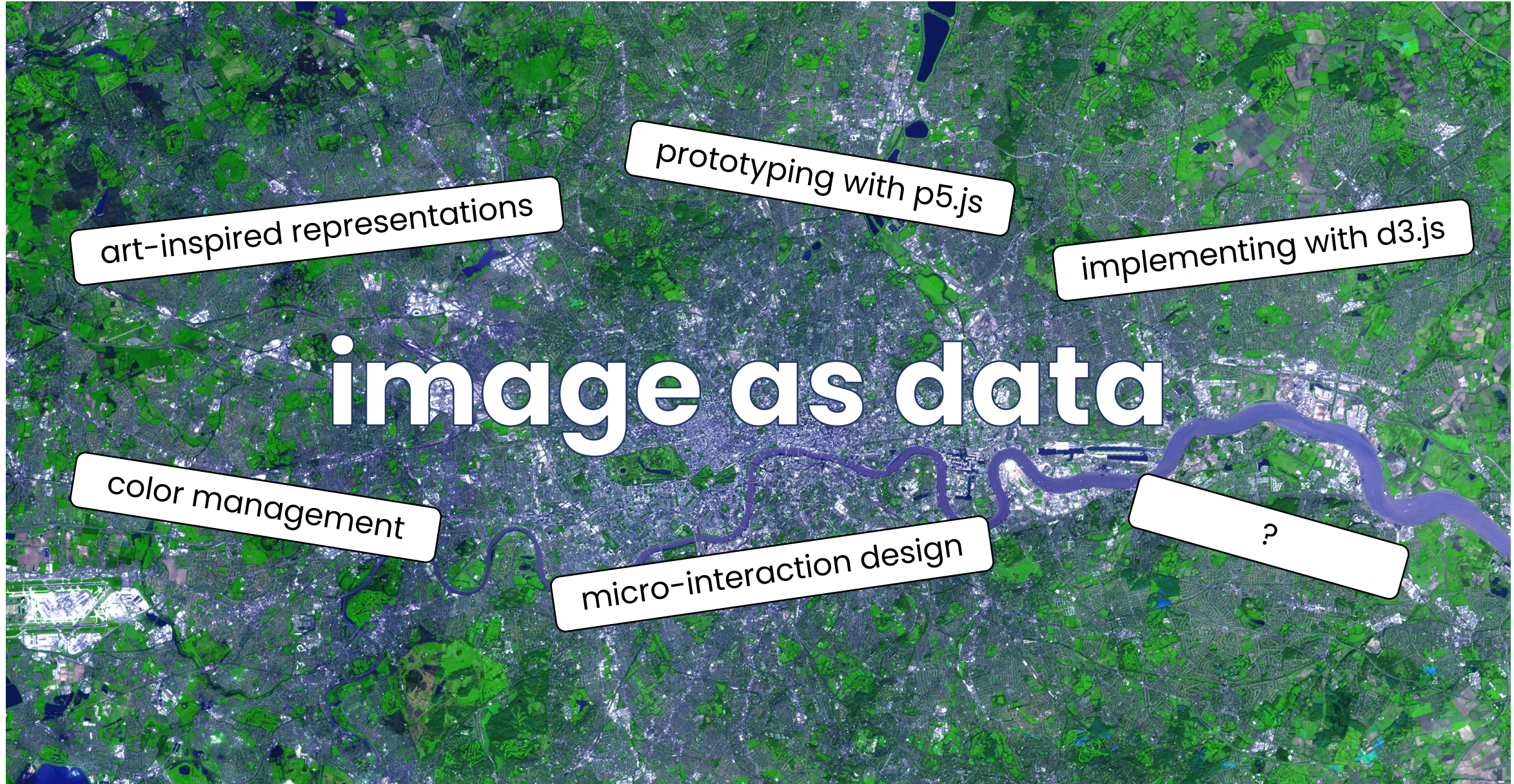
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② develop new data visualization methods

Combining traditional cartographic approaches with new EO data for engaging presentation of Digital Earth



art-inspired representations

prototyping with p5.js

implementing with d3.js

image as data

color management

micro-interaction design

?

What are the connections between the vitality levels, unique city features and satellite imagelets?

Explore our interactive visual story



www.social-dynamics.net/vitality

NOKIA
BELL
LABS

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24 October 2023 | @LondonDataVis