

AI IN THE BUILT ENVIRONMENT

DCP4300

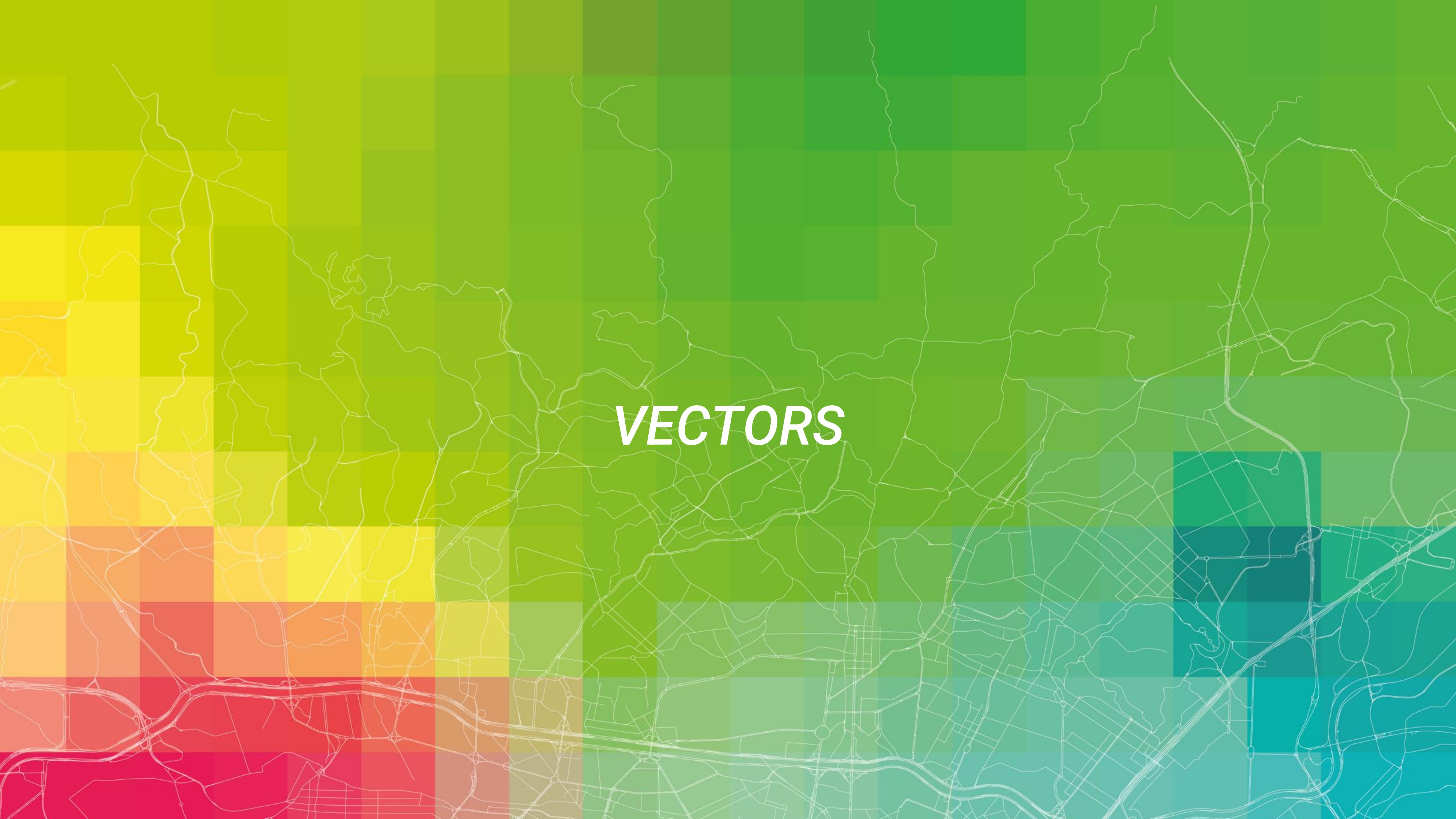
University of Florida
College of Design Construction and Planning

Professors:
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Dr. Charles Wang

TA:

Mobina Noorani
Jianhao Gao

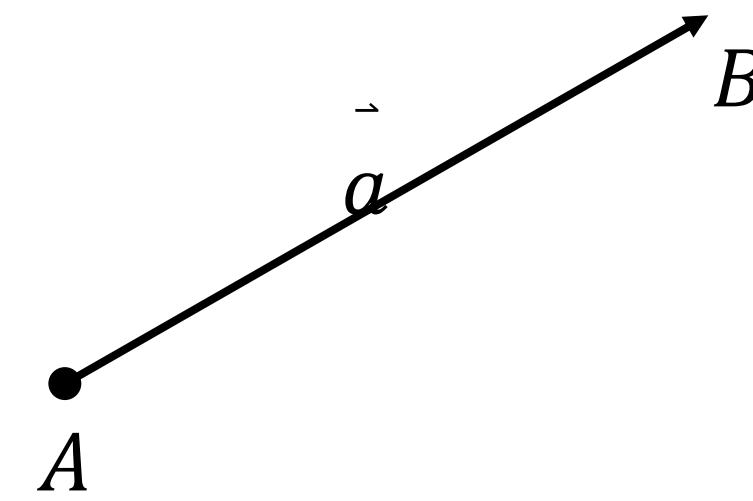




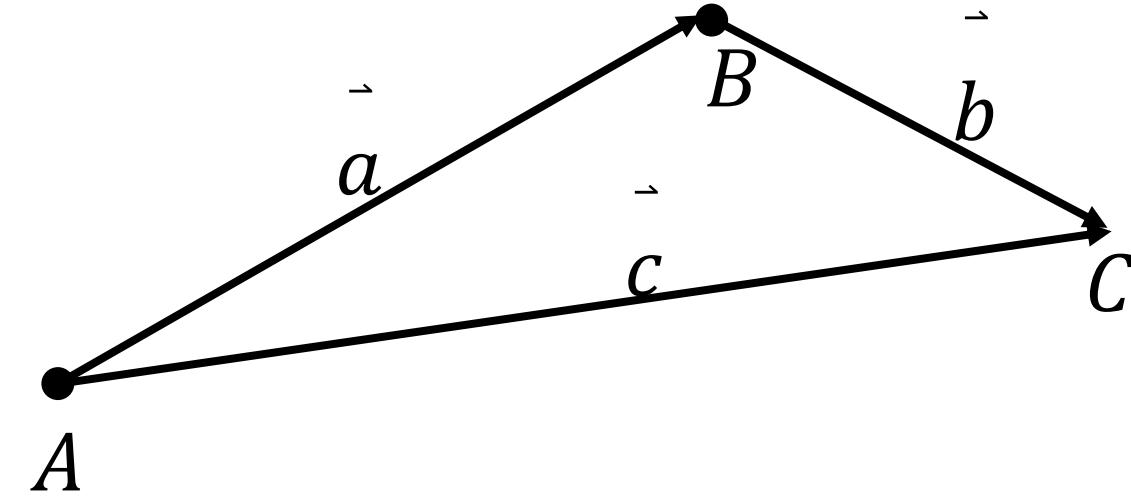
VECTORS

WHAT ARE VECTORS

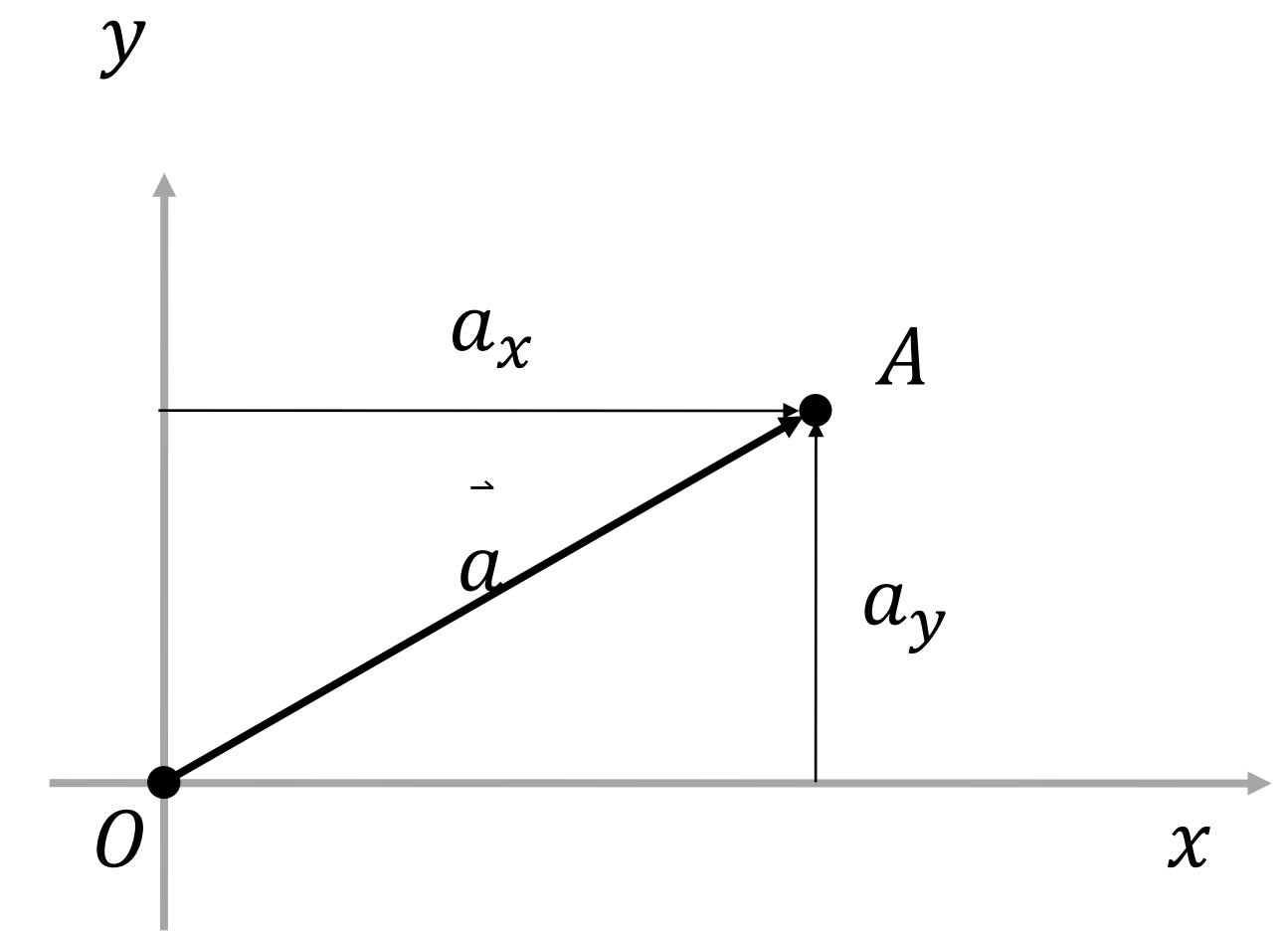
Vectors in Geometry



A vector pointing from point A to B



Addition and subtraction



Represent the coordinate of a point
in Cartesian coordinate system

Vectors in Algebra

$$\vec{a} = (2,3)$$

An example in 2 dimensions

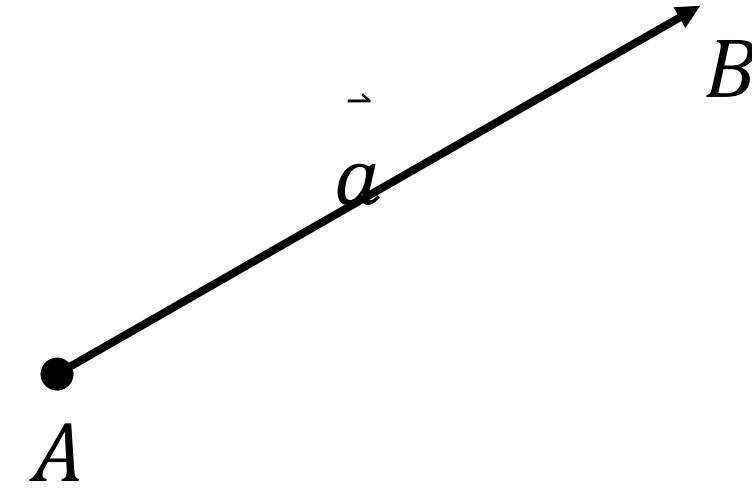
$$\vec{a} = (a_1, a_2, \dots, a_n)$$

Generalize to n-dimensional Euclidean space

Euclidean Distance

Measuring the similarities

$$\|\vec{a}\| = \sqrt{a_1^2 + a_2^2 + \cdots + a_n^2}$$



Magnitude (or length, norm) of a vector

$$\|AB\| = \sqrt{(B_1 - A_1)^2 + (B_2 - A_2)^2 + \cdots + (B_n - A_n)^2} = \|\vec{a}\|$$

FEATURE VECTORS

In the context of machine learning feature vectors are vectors that describe measurable properties of the object

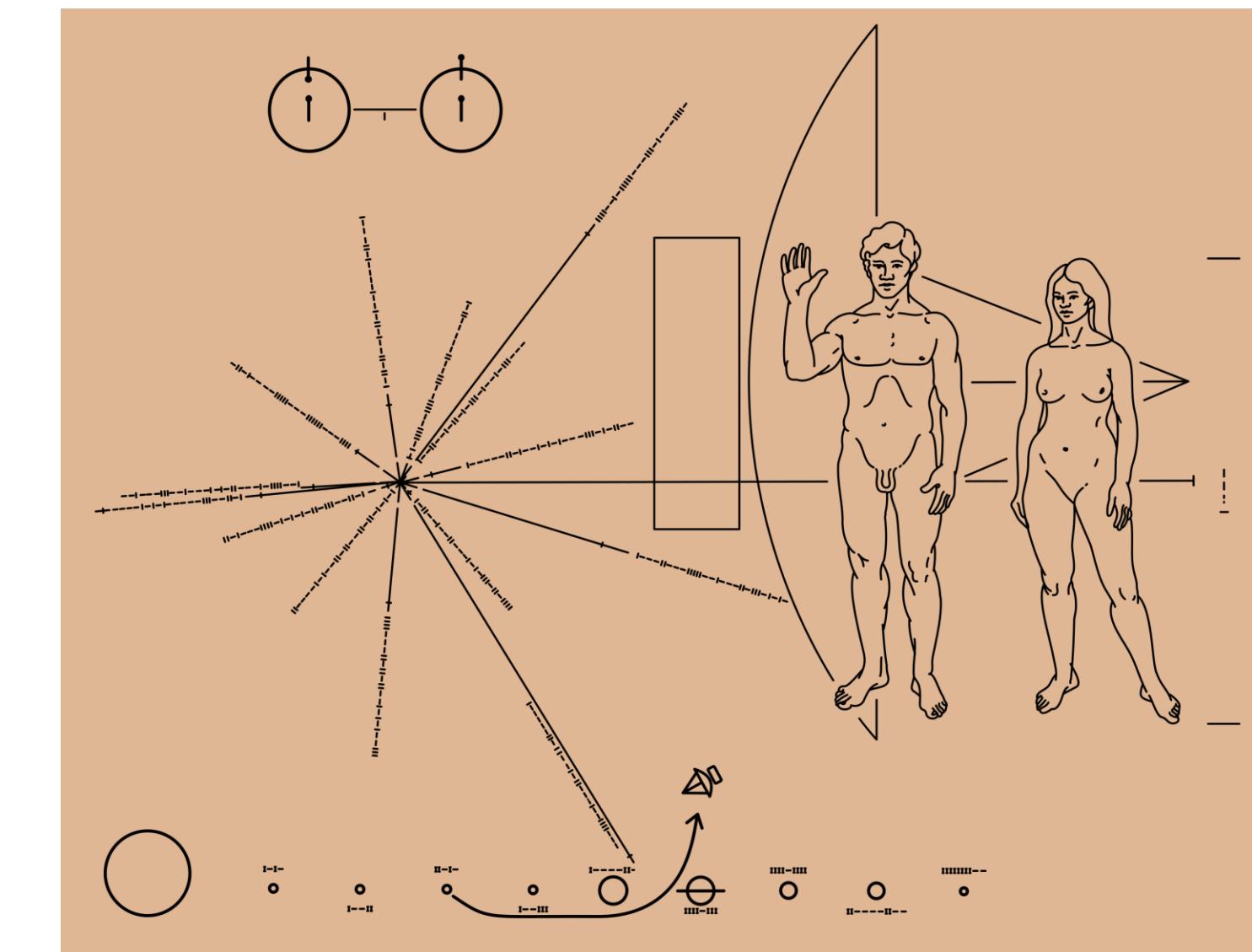
Feature Vector Examples



An apple

(color, size, weight, sweetness)

(0 red, 12.3 cm, 180 g, 2 very)



@Pioneer plaque

A person

(age, weight, height)

(25, 70 kg, 182 cm)

Feature Vector + Euclidean Distance



(color, size, weight, sweetness)
(0 red, 12.3 cm, 180 g, 2 very)

A



(color, size, weight, sweetness)
(1 orange, 11.7 cm, 170 g, 1 yes)

B

$$\|AB\| = \sqrt{(1 - 0)^2 + (11.7 - 12.3)^2 + (170 - 180)^2 + (2 - 1)^2} = 10.1173..$$

Feature Vector + Different Perspective



(color, size, weight, sweetness)

(0 red, 12.3 cm, 180 g, 2 very)



(price, do I like it?)

(0.75 Fr, 1 yes)

FEATURE VECTORS FOR DIGITAL OBJECTS

WHY

Images and texts are already numbers
why do we convert them to some other numbers?

An Example

Comparing different images



?



?



An Example

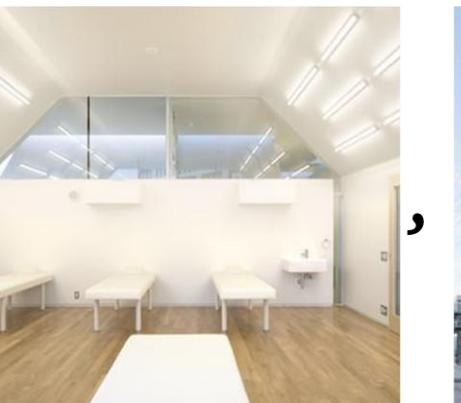
```
CompareTwoImage = EuclideanDistance[  
  Flatten@ImageData@ImageResize[#, {32, 32}],  
  Flatten@ImageData@ImageResize[#, {32, 32}]] &  
  
Out[•]:= EuclideanDistance[Flatten[ImageData[ImageResize[#, {32, 32}]]],  
  Flatten[ImageData[ImageResize[#, {32, 32}]]]] &
```

In[•]:= CompareTwoImage[, ]

Out[•]:= 21.5377

In[•]:= CompareTwoImage[, ]

Out[•]:= 16.5109

In[•]:= CompareTwoImage[, ]

Out[•]:= 19.0808

Similarly, we should not do word-by-word comparison for texts

FEATURE EXTRACTION

Computational methods for obtaining feature vectors

Feature Extraction

Feature Engineering



Edge Detection

RGB

Blur transformer

...

Machine Learning

Object Detection

Image Captioning

...

To be, or not to be,--that is the
question:-- Whether 'tis nobler in the
mind to suffer The slings and arrows of
outrageous fortune Or to take arms against
a sea of troubles, And by opposing end them?

Word Count / Word Frequency

...

Word Embedding

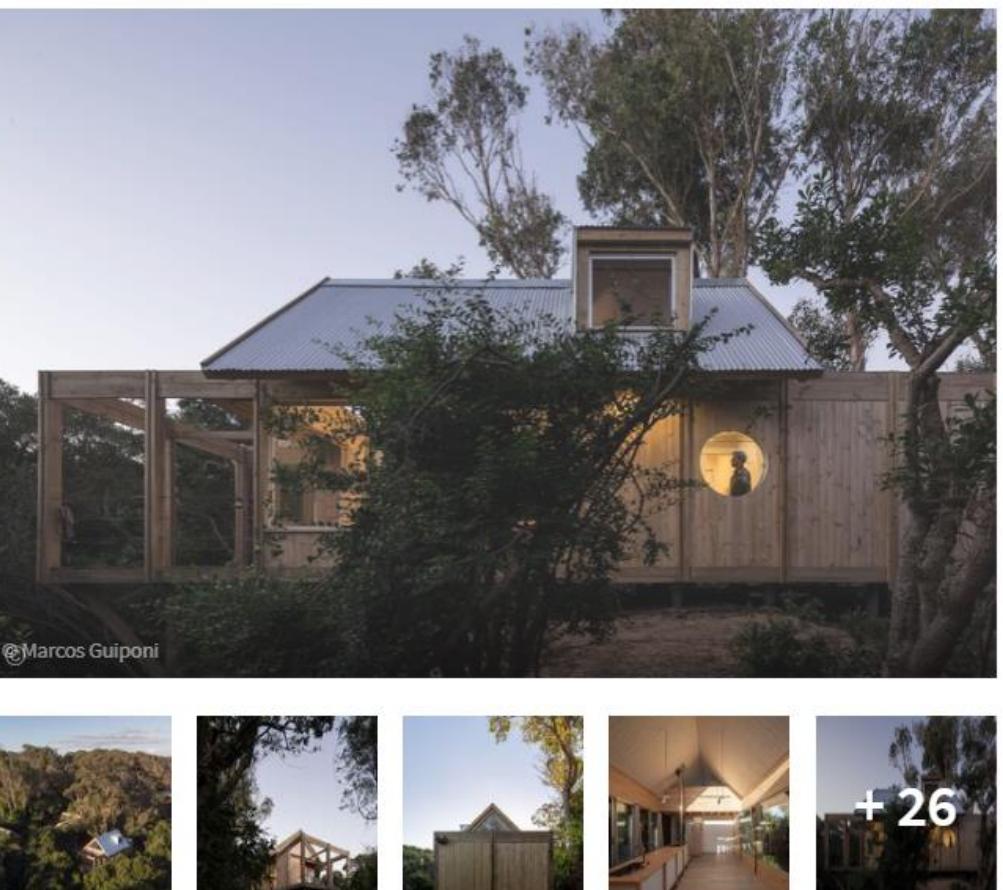
Sentiment Analysis

...

Word Frequency

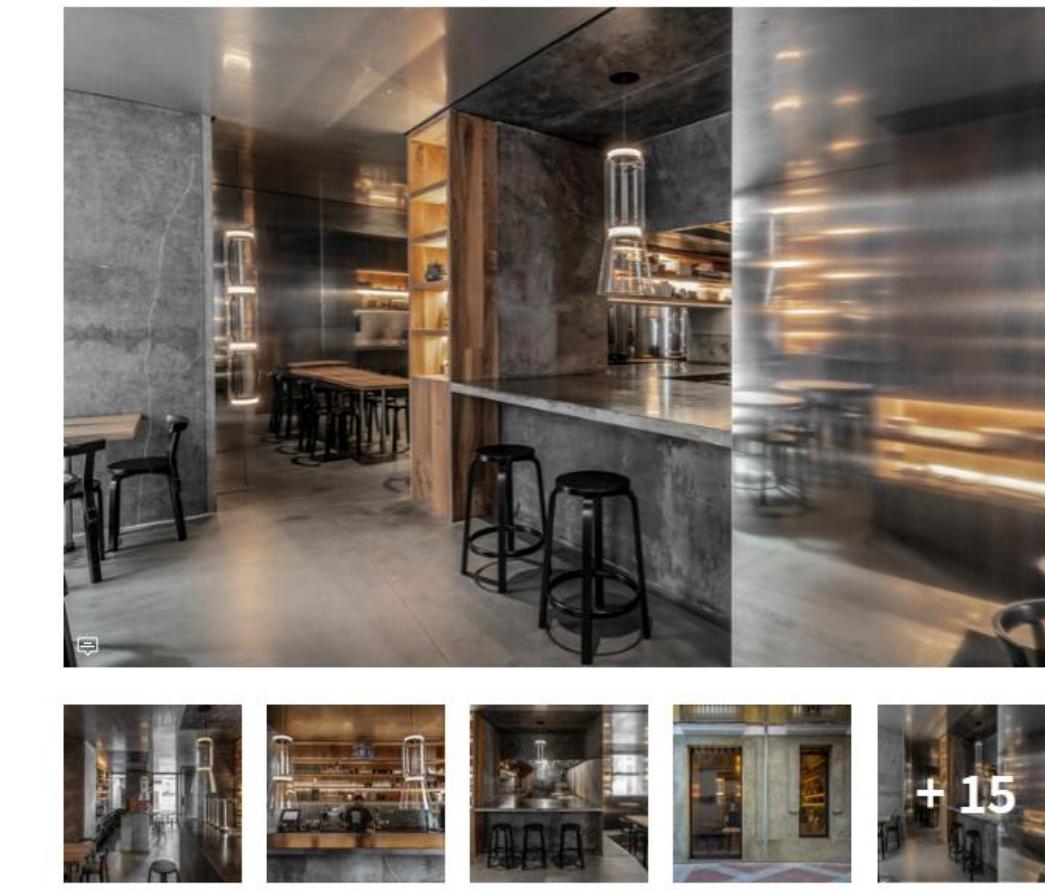
https://en.wikipedia.org/wiki/Bag-of-words_model

Punta Colorada III Shelter / TATÚ Arquitectura
about 9 hours ago



+ 26

Tribeca Restaurant – Alicante / Noname 29
about 5 hours ago



+ 15

the land is in an area of maritime forest near the first stretch of the oceanic beach in uruguay. here it has a diverse number of native species living in an obscure ecosystem. amongst these species are the eucaliptus, coronilla, or aruera among other valuable species that we must preserve to build a narrative about the future architecture project and its immediate landscape. at the same time, the topography of the land presents a pronounced hollow on its back and lateral side, because of two ravines that carry natural water from the mountains to the sea. it was decided that the project would try to keep this ecosystem as intact as possible to reduce the green footprint. it is decided to opt for a stilt-type foundation system made up of concrete piles that will be supported on the ground, leaving the entire construction suspended on the irregular surface of the ground. the shelter is assembled in a longitudinal position that divides the land into two different sides. the first one is pointed to the north, and it is organized in a logical way, as there is an interior-exterior access link. the second one is south facing where there is a new contemplation logic to look at the landscape from a series of specific cut-outs in the shell and cover. the distribution is articulated by the bathroom units that divide the rest areas of the social spaces. the project has been modulated with structural porches that are exposed inside and out of the building, giving rhythm and texture to it. finally, it was decided to increase the internal volume in the social area to acquire greater contact with the exterior and to generate a second bedroom-mezzanine from which to observe the deep horizon of the sea.

<https://www.archdaily.com/981901/punta-colorada-iii-shelter-tatu-arquitectura>

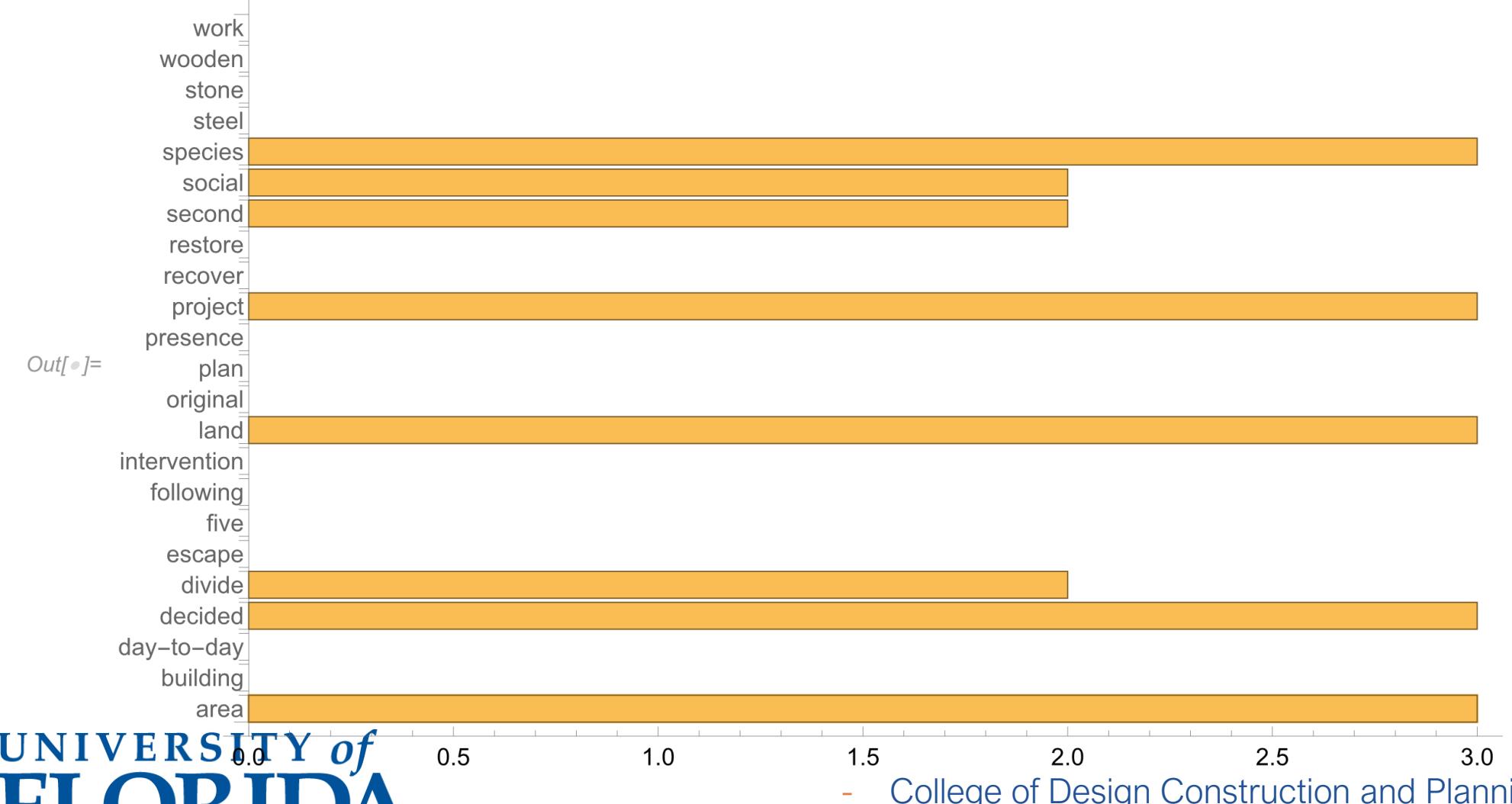
five hundred kilos of calatorao stones, stainless steel 3mx1 .5m plates, solid spanish walnut wood 50 mm thick. thickness is the word that would define the proposal and the "raw" presence of the material, responsible for building its friendly atmosphere. five large blocks of stone, which seem to float, build a fluctuating magma. space, alongside polished steel, escapes between these stones towards infinity, as if, once inside the premises, you could lose yourself beyond its limits, and escape into nothingness. although, you don't even try... these powerful blocks, in addition to articulating the space, take you to the heart, hide the structural elements and contain all the necessary machinery for the restaurant to work. the cavern, which for years was this restaurant, is transformed into a "magic box" which, however, maintains the soul of the place. the intervention on the façade, in a building from the end of the 19th century of which no plans are preserved, is the result of an almost archaeological investigation to discover its origin. the facade of the premises has undergone different interventions throughout history, and the action seeks to re-establish the closest thing to what the original building could have been. the façade has been cleaned of foreign elements, hollows have been restored following the traces of the old wooden landings, the lost massifs have been rebuilt, following the laws of the building, and a lime mortar has been laid that worthily recovers the base of the building. in this way, the façade recovers the original plan and is closer to the massive appearance of the time of its construction, restoring the power of the original image, as well as the slenderness of the openings, so characteristic of the ground floors of historical architecture from alicante. in this proposal, the work is claimed as a factory, improvising and solving in situ with the trades on a continuous day-to-day basis, drawing details, adjusting layouts, and comparing samples. exciting day-to-day with a project that does not have an image final, why a final image? the process is committed, and the construction is humanized so that each stone has its name. the materials have their own life, and identity: each stone, each steel plate, each wooden board... each one of them is precisely measured on-site, and templates are drawn, cut and later find their place on the site. every detail is taken care of in a work without details apparent. a technic ceiling without diffusers, without speakers, without detectors, and a "night owl" lighting made of blown glass, with a presence but then disappears. once seated at the table, all this disappears so that we can focus on the wonderful hamburgers

<https://www.archdaily.com/981838/tribeca-restaurant-nil-alicante-nomame-29>

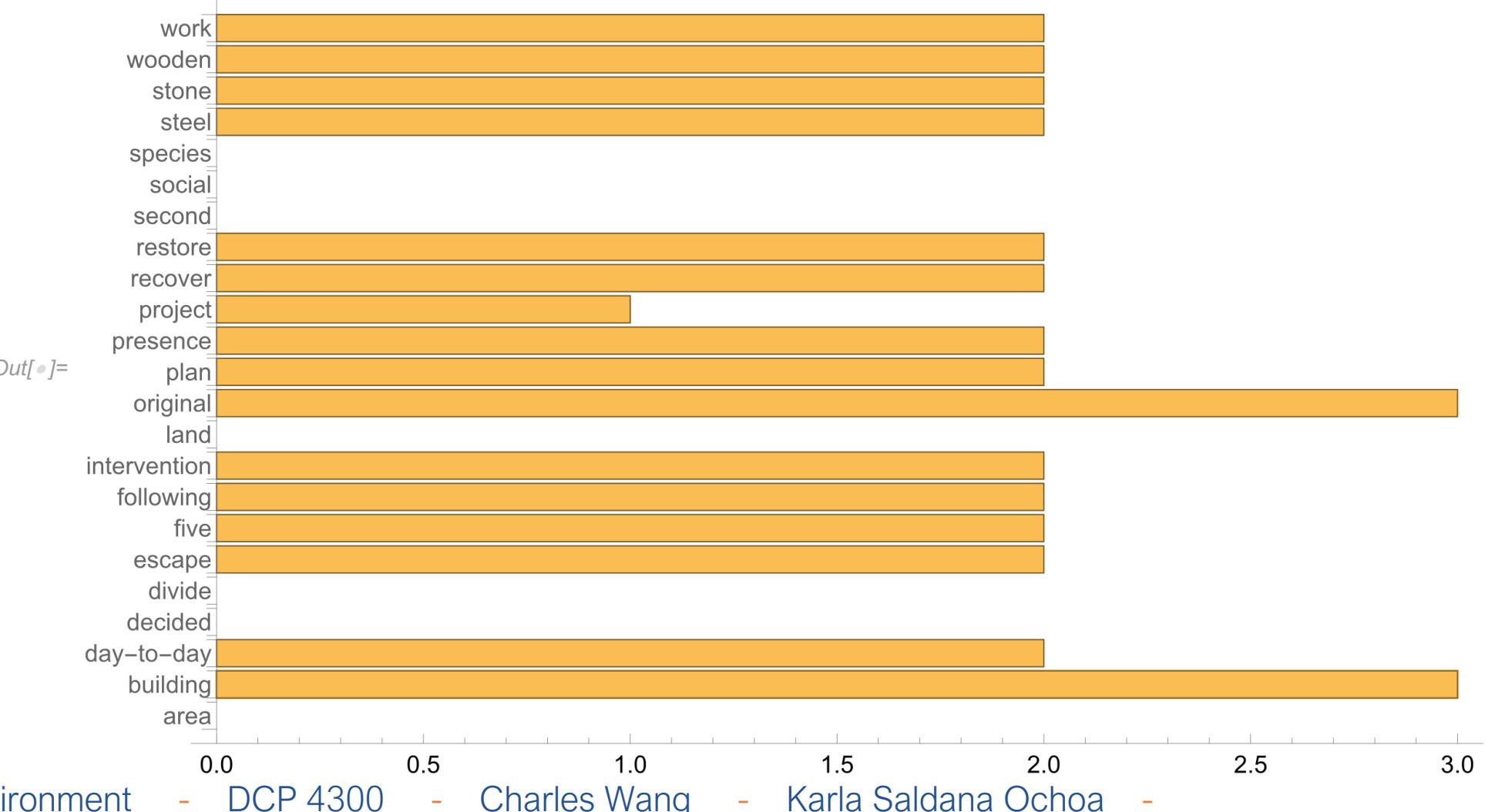
Word Histogram

https://en.wikipedia.org/wiki/Bag-of-words_model

Punta Colorado III Shelter / TATÚ Arquitectura
about 9 hours ago



Tribeca Restaurant – Alicante / Noname 29
about 5 hours ago



Machine Learning (Object Detection)

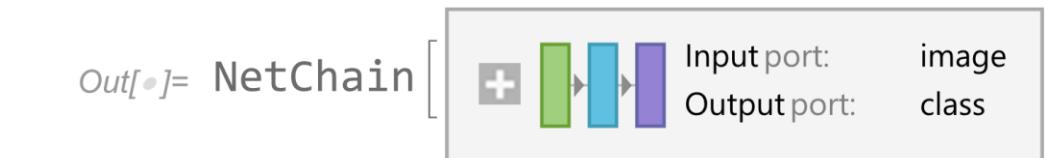
```
In[•]:= model = NetModel["VGG-16 Trained on ImageNet Competition Data"]
```



```
In[•]:= model[, {"TopProbabilities", 10}]
```

Out[•]= {vat → 0.00299698, bathtub → 0.00330974,
bucket → 0.00428974, washbasin → 0.00527512,
hamper → 0.00952213, lynx → 0.0144289, Persian cat → 0.0323229,
tiger cat → 0.0766838, Egyptian cat → 0.213713, tabby cat → 0.562044}

```
In[•]:= model = NetModel["VGG-16 Trained on ImageNet Competition Data"]
```



```
In[•]:= model[, {"TopProbabilities", 10}]
```

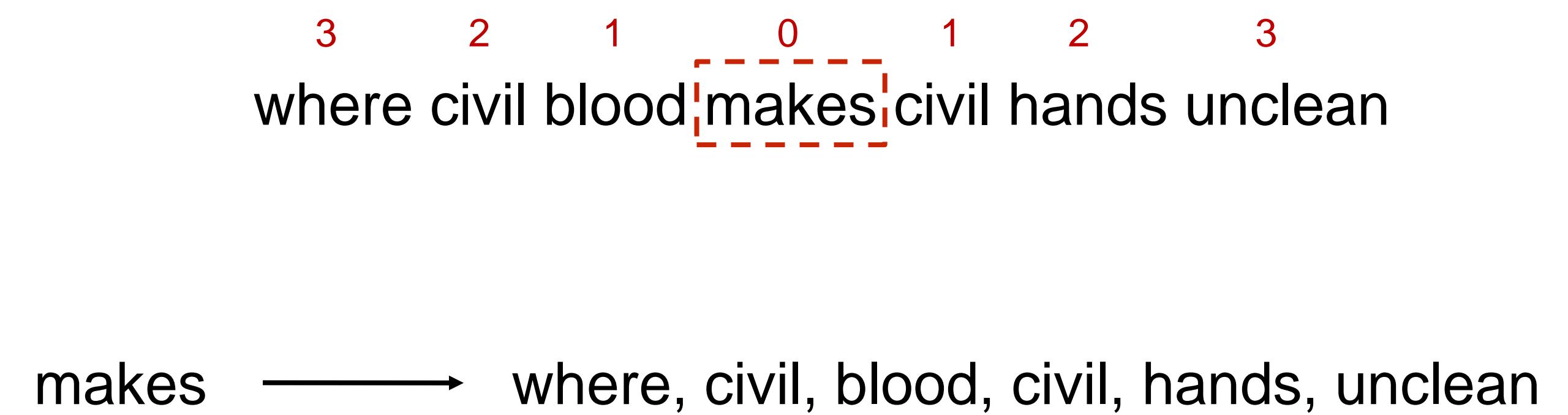
Out[•]= {Tibetan terrier → 0.00020129, English cocker spaniel → 0.000205052,
Great Pyrenees → 0.000418824, Tibetan mastiff → 0.00057785, otter hound → 0.000684315,
kuvasz → 0.0024348, Sussex spaniel → 0.002732, clumber spaniel → 0.00319501,
Labrador retriever → 0.0165675, golden retriever → 0.971482}

Machine Learning (Word2Vec)

https://en.wikipedia.org/wiki/Bag-of-words_model

PROLOGUE

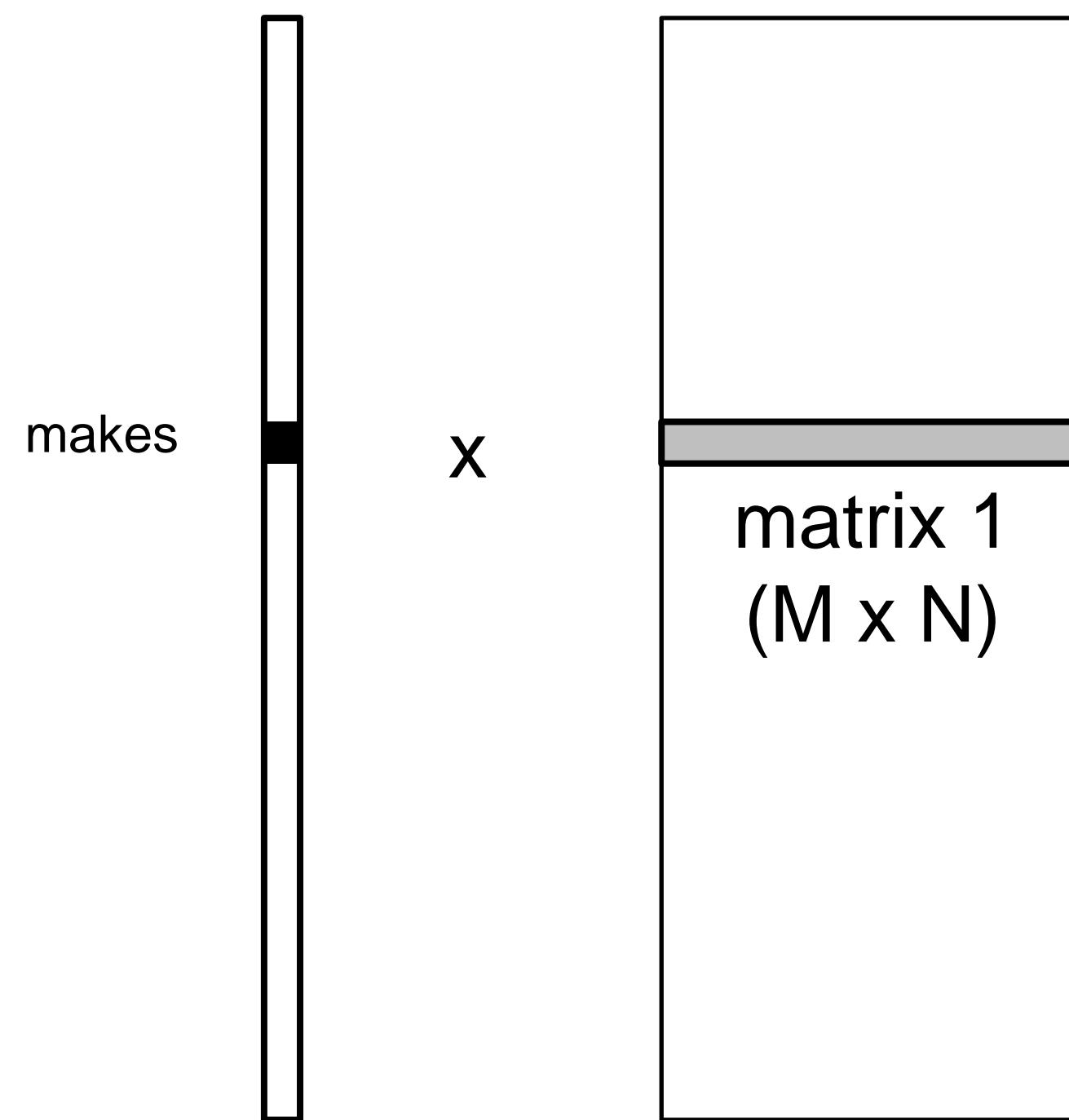
*Two households, both alike in dignity,
In fair Verona, where we lay our scene,
From ancient grudge break to new mutiny,
Where civil blood makes civil hands unclean.
From forth the fatal loins of these two foes
A pair of star-cross'd lovers take their life;
Whose misadventured piteous overthrows
Do with their death bury their parents' strife.
The fearful passage of their death-mark'd love,
And the continuance of their parents' rage,
Which, but their children's end, nought could remove,
Is now the two hours' traffic of our stage;
The which if you with patient ears attend,
What here shall miss, our toil shall strive to mend.*



Machine Learning (Word2Vec)

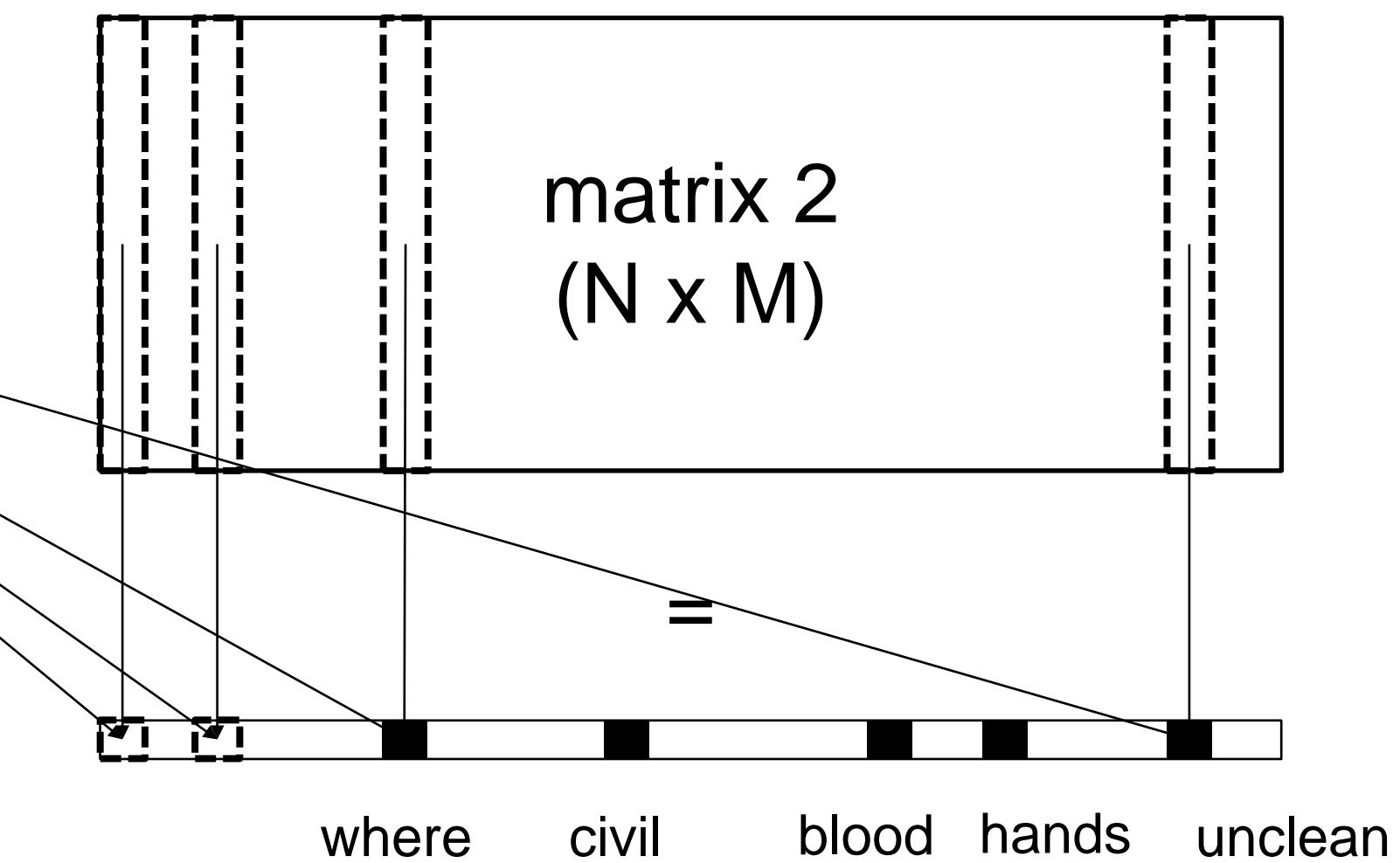
<https://www.youtube.com/watch?v=ERibwqs9p38>

M-dimensional
“one-hot” vector



N-dimensional
embedding vector

=



The “embedding layer”

M-dimensional vector

Machine Learning (Word2Vec)

<https://www.youtube.com/watch?v=ERibwqs9p38>

The similarity of words are determined by their meanings (i.e., their neighboring words)

```
In[•]:= model = NetModel["GloVe 100-Dimensional Word Vectors Trained on Tweets"]
```

Out[•]= EmbeddingLayer [ Input: string
Output: matrix(size: n×100)]

```
In[•]:= EuclideanDistance[model["son"], model["daughter"]]
```

Out[•]= 0.14814

```
In[•]:= EuclideanDistance[model["car"], model["cat"]]
```

Out[•]= 0.72364

FEATURE EXTRACTION

Demonstration with the previous collected data

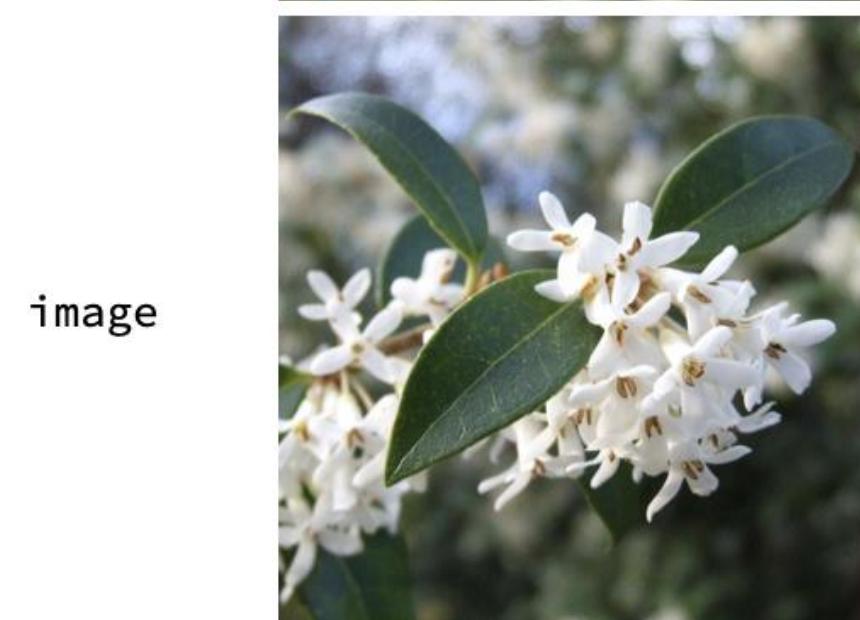
CODE on IMAGES



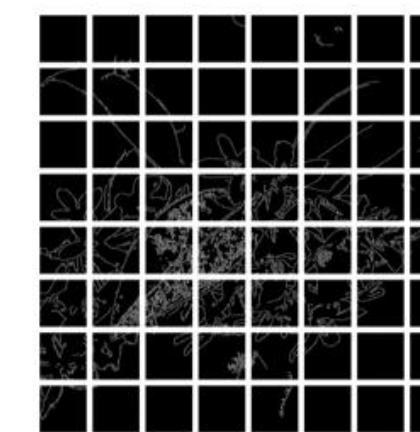
-> "colors"



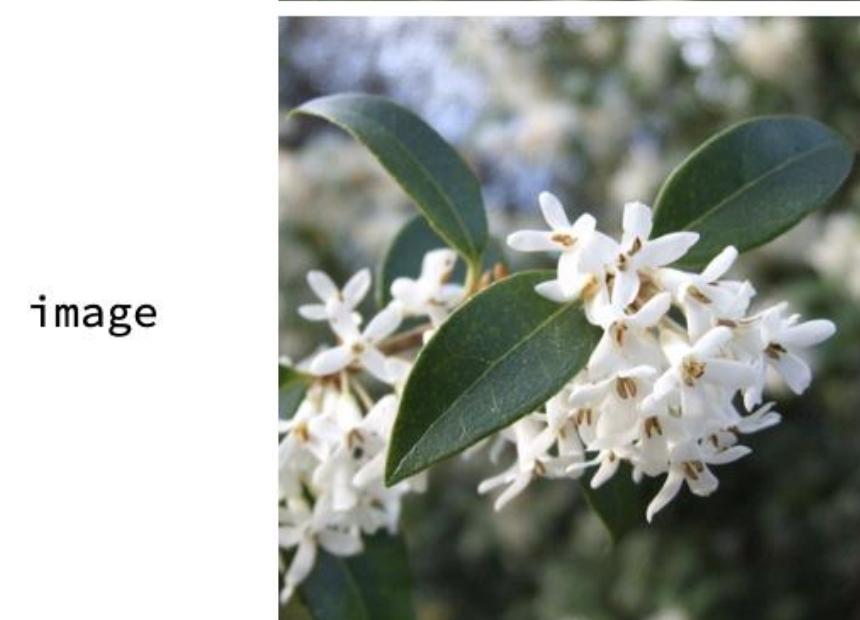
1600	0	1600	0	1600
0	1600	0	1600	0
1600	0	1516	84	1536
64	1600	0	1562	38
1477	123	1494	106	1558
42	1600	0	1600	0
1600	0	1600	0	1512



-> "edges"



0.439216	0.470588	0.541176
0.694118	0.733333	0.862745
0.780392	0.811765	0.898039
0.733333	0.741176	0.74902
0.462745	0.490196	0.458824
0.505882	0.533333	0.458824
0.662745	0.694118	0.701961



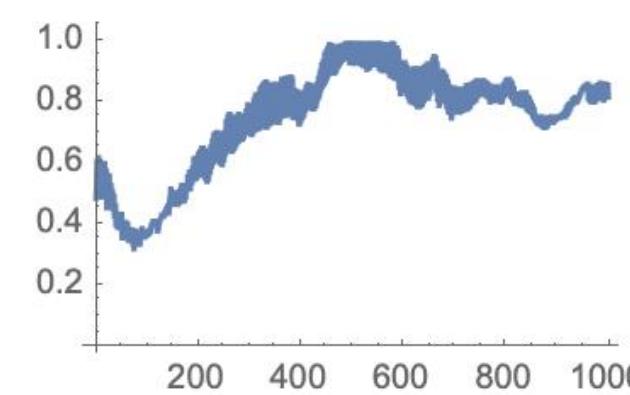
-> "feature extraction"

common privet
common jasmine
laurel
California laurel
fruit tree
pride-of-rochester

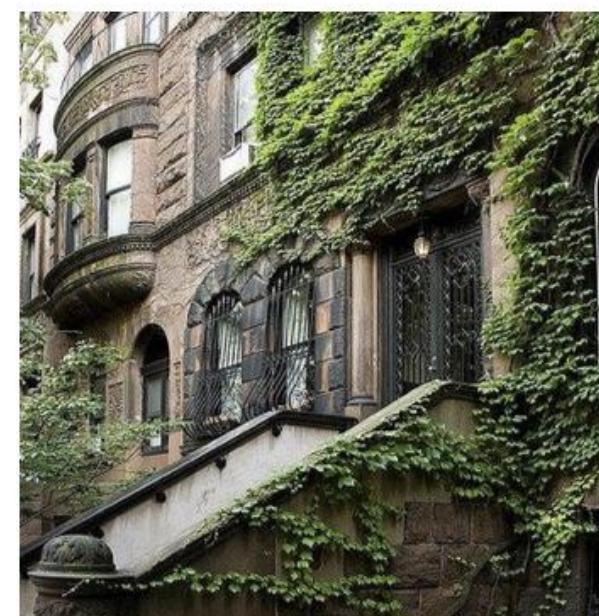
8.22561	-8.62608	28.0713
-3.54004	12.2321	3.18221
-6.41089	1.24627	-2.62163



-> "fourier"



311.196 + 0. i	-2.8447 + 8.53134 i
-2.8447 - 8.53134 i	-18.8027 + 15.8672 i
0.0507741 - 1.67722 i	-0.855818 - 0.620666 i
11.2859 + 32.356 i	2.20177 + 1.97652 i
1.98793 + 0.293197 i	-2.49415 + 16.4691 i
1.08693 - 0.0374585 i	-0.728638 - 0.404993 i
-7.28062 + 7.17637 i	0.616701 + 0.874254 i

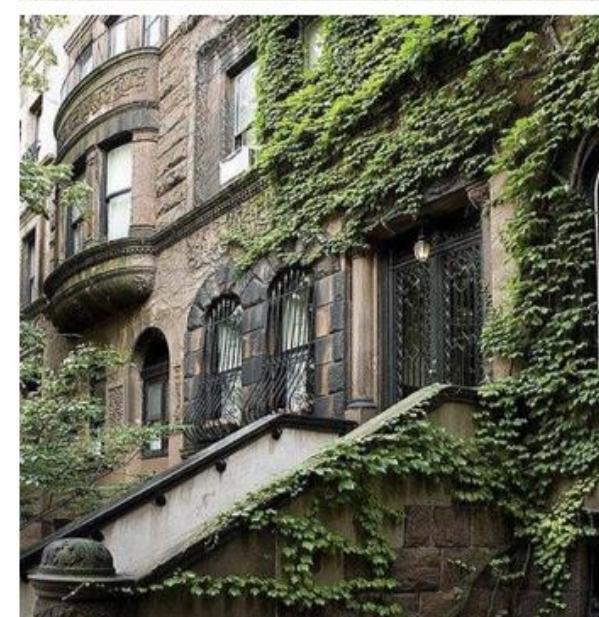


image

-> "colors"

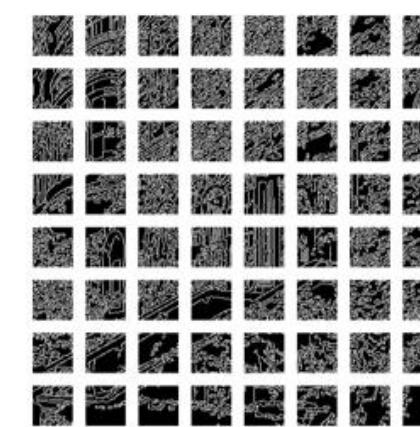


0.745098 0.741176 0.662745 0.694118 0.666667
0.635294 0.705882 0.658824 0.627451 0.494118
0.490196 0.423529 0.368627 0.427451 0.278431
0.447059 0.517647 0.313725 0.34902 0.423529
0.196078 0.203922 0.235294 0.133333 0.301961
0.305882 0.196078 0.254902 0.282353 0.172549



image

-> "edges"



1146 454 1138
462 1057 543
1107 493 1064
536 991 609
1156 444 1204



image

-> "feature extraction"

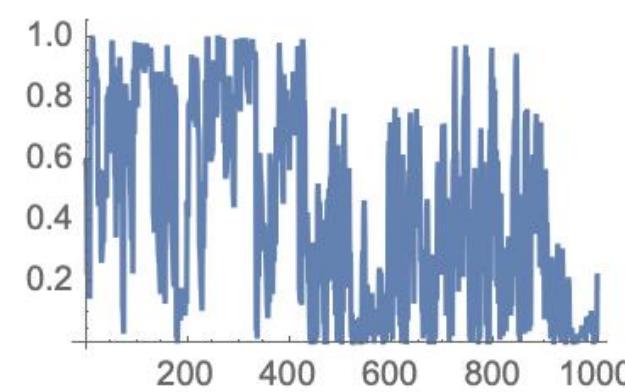
Boston ivy
vine
vascular plant
flora
support
stair

11.9924 5.44124 -2.30834
0.115535 2.4649 4.43479
5.21442 4.58633 -3.29425

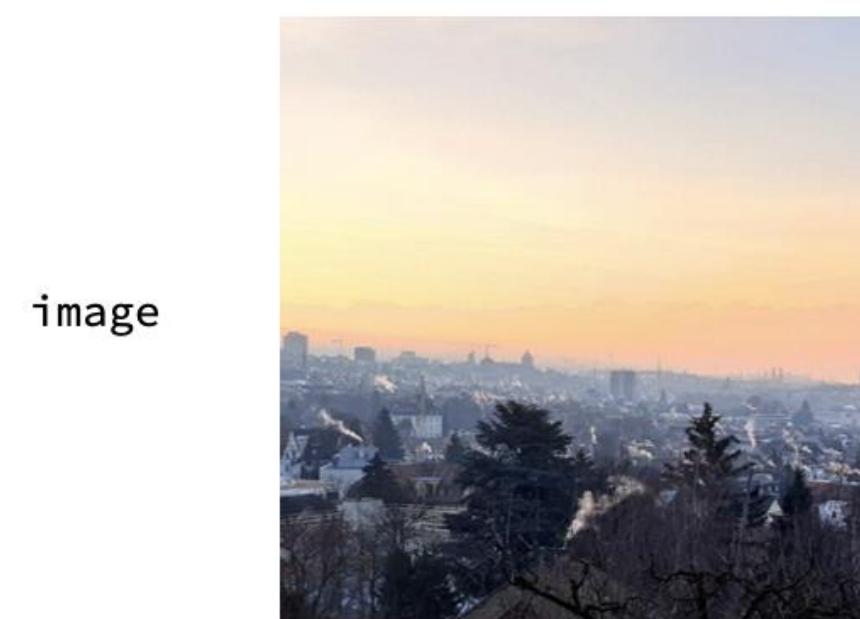


image

-> "fourier"

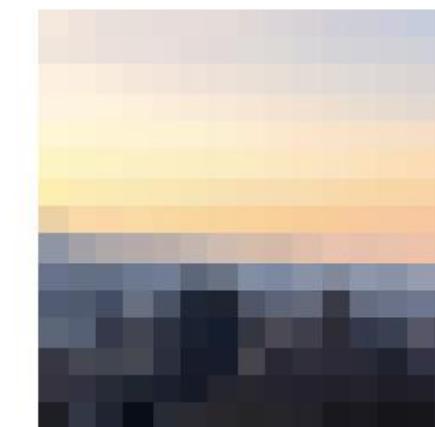


$232.95 + 0. i \quad 6.82914 + 15.0475 i$

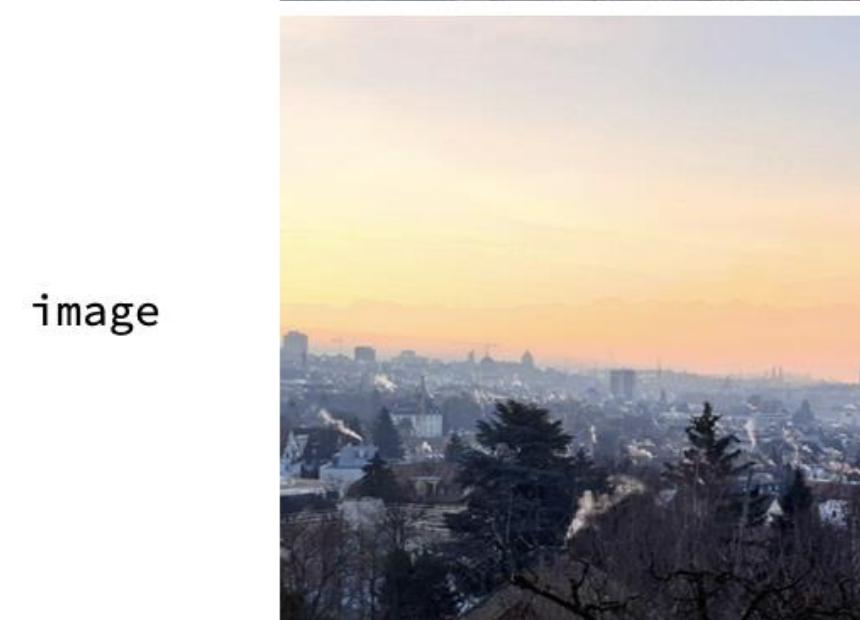


image

-> "colors"

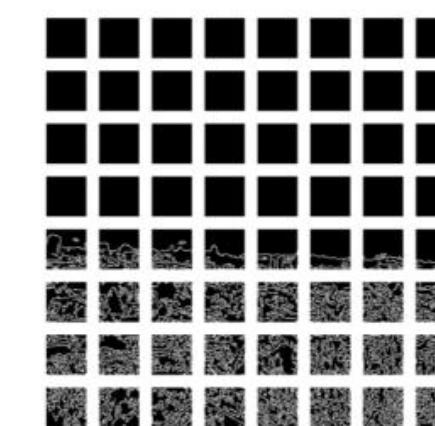


0.956863	0.901961	0.858824	0.92549	0.878431
0.854902	0.913725	0.870588	0.85098	0.905882
0.862745	0.85098	0.894118	0.85098	0.843137
0.866667	0.839216	0.839216	0.835294	0.823529
0.843137	0.811765	0.807843	0.85098	0.796078
0.803922	0.862745	0.776471	0.8	0.866667

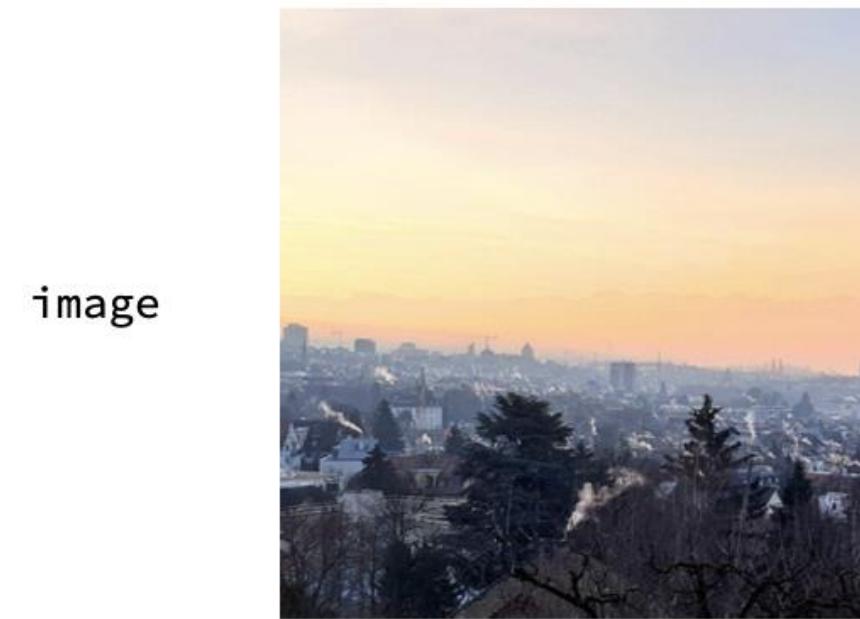


image

-> "edges"



1600	0	1600
0	1600	0
1600	0	1600
0	1600	0
1600	0	1600

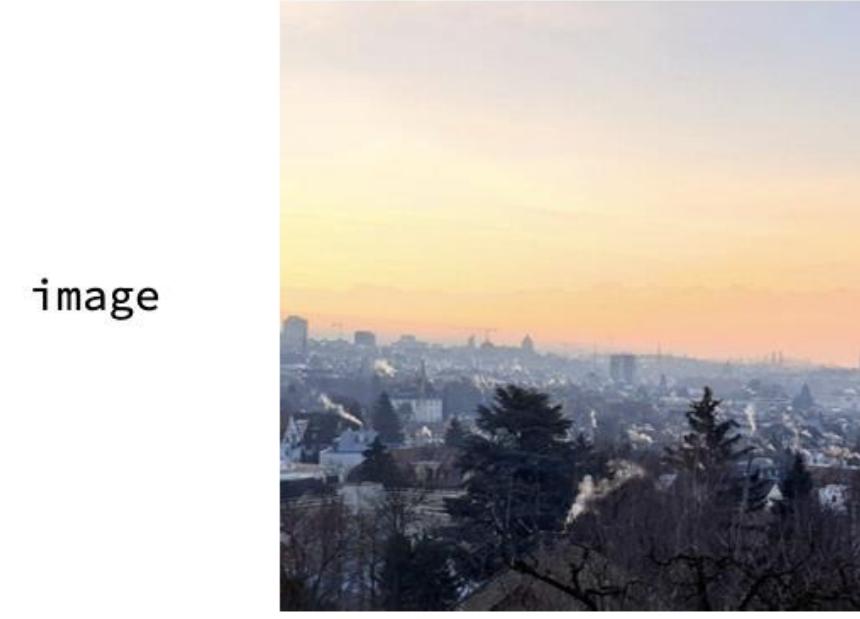


image

-> "feature extraction"

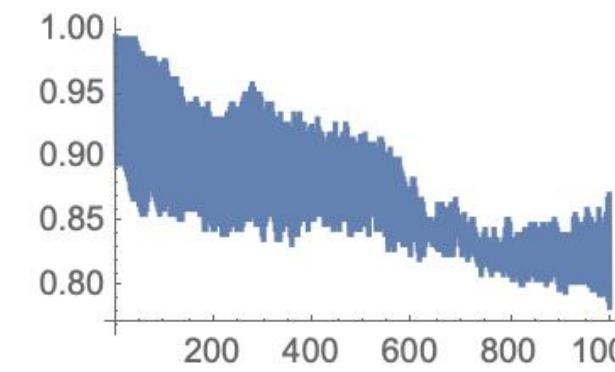
- atmospheric phenomenon
- physical phenomenon
- natural phenomenon
- cloud
- mount
- atmosphere

7.15525	4.59606	-1.56497
-1.7739	-0.335489	13.6057
6.20777	-4.12575	-0.151123



image

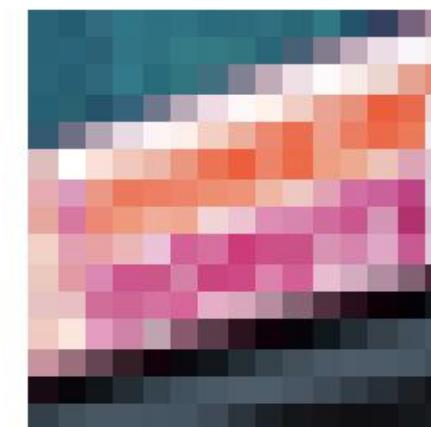
-> "fourier"



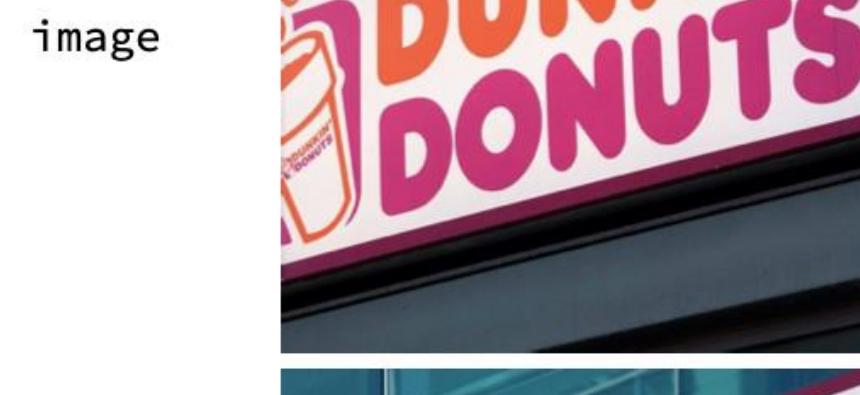
$431.125 + 0.i \quad 13.5396 + 6.74412i$



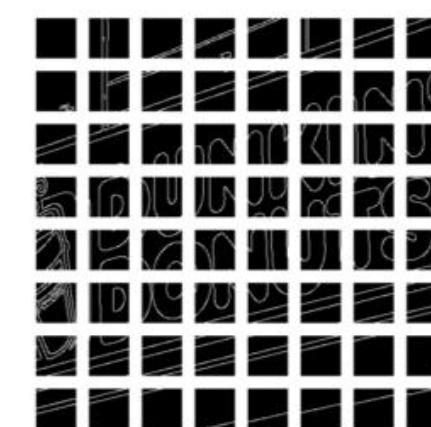
-> "colors"



0.0352941	0.384314	0.47451	0.0784314	0.403922
0.490196	0.0431373	0.462745	0.537255	0.027451
0.462745	0.52549	0.0196078	0.439216	0.501961
0.	0.403922	0.470588	0.0392157	0.4
0.466667	0.172549	0.423529	0.505882	0.447059
0.443137	0.552941	0.745098	0.643137	0.72549



-> "edges"



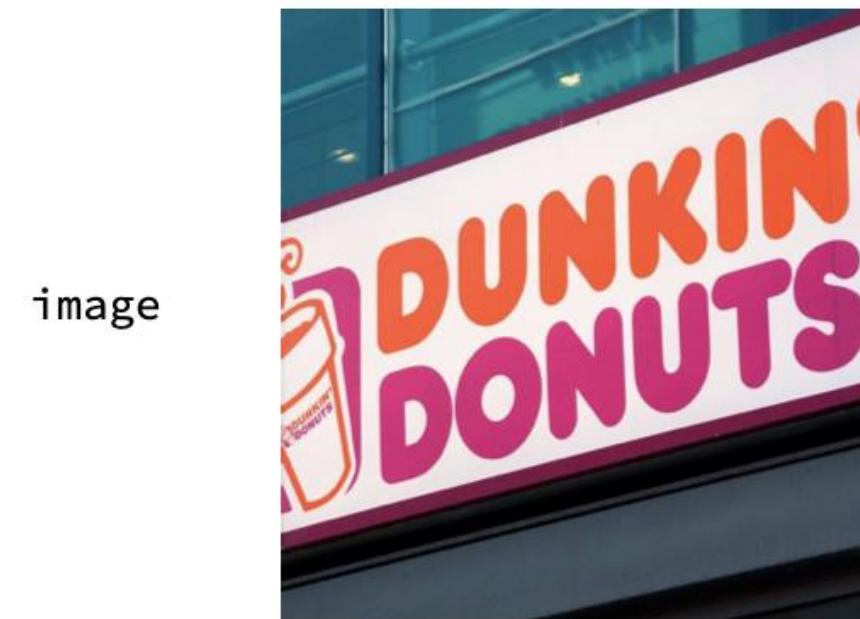
1600	0	1515
85	1600	0
1557	43	1503
97	1511	89
1500	100	1525



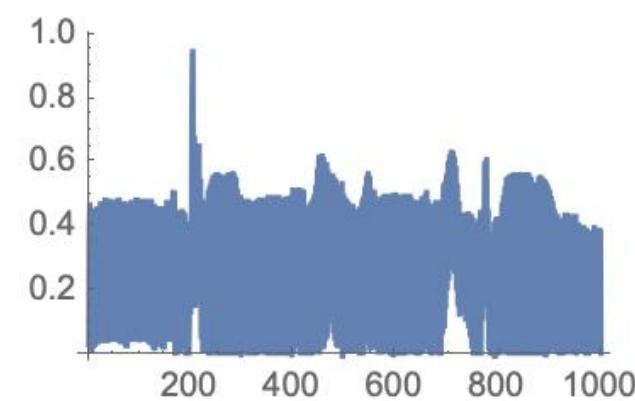
-> "feature extraction"

- casino
- grocery store
- supermarket
- self-propelled vehicle
- motor vehicle
- automobile

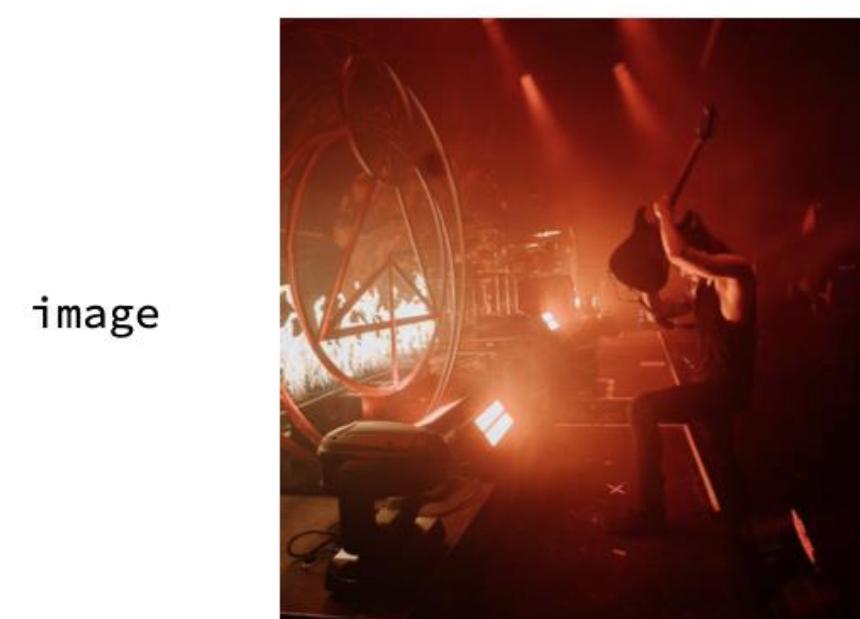
1.48464	8.58569	-0.247135
9.6562	1.21292	-4.77248
-4.94734	4.30959	12.4666



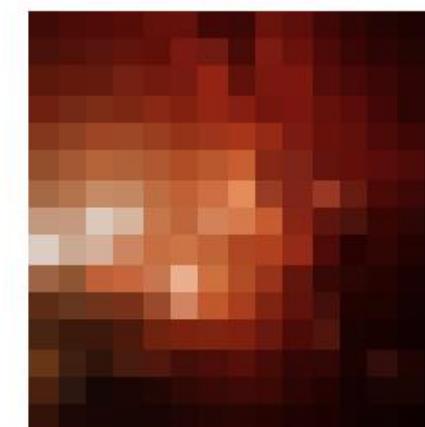
-> "fourier"



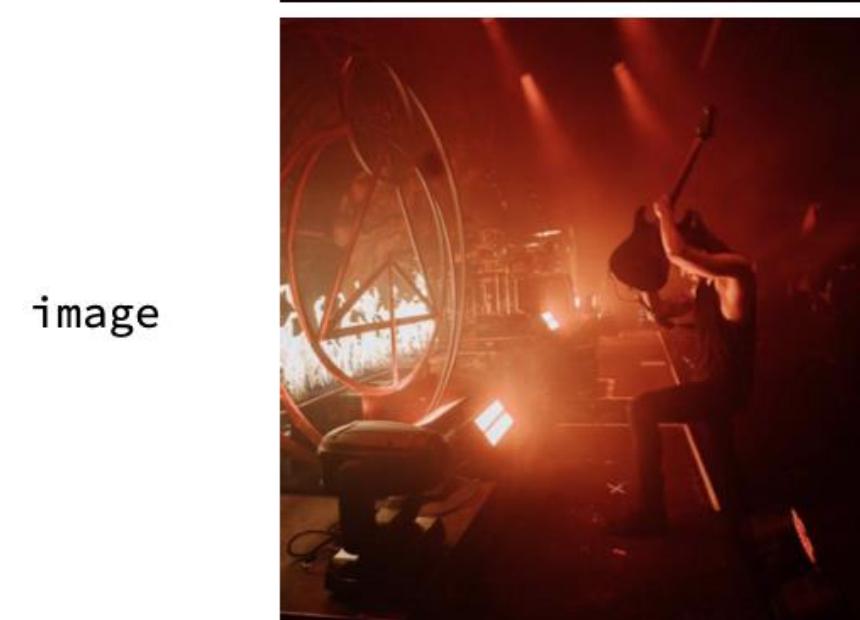
$$357.98 + 0. \text{i} \quad 21.9133 - 10.4063 \text{i}$$



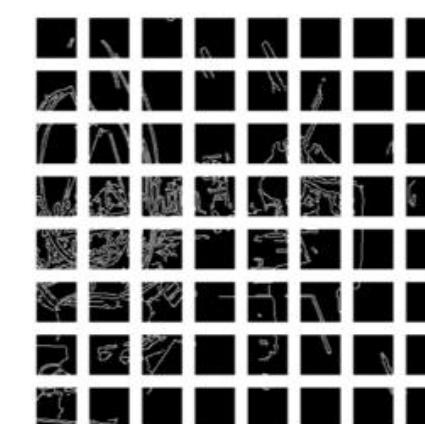
-> "colors"



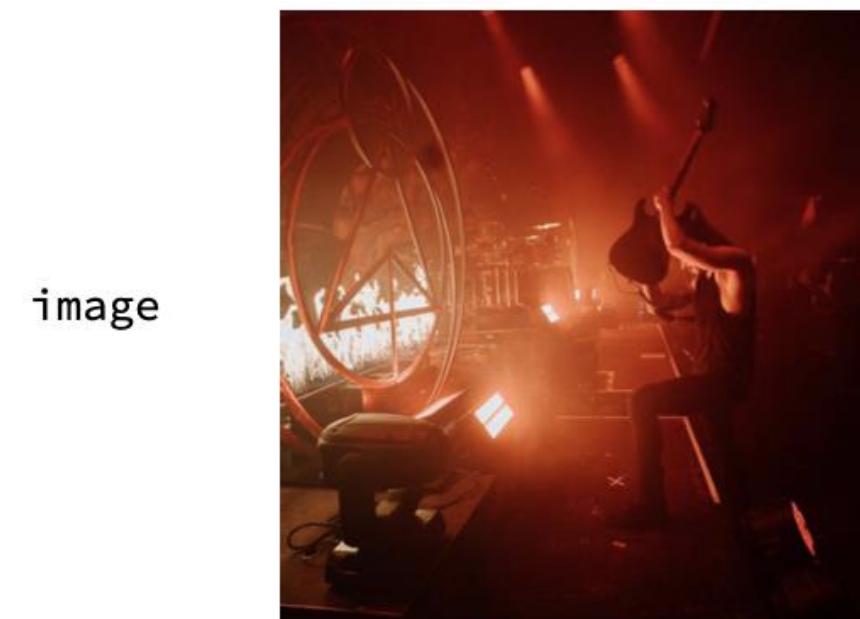
0.286275	0.0235294	0.0156863	0.337255	0.0196078
0.0156863	0.384314	0.00784314	0.0117647	0.443137
0.0117647	0.0117647	0.294118	0.0117647	0.0156863
0.407843	0.0156863	0.0117647	0.396078	0.00392157
0.0117647	0.227451	0.00392157	0.0117647	0.152941
0.0117647	0.00784314	0.117647	0.00784314	0.00784314



-> "edges"



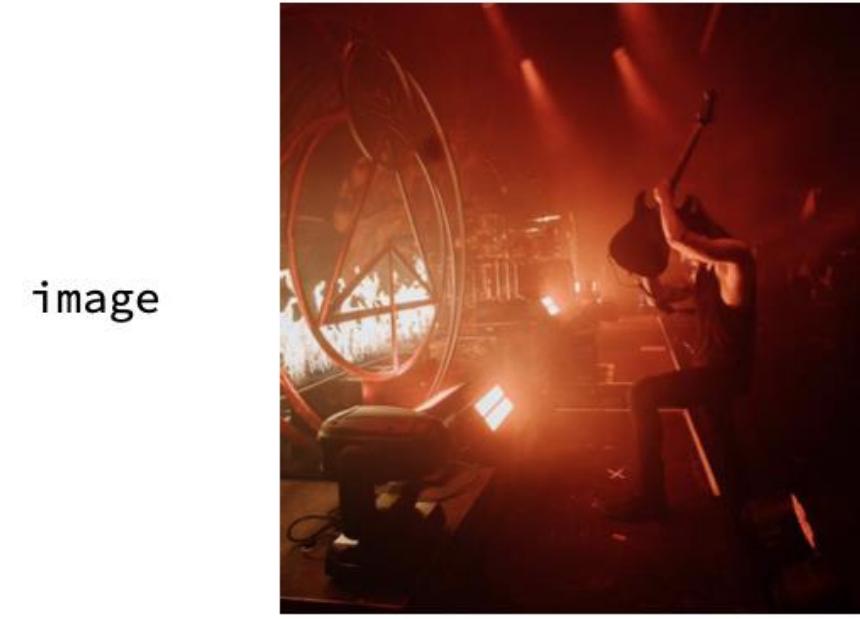
1597	3	1538
62	1600	0
1581	19	1594
6	1573	27
1600	0	1600



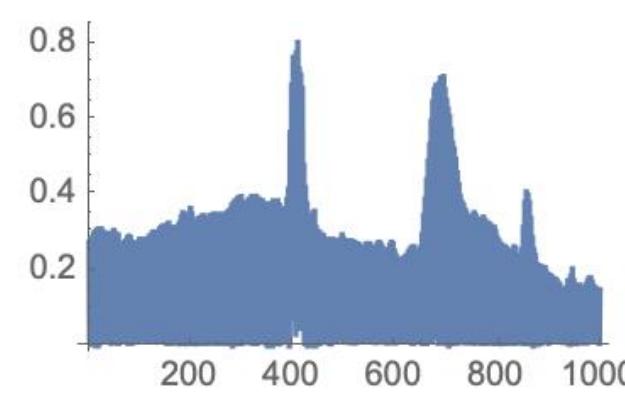
-> "feature extraction"

- laser
- primate
- hominid
- person
- light source
- fairy light

10.2982	-1.38993	9.04966
-3.65853	-4.3973	-4.61546
-9.81738	-16.1137	1.08928



-> "fourier"



$141.403 + 0.i \quad 74.3727 + 10.9785 i$

image



-> "colors"

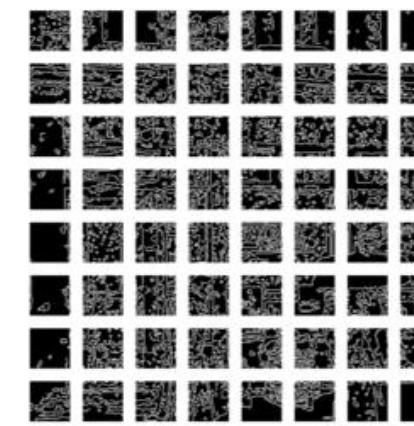


0.513725 0.556863 0.470588 0.52549 0.560784
0.478431 0.784314 0.776471 0.662745 0.65098
0.627451 0.513725 0.639216 0.619608 0.533333
0.721569 0.709804 0.643137 0.568627 0.552941
0.501961 0.533333 0.509804 0.443137 0.682353
0.67451 0.619608 0.54902 0.537255 0.482353

image



-> "edges"



1281 319 1216
384 1570 30
1187 413 1254
346 1310 290
1343 257 1562

image



-> "feature extraction"

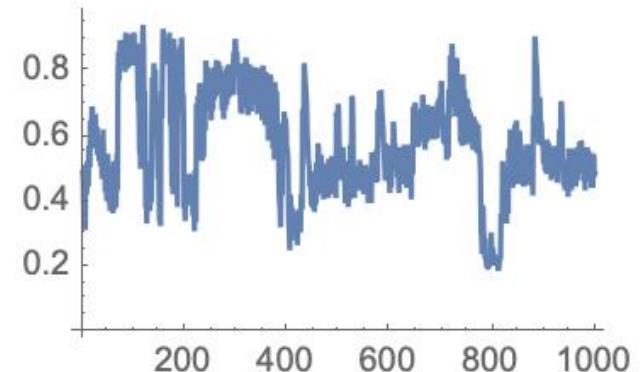
sprinkler
crucifix
lock
padlock
cockpit
abacus

10.2982 -1.38993 9.04966
-3.65853 -4.3973 -4.61546
-9.81738 -16.1137 1.08928

image



-> "fourier"

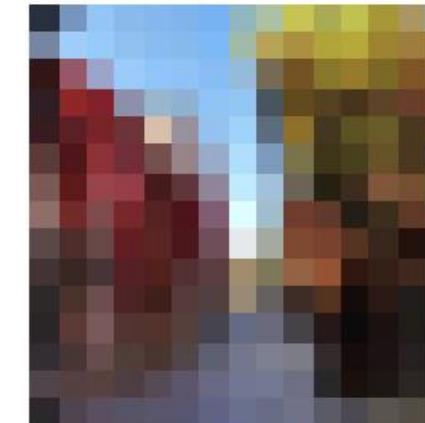


381.644 + 0. i 5.46611 + 14.145 i

image



-> "colors"

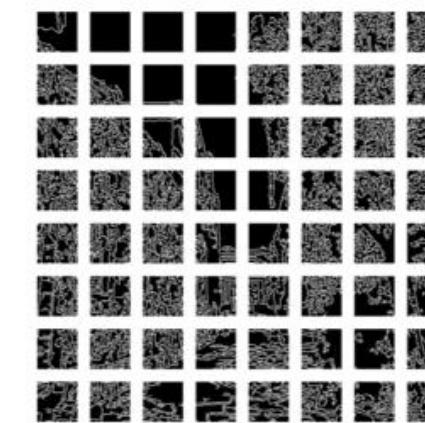


0.298039 0.392157 0.494118 0.541176 0.792157
1. 0.498039 0.737255 0.94902 0.454902
0.713725 0.956863 0.45098 0.709804 0.917647
0.666667 0.74902 0.560784 0.737255 0.713725
0.231373 0.713725 0.717647 0.172549 0.690196
0.592157 0.141176 0.592157 0.572549 0.486275

image



-> "edges"



1477 123 1600
0 1600 0
1600 0 1596
4 1275 325
1155 445 1080

image



-> "feature extraction"

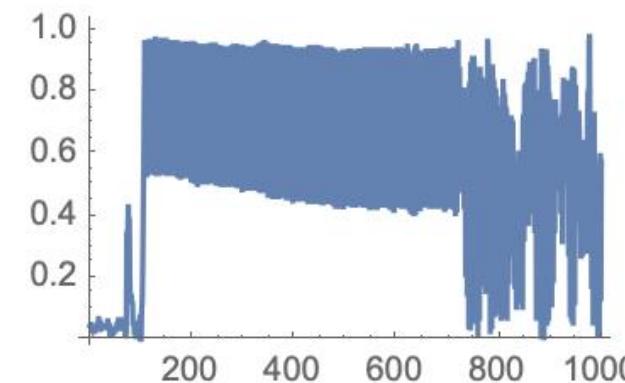
- Boston ivy
- tree
- flowering tree
- maple tree
- boxelder
- California box elder

8.05123 -1.32554 -1.67072
-4.65785 3.92969 2.48092
1.45389 -6.90618 2.5591

image



-> "fourier"



258.052 + 0. i 15.2118 + 2.63635 i

CODE on TEXT

text	To be, or not to be,--that is the question:-- Whether 'tis nobler in the mind to suffer The slings and arrows of outrageous fortune Or to take arms against a sea of troubles, And by opposing end them?	-> "Sentiment Analysis"	Qualifying text by positive, neutral or negative	0.232578	0.908024	0.0687178
				0.68047	-0.039263	0.30186
				0.032246	-0.41376	0.13228
				0.17118	0.22419	-0.10046
				0.67846	0.057204	-0.34448
				0.55963	0.10032	0.18677
				-2.0932	0.22171	-0.39868
				3.8826	0.47466	-0.95658
				-0.32752	0.12751	0.088359
				-0.094375	0.018324	0.21048
				0.082279	-0.09434	-0.073297
						-0.064699
						-0.26044

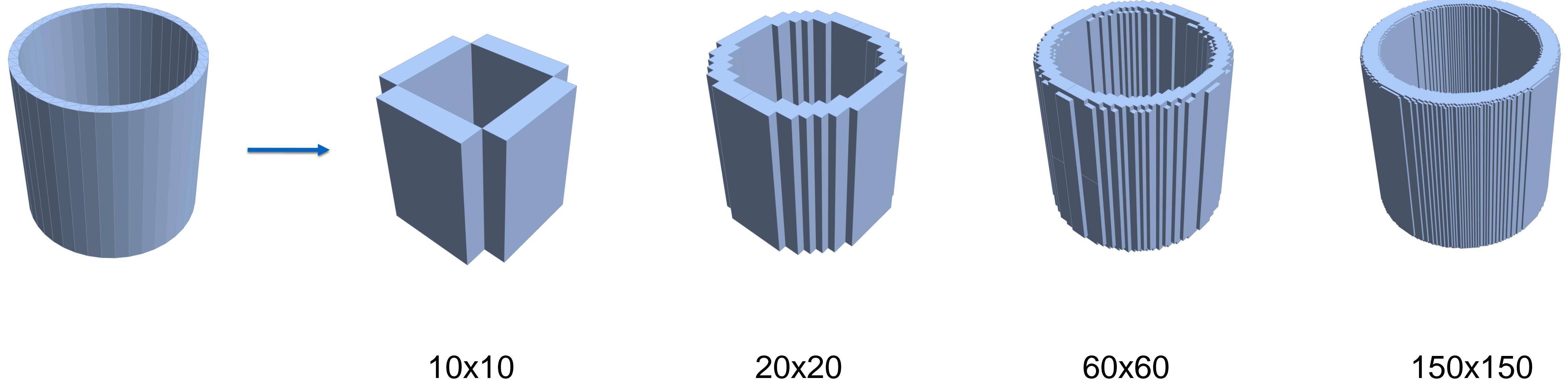
text	say we end The heartache, and the thousand natural shocks That flesh is heir to,--'tis a consummation Devoutly to be wish'd. To die,--to sleep;-- To sleep: perchance to dream:--ay, there's the rub; For in that sleep of death what dreams may come, Whe	-> "Sentiment Analysis"	Qualifying text by positive, neutral or negative	0.232578	0.908024	0.0687178		
text	say we end The heartache, and the thousand natural shocks That flesh is heir to,--'tis a consummation Devoutly to be wish'd. To die,--to sleep;-- To sleep: perchance to dream:--ay, there's the rub; For in that sleep of death what dreams may come, Whe	-> "Word2Vec"	Qualifying text by it's content with word-embeddings	0.68047 0.032246 0.17118 0.67846 0.55963 -2.0932 3.8826 -0.32752 -0.094375 0.082279	-0.039263 -0.41376 0.22419 0.057204 0.10032 0.22171 0.47466 0.12751 0.018324 -0.09434	0.30186 0.13228 -0.10046 -0.34448 0.18677 -0.39868 -0.95658 0.088359 0.21048 -0.073297	-0.17792 -0.29847 -0.43653 -0.42785 -0.26854 0.20912 -0.37788 0.16351 -0.03088 -0.064699	0.42962 -0.085253 0.33418 -0.43275 0.037334 -0.55725 0.20869 -0.21634 -0.19722 -0.26044

text	so long life; For who would bear the whips and scorns of time, The oppressor's wrong, the proud man's contumely, The pangs of despis'd love, the law's delay, The insolence of office, and the spurns That patient merit of the unworthy takes, When he himself might his quietus make With a bare bodki	-> "Sentiment Analysis"	Qualifying text by positive, neutral or negative	0.232578	0.908024	0.0687178		
text	so long life; For who would bear the whips and scorns of time, The oppressor's wrong, the proud man's contumely, The pangs of despis'd love, the law's delay, The insolence of office, and the spurns That patient merit of the unworthy takes, When he himself might his quietus make With a bare bodki	-> "Word2Vec"	Qualifying text by it's content with word-embeddings	0.68047 0.032246 0.17118 0.67846 0.55963 -2.0932 3.8826 -0.32752 -0.094375 0.082279	-0.039263 -0.41376 0.22419 0.057204 0.10032 0.22171 0.47466 0.12751 0.018324 -0.09434	0.30186 0.13228 -0.10046 -0.34448 0.18677 -0.39868 -0.95658 0.088359 0.21048 -0.073297	-0.17792 -0.29847 -0.43653 -0.42785 -0.26854 0.20912 -0.37788 0.16351 -0.03088 -0.064699	0.42962 -0.085253 0.33418 -0.43275 0.037334 -0.55725 0.20869 -0.21634 -0.19722 -0.26044

text	who would these fardels bear, To grunt and sweat under a weary life, But that the dread of something after death,-- The undiscover'd country, from whose bourn No traveller returns,--puzzles the wil	-> "Sentiment Analysis"	Qualifying text by positive, neutral or negative	0.232578	0.908024	0.0687178
				0.68047	-0.039263	0.30186
				0.032246	-0.41376	0.13228
				0.17118	0.22419	-0.10046
				0.67846	0.057204	-0.34448
				0.55963	0.10032	0.18677
				-2.0932	0.22171	-0.39868
				3.8826	0.47466	-0.95658
				-0.32752	0.12751	0.088359
				-0.094375	0.018324	0.21048
				0.082279	-0.09434	-0.073297
					-0.064699	-0.26044

CODE on 3D OBJECTS

A voxel is a unit of graphic information that defines a point in three-dimensional space



Online Voxelizer

Convert your 3D model or image into voxels in your browser.
All data is fast and securely processed on your local machine.

1x1x1
1 voxels

1

1.00

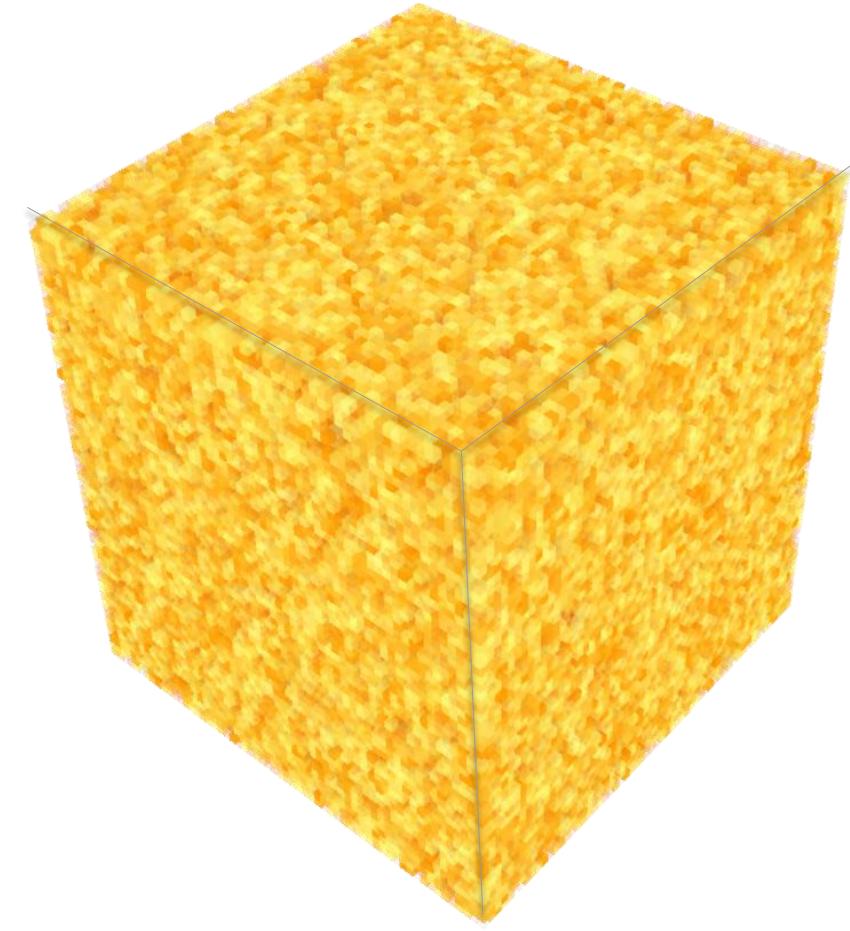
open file save as xml

- .obj (tris) .obj (quads) .dae (tris) .stl .schematic
- blender.py C4D.py .json .xml .py
- .js .ts .png avorion avorion
- .vox .scad .qb .txt .pdf
- .pdf .kvx .occ .occ pixel art
- .binvox sprite stack hexahedral povray img seq.

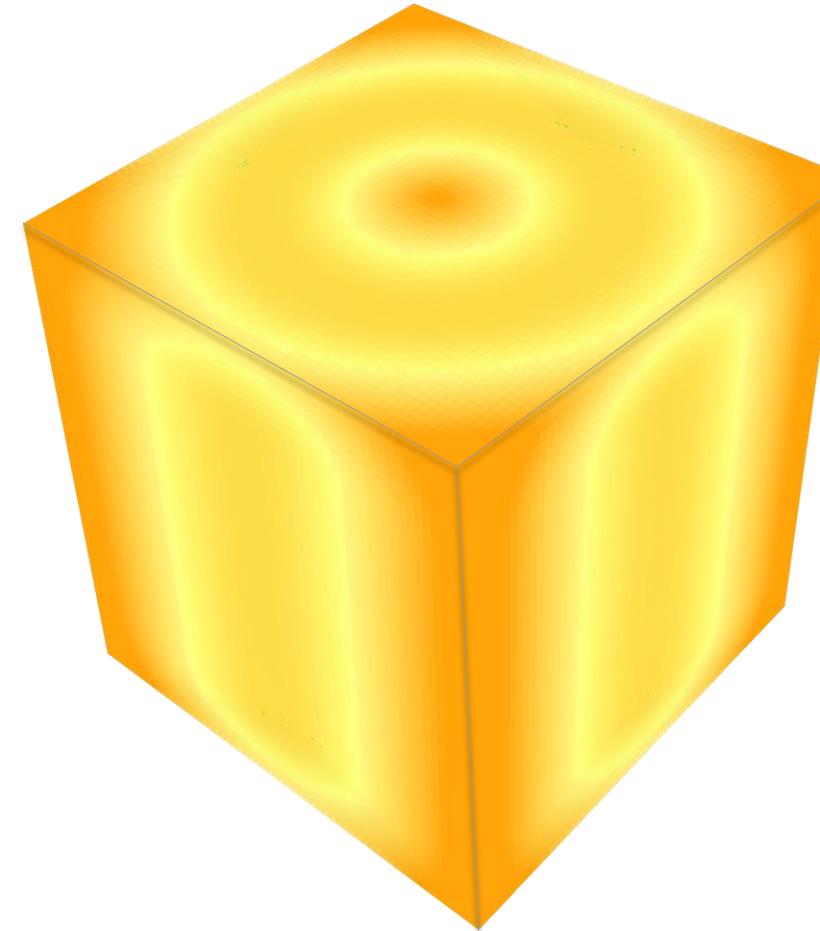
Export as Single Object

- obj (tris) obj (quads) dae (tris) glb minecraft

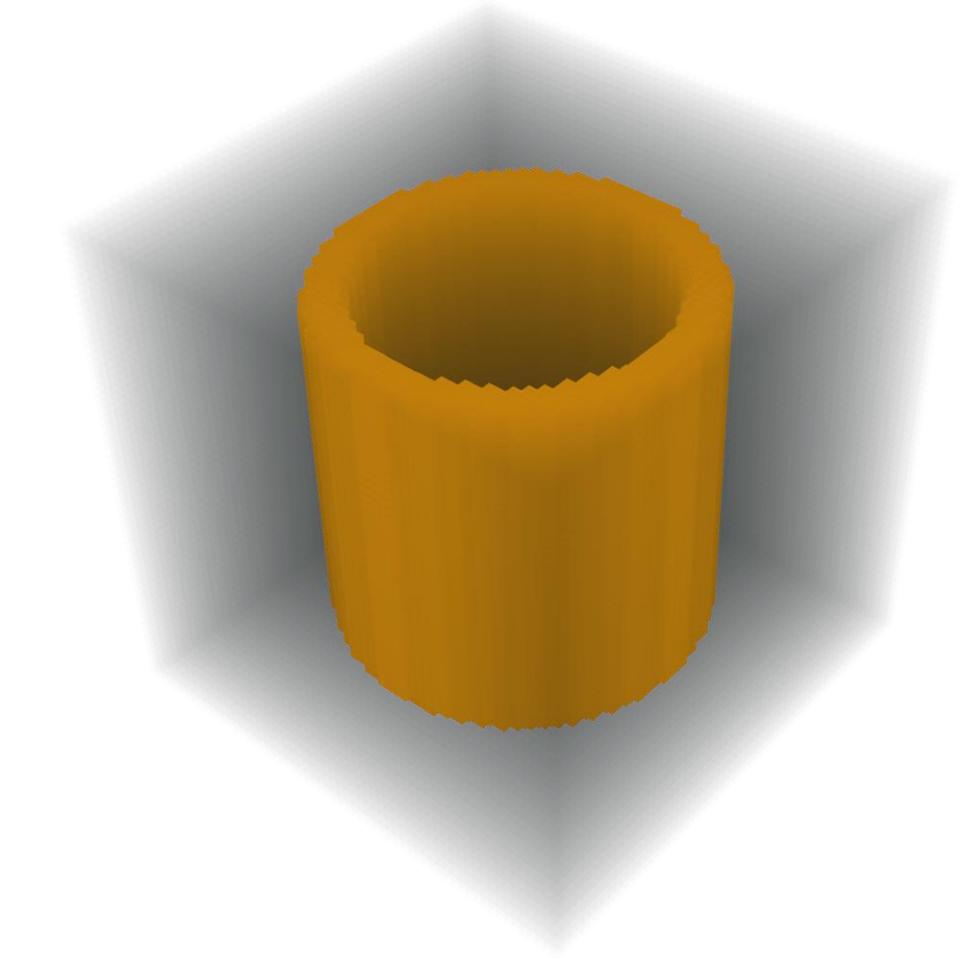
Currently you can fond several online platforms to transform 3D models from mesh to voxels



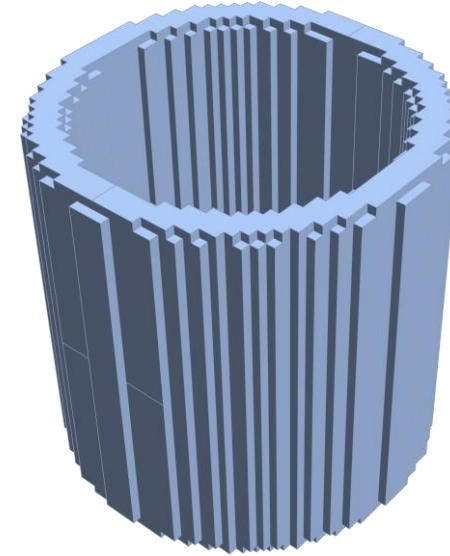
3D space voxel
60x60x60



Distances from
an object to every
3D point in a
60x60x60 3D
space



Selecting only
shortest
distances to the
object



The final voxel

3D object

Numerical vector

	→ { -154.283, -74.851, -78.3065, -13.9489, -108.249, 49.9639, 135.499 }
	→ { 1218.48, -4545.57, 2019.53, 5668.56, 441.047, 891.547, -4108.11 }
	→ { -136.967, -97.8868, -10.4024, -45.0804, -121.087, 25.0047, -137.749 }
	→ { 562.349, -1510.23, 1288.7, 2649.55, 376.452, 99.3022, -832.582 }
	→ { 30.9925, 17.1258, 621.028, 98.4733, -205.557, -210.251, 96.3287 }
	→ { -99.2109, -52.4264, 63.3743, -16.1669, -43.6128, 8.52891, -43.4448 }

Consider it as an image, therefore you can extract features as with Fourier

Self Organizing Maps

FEATURE VECTORS AND EUCLIDEAN DISTANCE

A reminder from the last lecture

Feature Vector

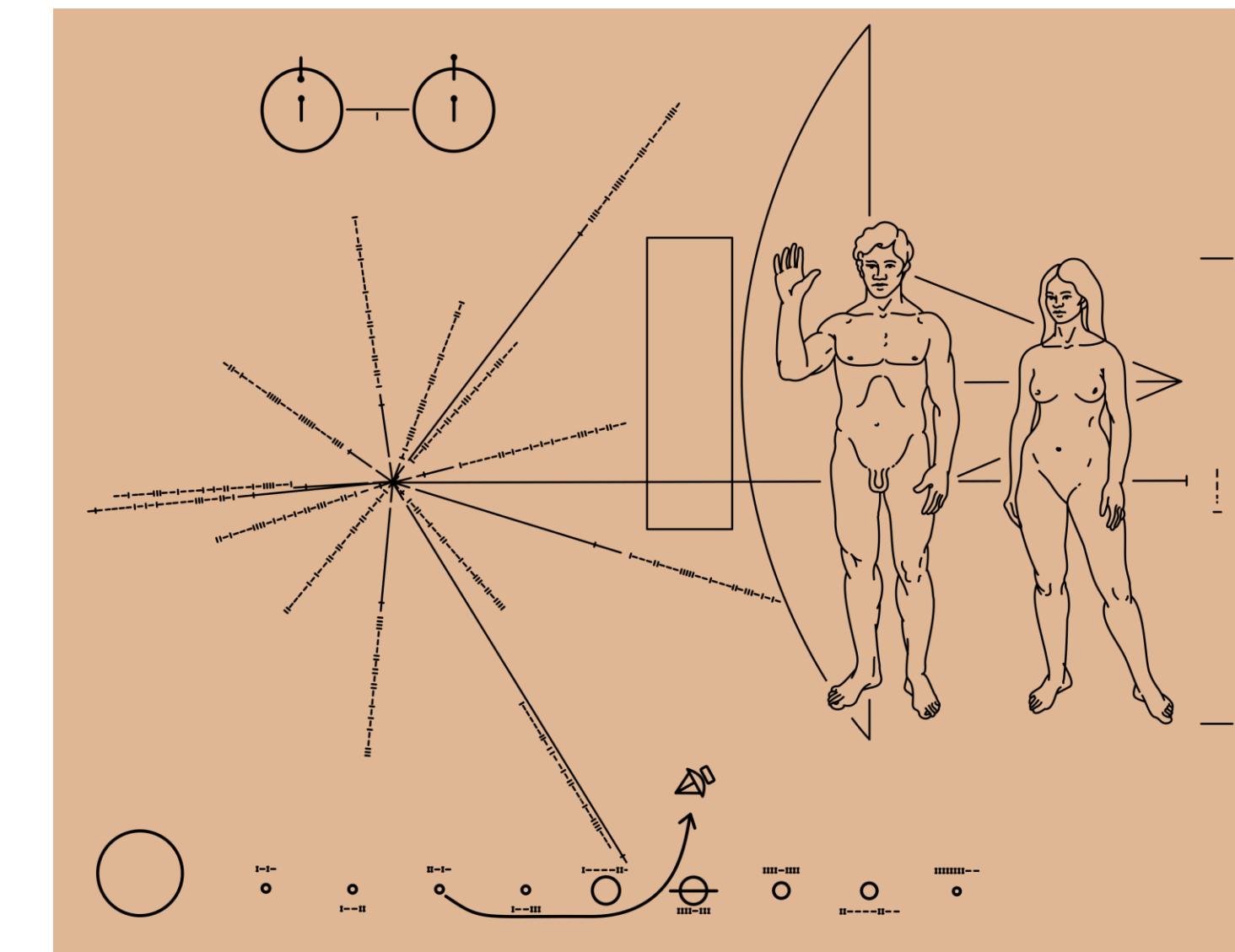
Numerical features that represent some object



An apple

(color, size, weight, sweetness)

(0 red, 12.3 cm, 180 g, 2 very)



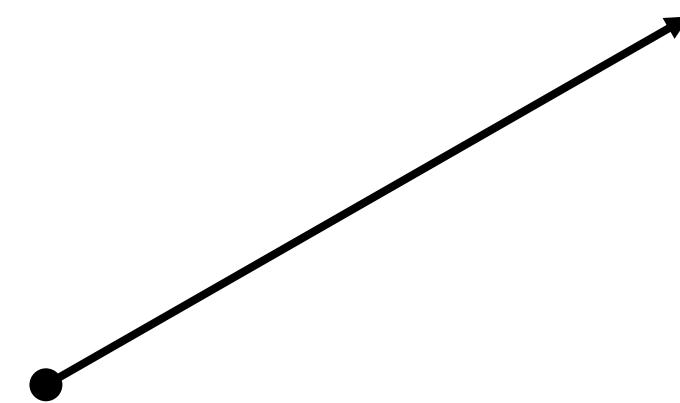
A person

(sex, age, weight, height)

(0 male, 25, 70 kg, 182 cm)

Euclidean distance

distance between two points in Euclidean space



Feature Vector + Euclidean Distance

A Common Ground for Comparing Objects



(color, size, weight, sweetness)

(0 red, 12.3 cm, 180 g, 2 very)

A



(color, size, weight, sweetness)

(1 orange, 11.7 cm, 170 g, 1 yes)

B

SELF-ORGANIZING MAP (SOM)

SUPERVISED

UNSUPERVISED

SEMI-SUPERVISED

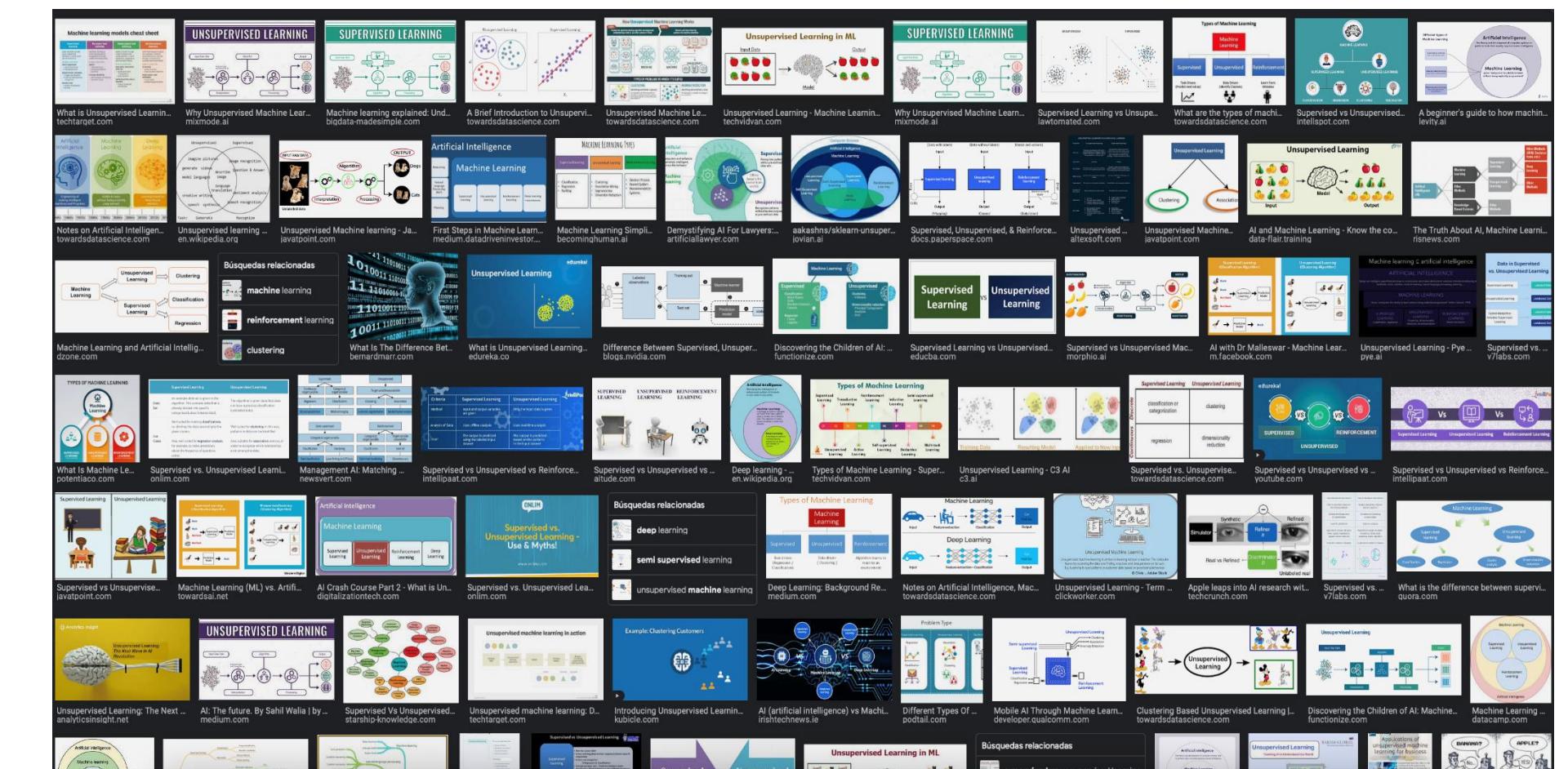
REINFORCEMENT LEARNING

SUPERVISED

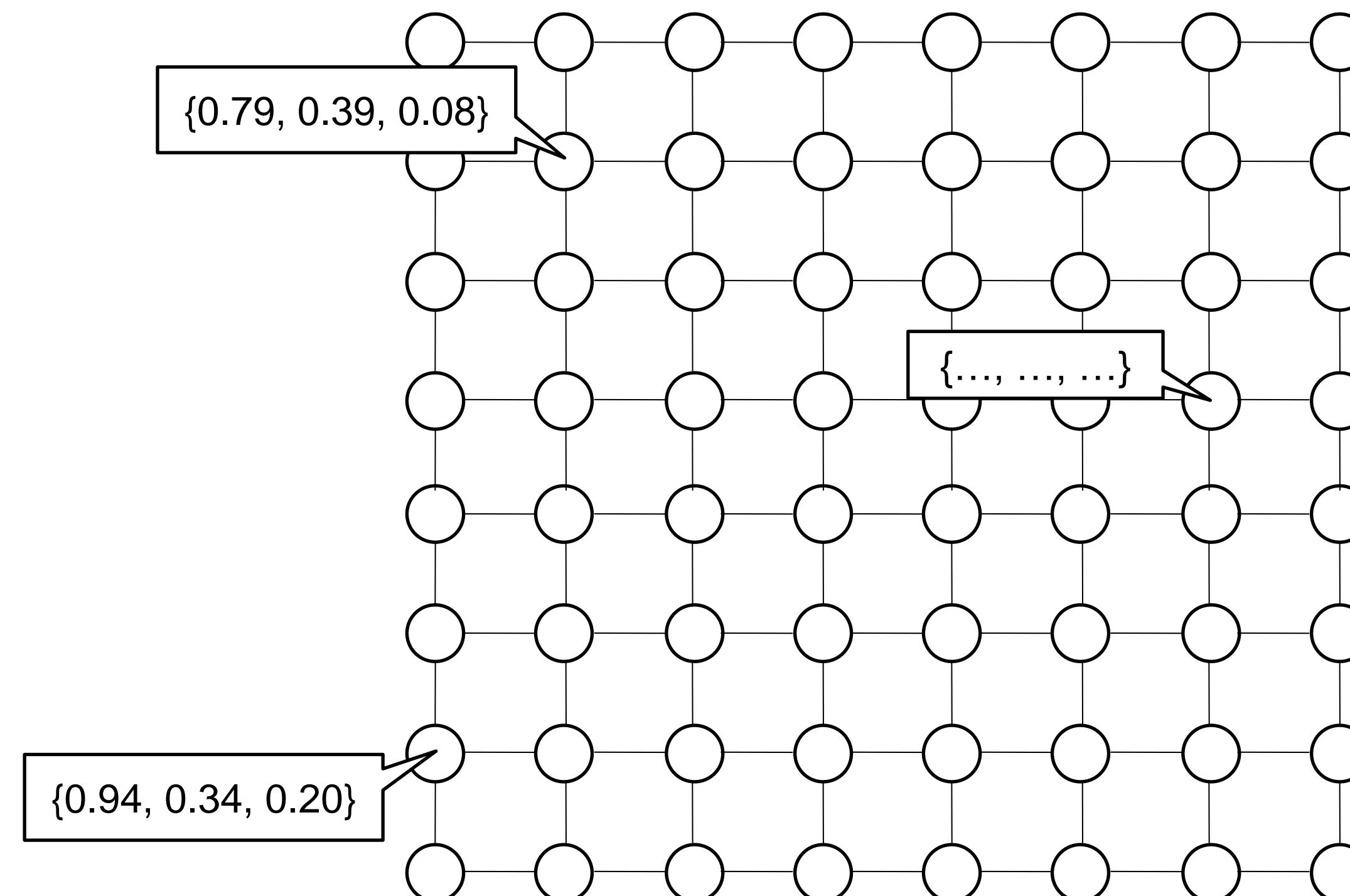
UNSUPERVISED

SEMI-SUPERVISED

REINFORCEMENT LEARNING



Self-organizing map Kohonen, 1982

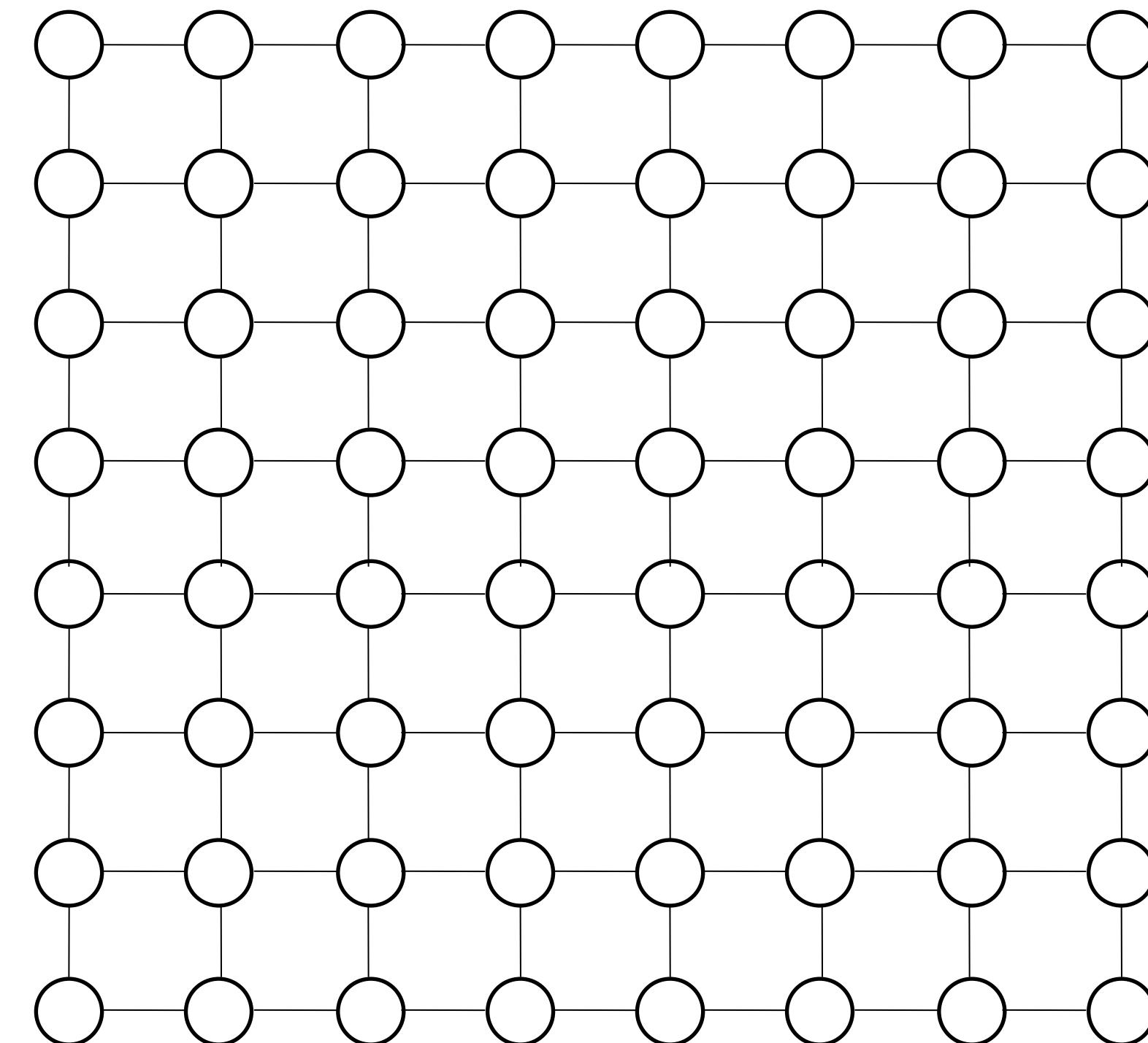


SOM is a grid of feature vectors (cells / units)
above is an example of $8 \times 8 \times 3$ SOM
where 8×8 is the size, 3 is the dimensionality of feature vectors

WHAT DOES SOM DO

A Projection from Given Data on Regular Grid

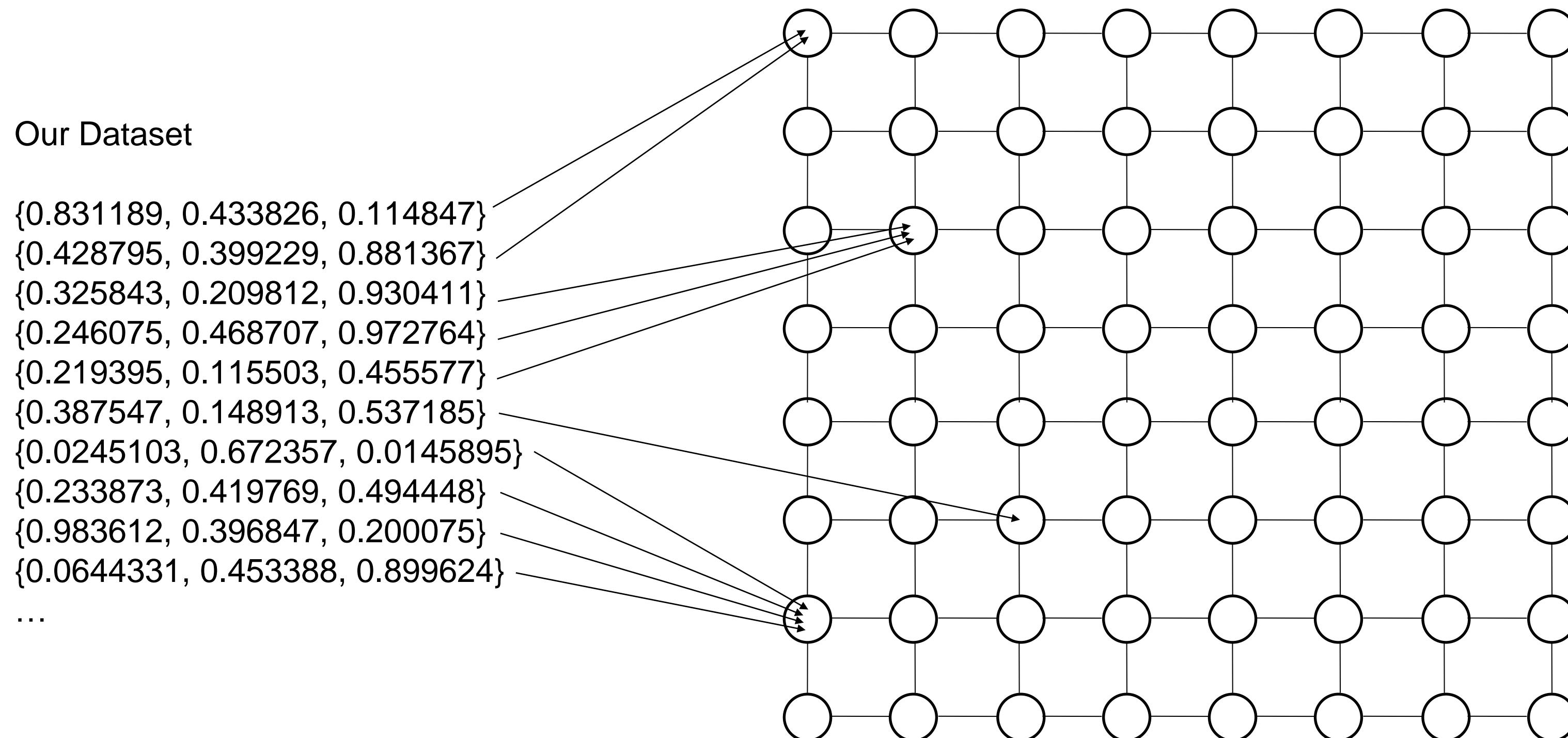
A “compressed” representation of our data



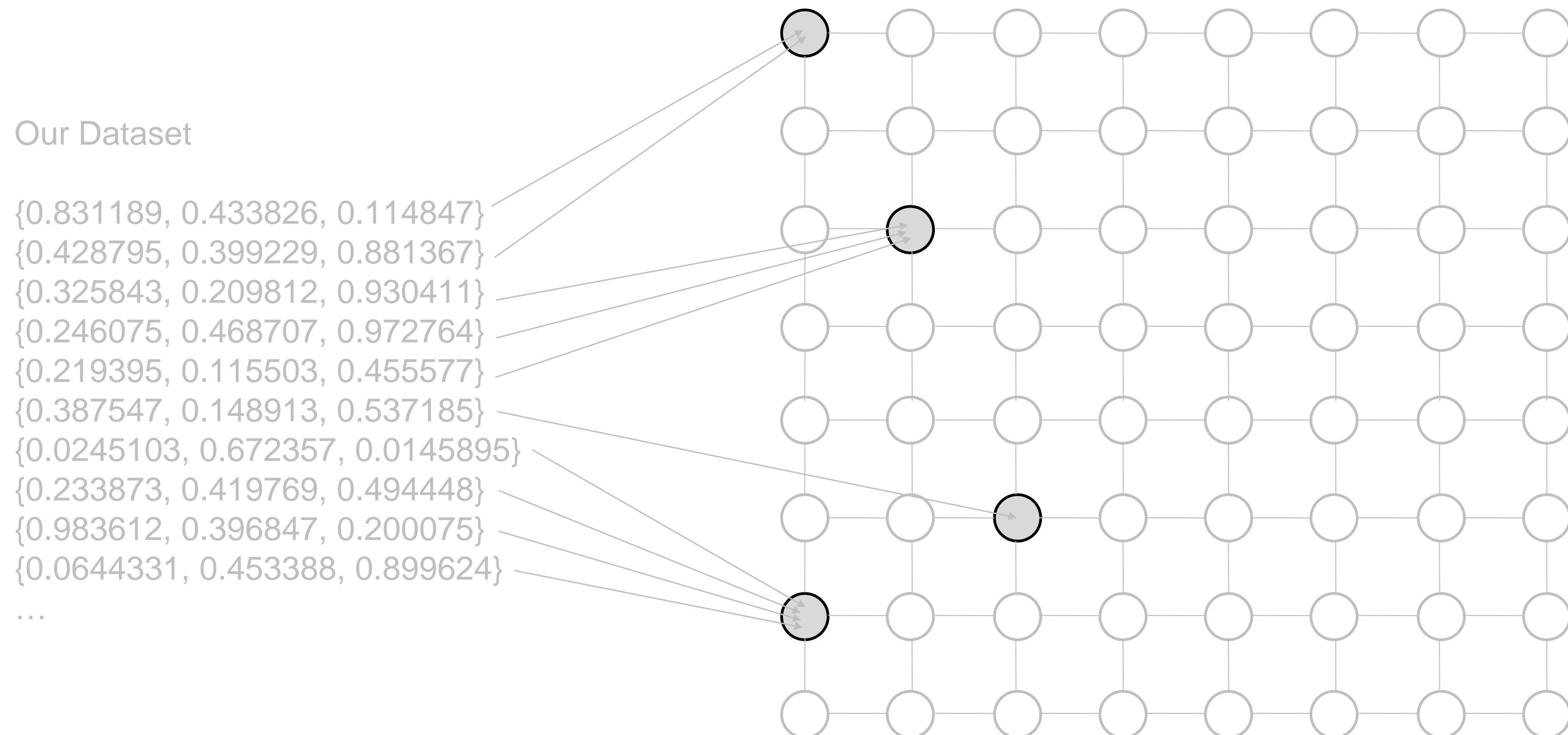
Each SOM cell represents a cluster of similar items from our dataset

A Projection from Given Data on Regular Grid

A “compressed” representation of our data



The Best Matching Unit (BMU)



For the items of our dataset, their corresponding SOM cells are called their **BEST MATCHING UNIT**

MORE IN DETAIL

Training the SOM

A Huge Dataset Impossible to Manage Manually

For example 100k feature vectors of apples

(color, size, weight, sweetness)



(0 red, 12.3 cm, 180 g, 2 very)



(1 orange, 11.7 cm, 170 g, 1 yes)

...

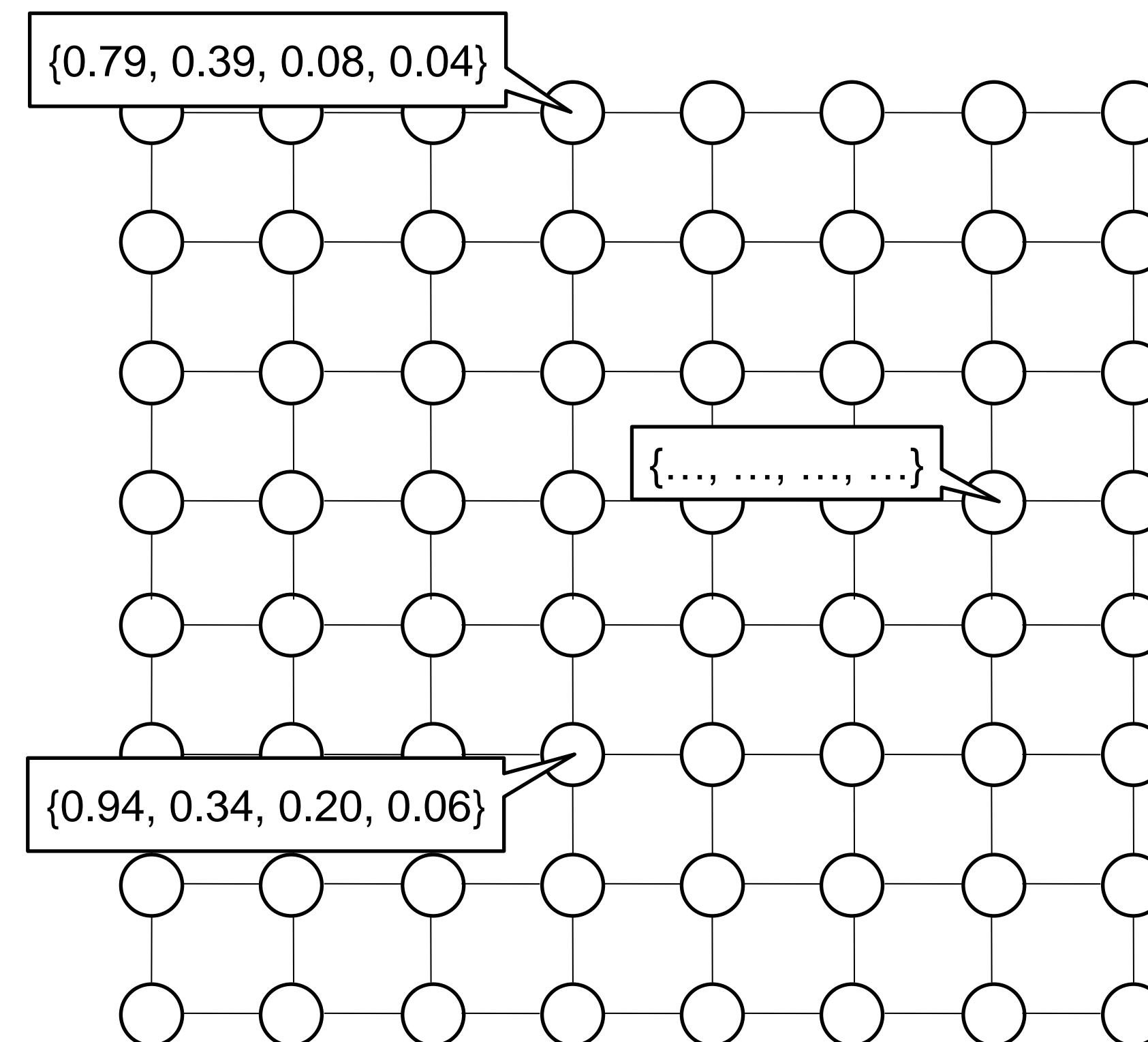
(..., ..., ..., ...)

But we know some of them are similar to each other

A Random SOM

Our dataset

{0.837001,0.727544,0.0394684,0.299028}
{0.684913,0.337634,0.892134,0.794974}
{0.178787,0.837747,0.2533,0.182625}
{0.352355,0.611677,0.643471,0.486624}
{0.0623343,0.330299,0.440126,0.550363}
{0.95928,0.453402,0.250339,0.138137}
{0.906858,0.0194981,0.464387,0.836483}
{0.70246,0.532199,0.463251,0.0710004}
{0.84464,0.606172,0.864091,0.26712}
{0.427036,0.299789,0.128026,0.759577}
...



We create a SOM with its feature vectors randomly initialized

Find BMU

Our dataset

{0.837001,0.727544,0.0394684,0.299028}

{0.684913,0.337634,0.892134,0.794974}

{0.178787,0.837747,0.2533,0.182625}

{0.352355,0.611677,0.643471,0.486624}

{0.0623343,0.330299,0.440126,0.550363}

{0.95928,0.453402,0.250339,0.138137}

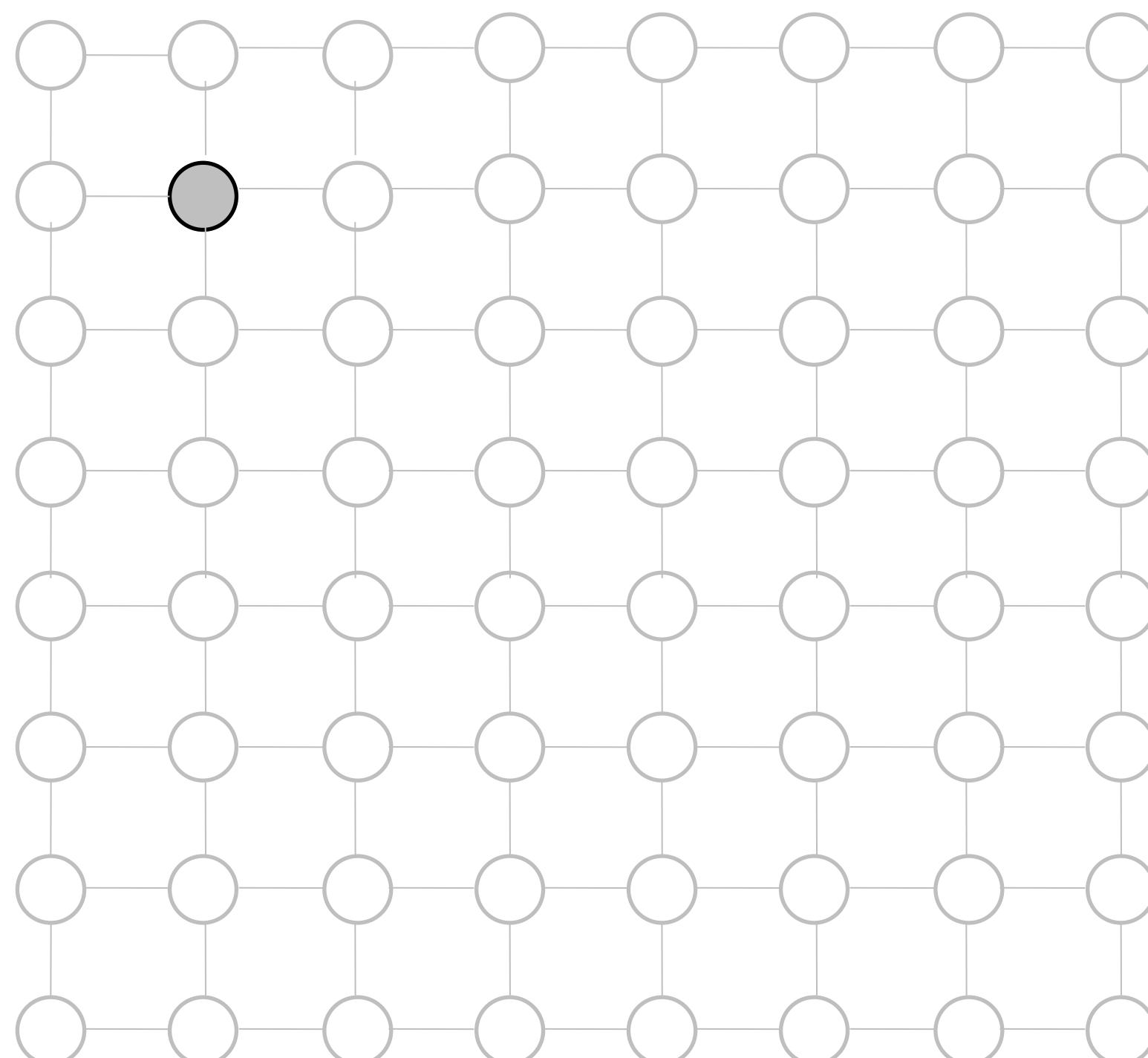
{0.906858,0.0194981,0.464387,0.836483}

{0.70246,0.532199,0.463251,0.0710004}

{0.84464,0.606172,0.864091,0.26712}

{0.427036,0.299789,0.128026,0.759577}

...



We randomly select one item from our dataset, find its BMU

Update BMU Feature Vector

“Stretching” the SOM in feature space

Our dataset

{0.837001,0.727544,0.0394684,0.299028}

{0.684913,0.337634,0.892134,0.794974}

{0.178787,0.837747,0.2533,0.182625}

{0.352355,0.611677,0.643471,0.486624}

{0.0623343,0.330299,0.440126,0.550363}

{0.95928,0.453402,0.250339,0.138137}

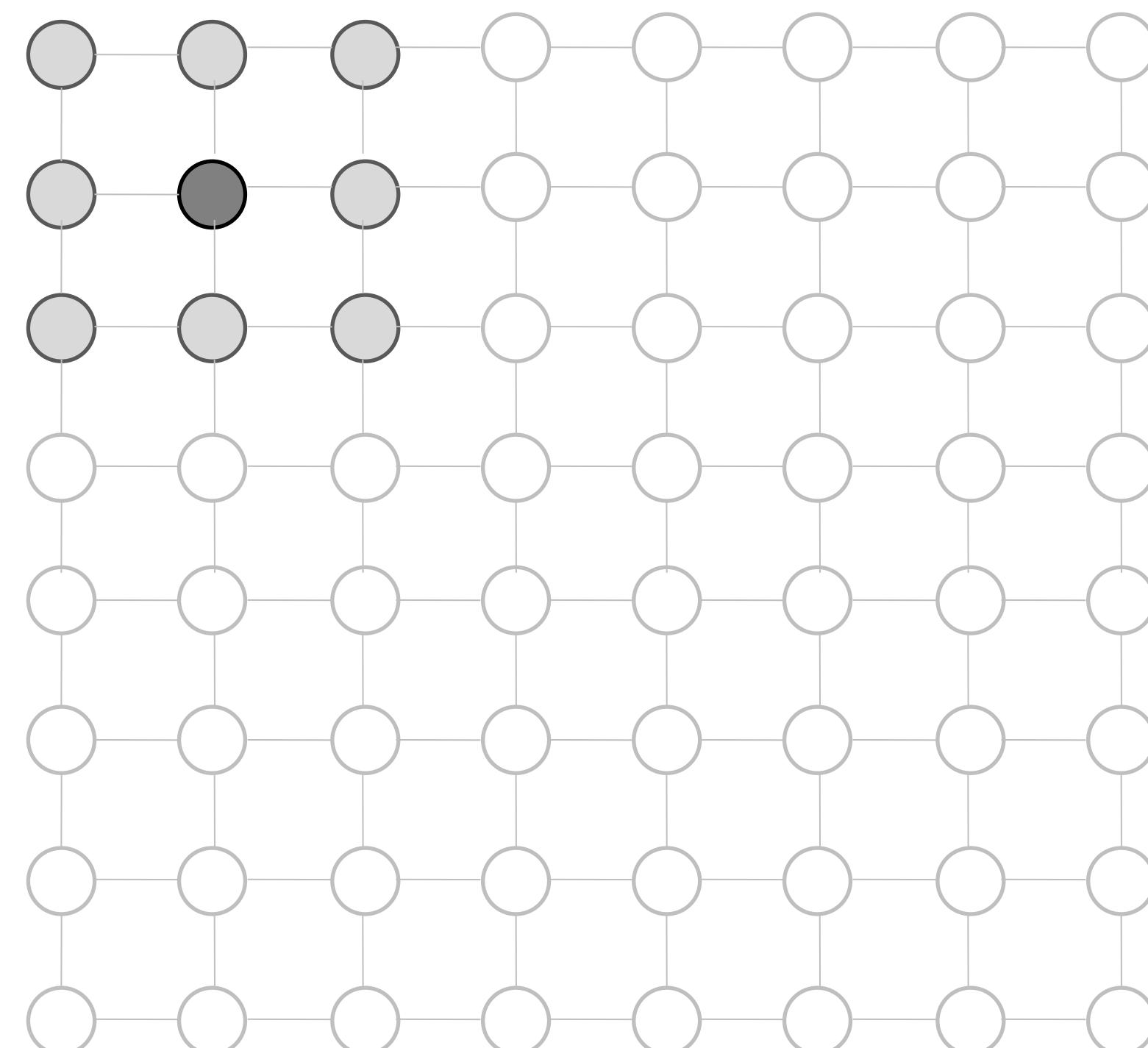
{0.906858,0.0194981,0.464387,0.836483}

{0.70246,0.532199,0.463251,0.0710004}

{0.84464,0.606172,0.864091,0.26712}

{0.427036,0.299789,0.128026,0.759577}

...



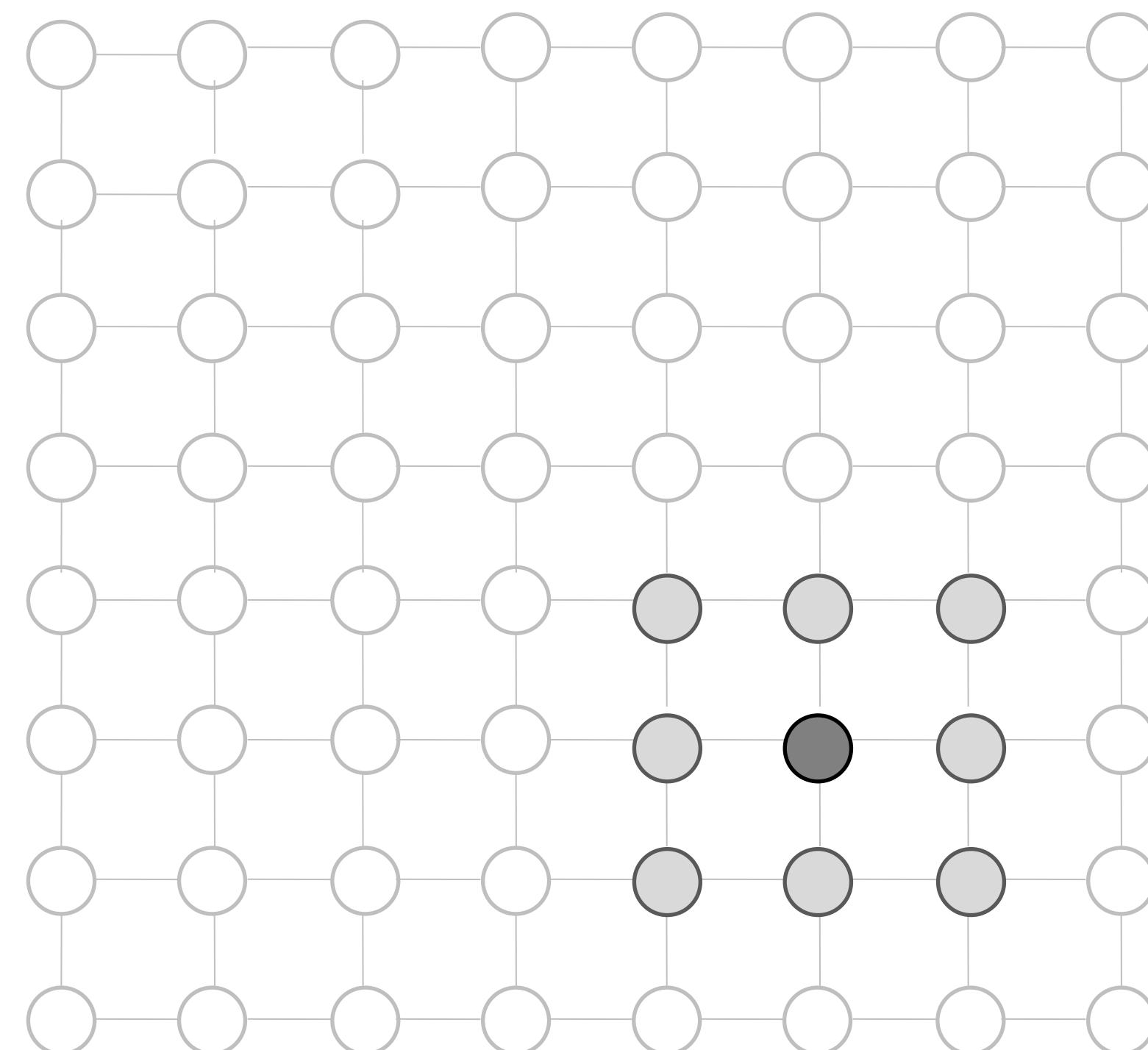
We update the BMU and its neighbors' feature vectors so that they are similar to our selected element
The update is stronger to the BMU than to its neighbors

Update BMU Feature Vector

“Stretching” the SOM in feature space

Our dataset

```
{0.837001,0.727544,0.0394684,0.299028}  
{0.684913,0.337634,0.892134,0.794974}  
{0.178787,0.837747,0.2533,0.182625}  
{0.352355,0.611677,0.643471,0.486624}  
{0.0623343,0.330299,0.440126,0.550363}  
{0.95928,0.453402,0.250339,0.138137}  
{0.906858,0.0194981,0.464387,0.836483}  
{0.70246,0.532199,0.463251,0.0710004}  
{0.84464,0.606172,0.864091,0.26712}  
{0.427036,0.299789,0.128026,0.759577}  
...
```



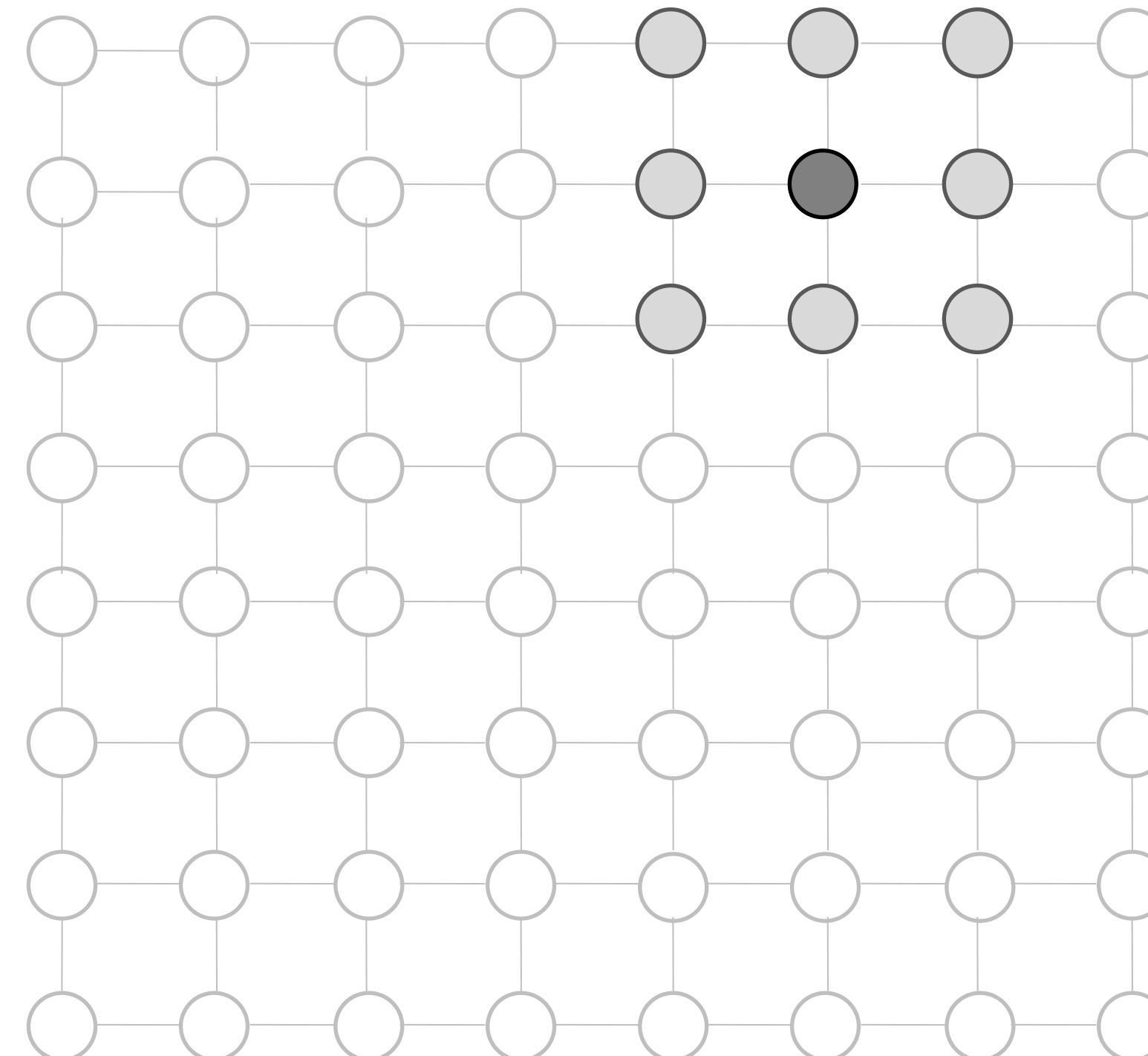
We move to another randomly selected item, and repeat the process

Update BMU Feature Vector

“Stretching” the SOM in feature space

Our dataset

```
{0.837001,0.727544,0.0394684,0.299028}  
{0.684913,0.337634,0.892134,0.794974}  
{0.178787,0.837747,0.2533,0.182625}  
{0.352355,0.611677,0.643471,0.486624}  
{0.0623343,0.330299,0.440126,0.550363}  
{0.95928,0.453402,0.250339,0.138137}  
{0.906858,0.0194981,0.464387,0.836483}  
{0.70246,0.532199,0.463251,0.0710004}  
{0.84464,0.606172,0.864091,0.26712}  
{0.427036,0.299789,0.128026,0.759577}  
...
```

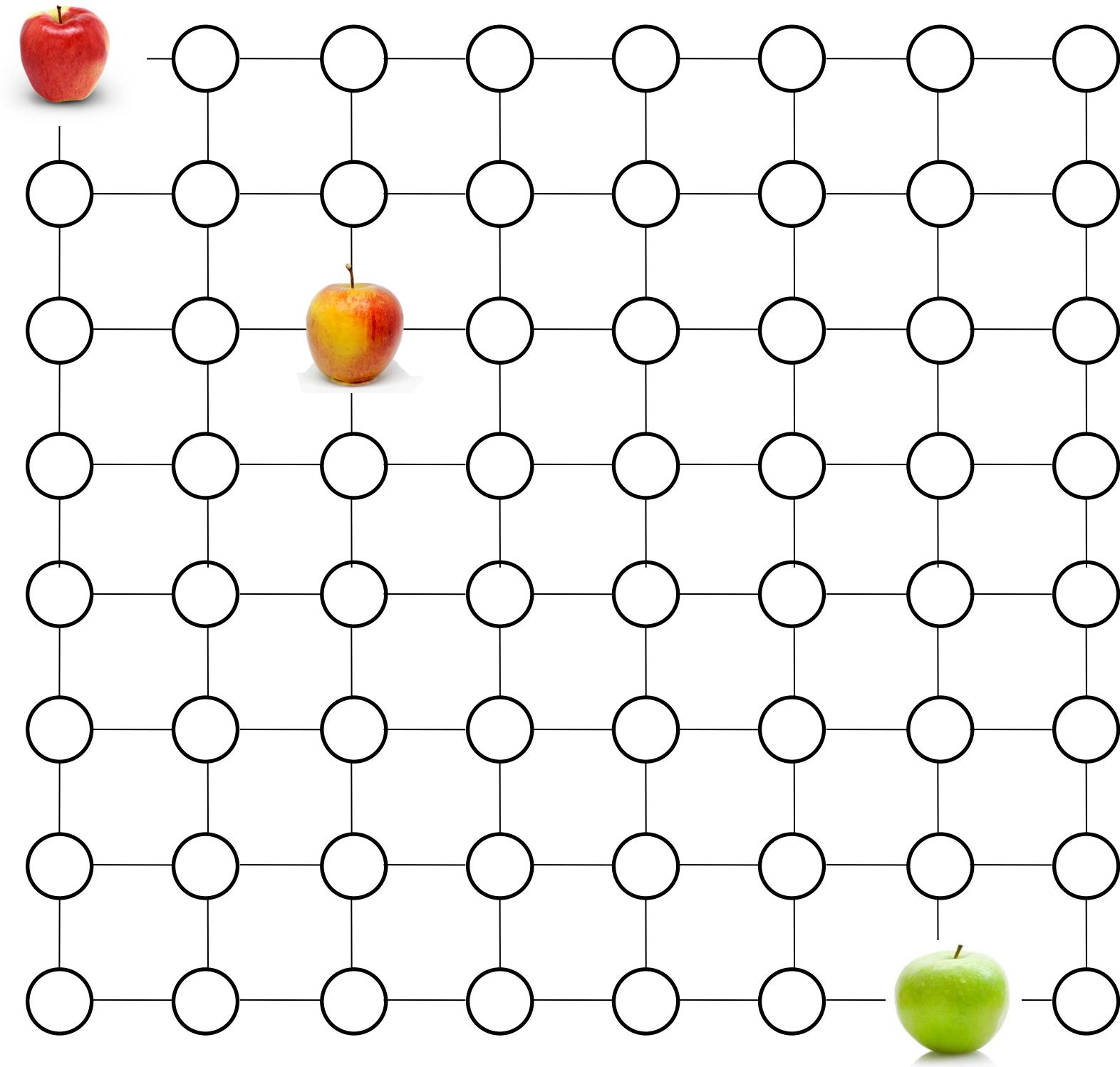


Repeating the process over the entire dataset called an Epoch
We do many Epochs with the radius of neighbor cells decreasing

WHAT IS A TRAINED SOM GOOD FOR

Data Visualization

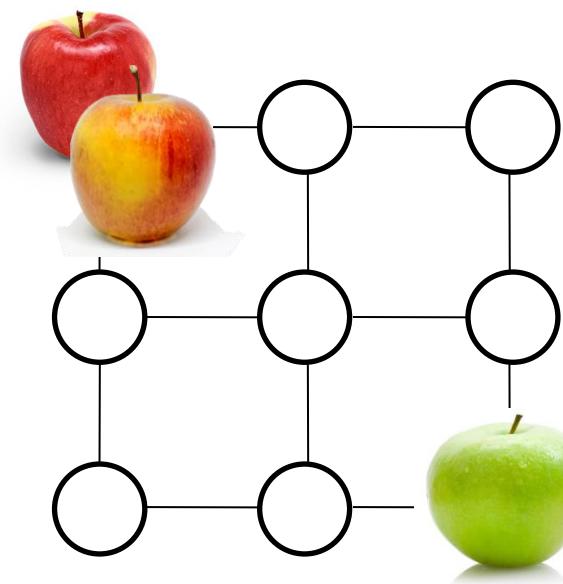
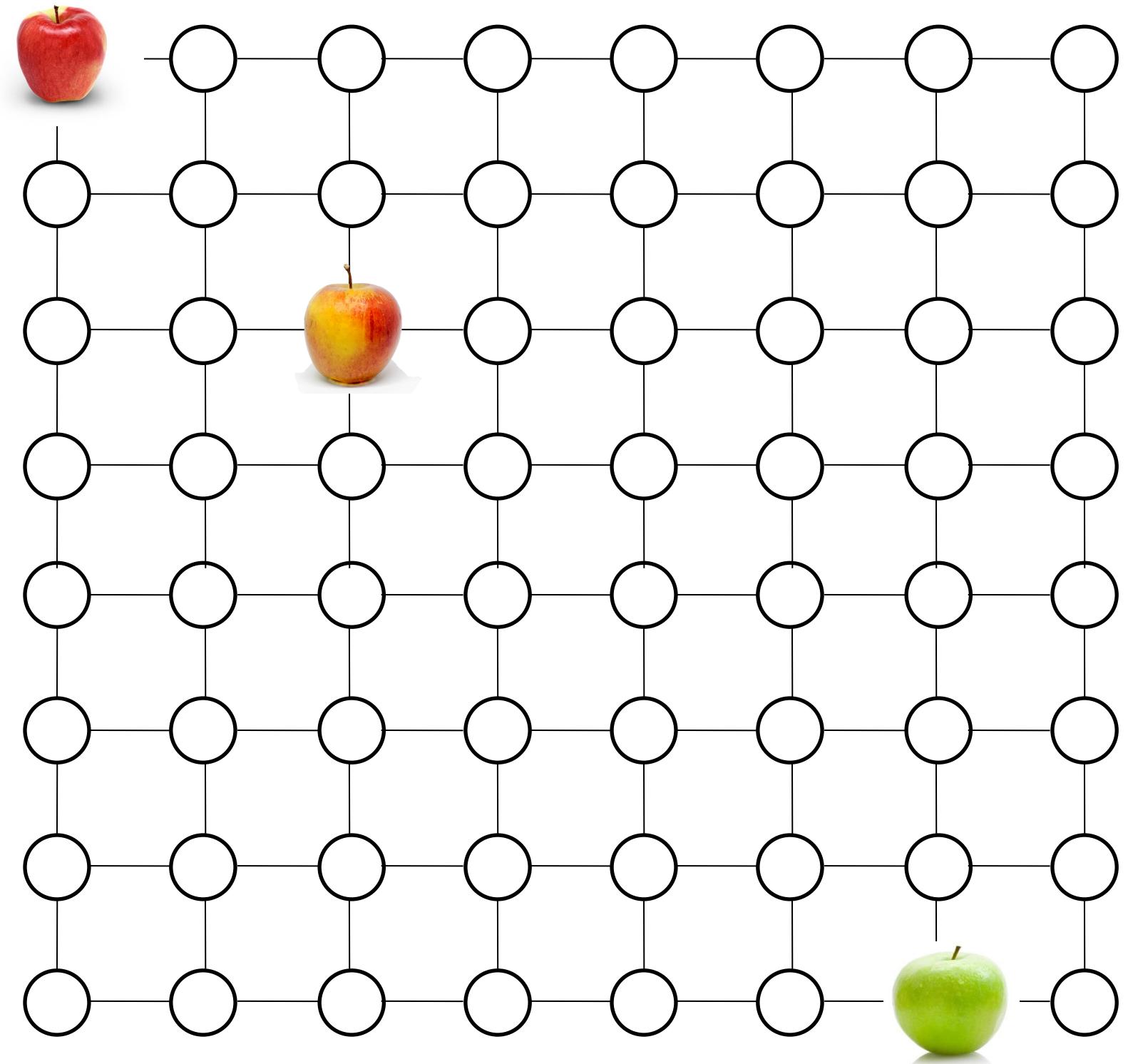
An overview of a huge dataset



Render each SOM cell using the items it contains

Clustering

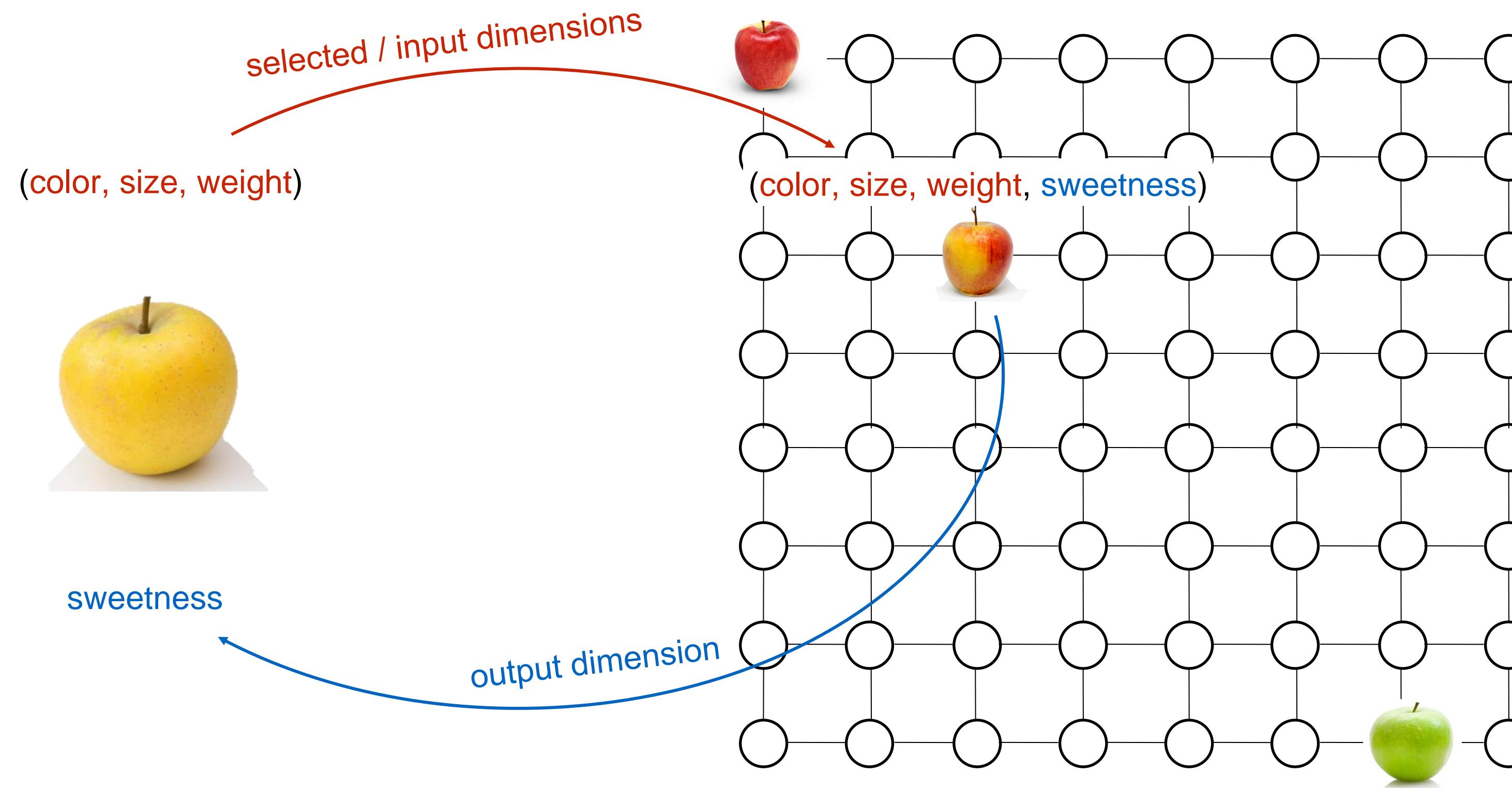
Group similar items



By playing with SOM size we can group our data to different number of clusters

Make Predictions

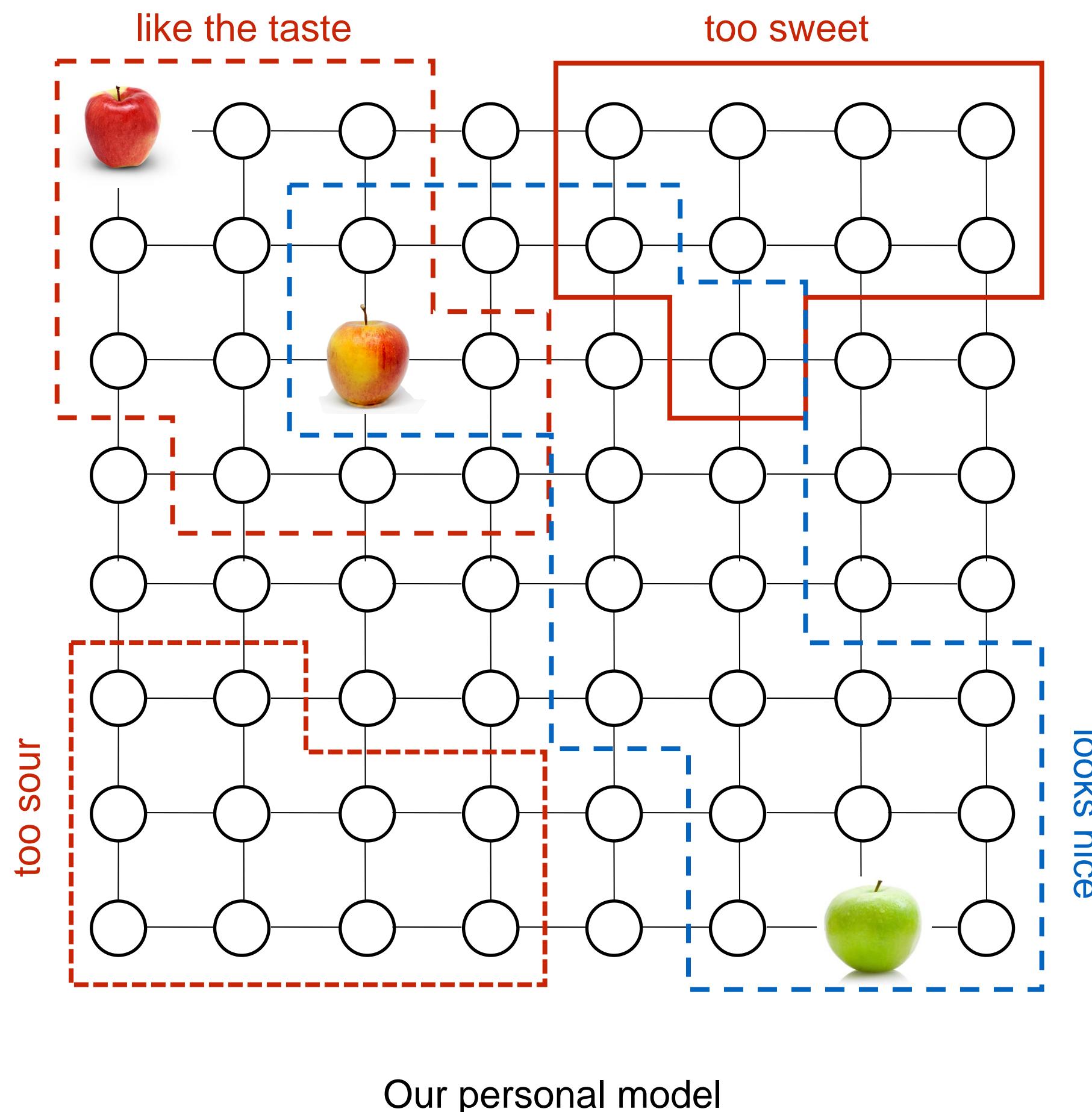
Use some dimensions to predict other dimensions



Calculate the Euclidean distance and find the BMU using only selected dimensions

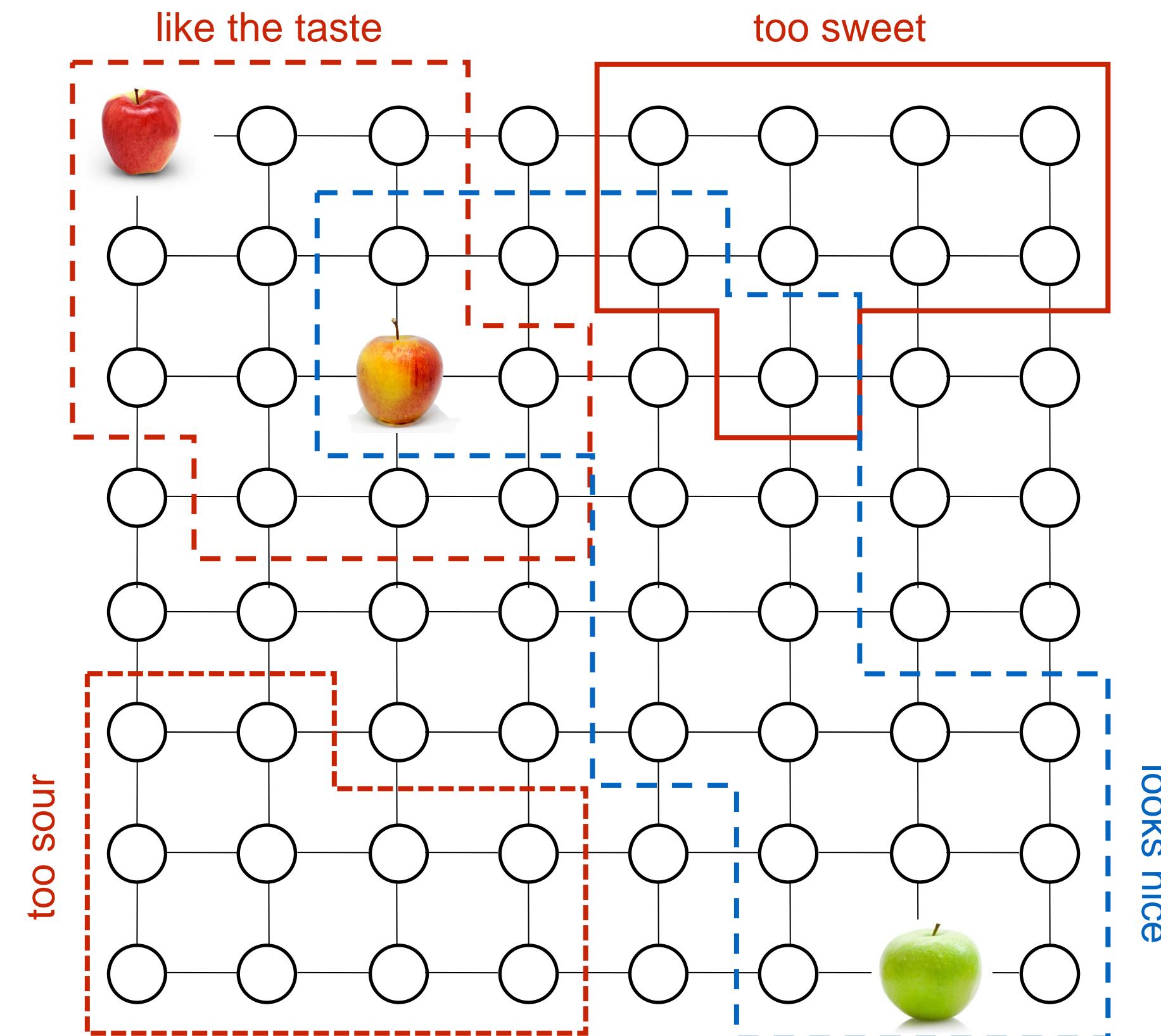
Creating (Personal) Labels

Give personal meanings to the SOM cells (clusters)



Reverse Data Visualization

Project SOM cells (e.g. personal labels) back to our dataset



e.g. project the personal label back into space



NAVIGATING THE SPACE

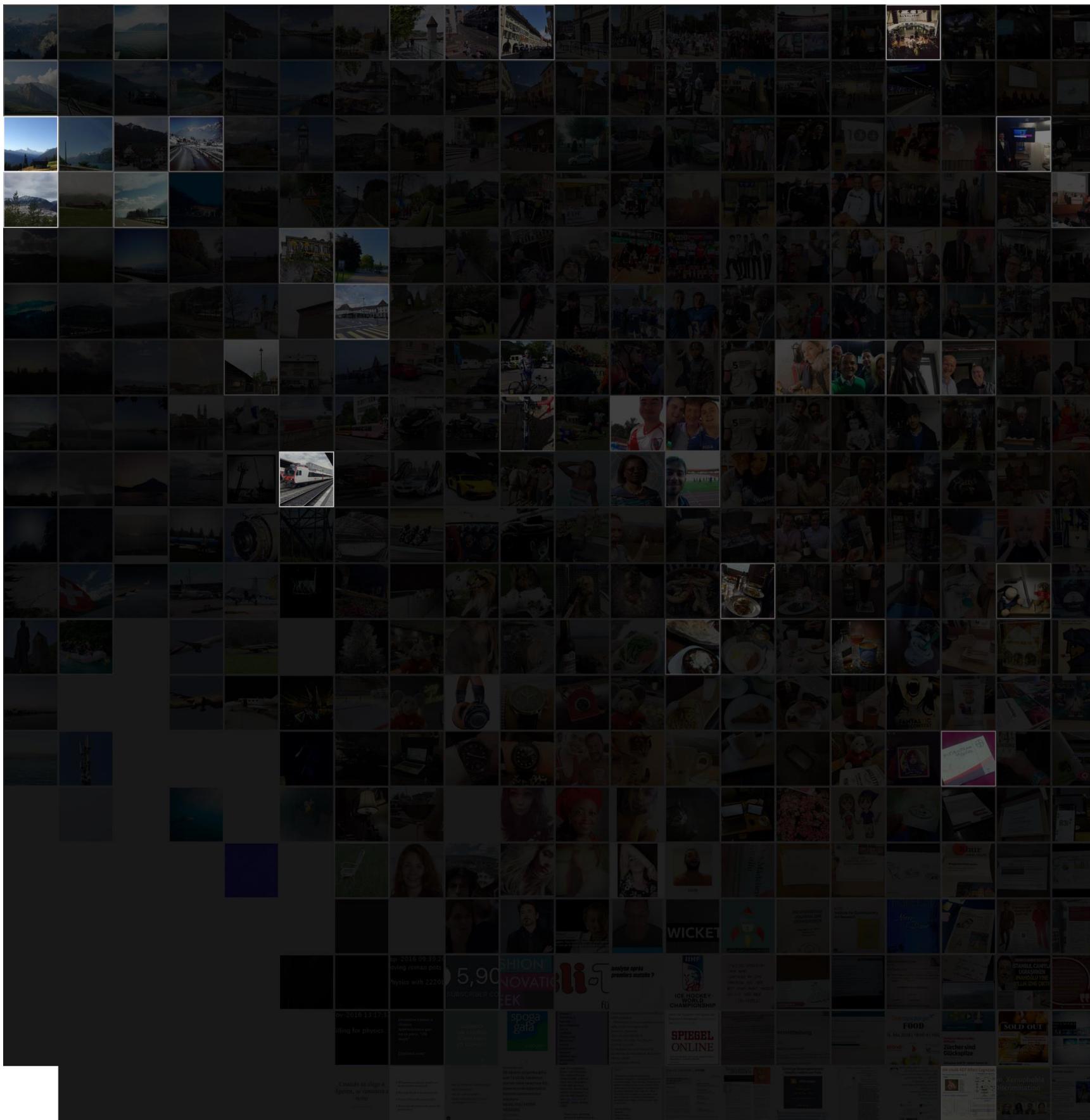
Working with some tweets within Switzerland

A SOM of Swiss Tweets

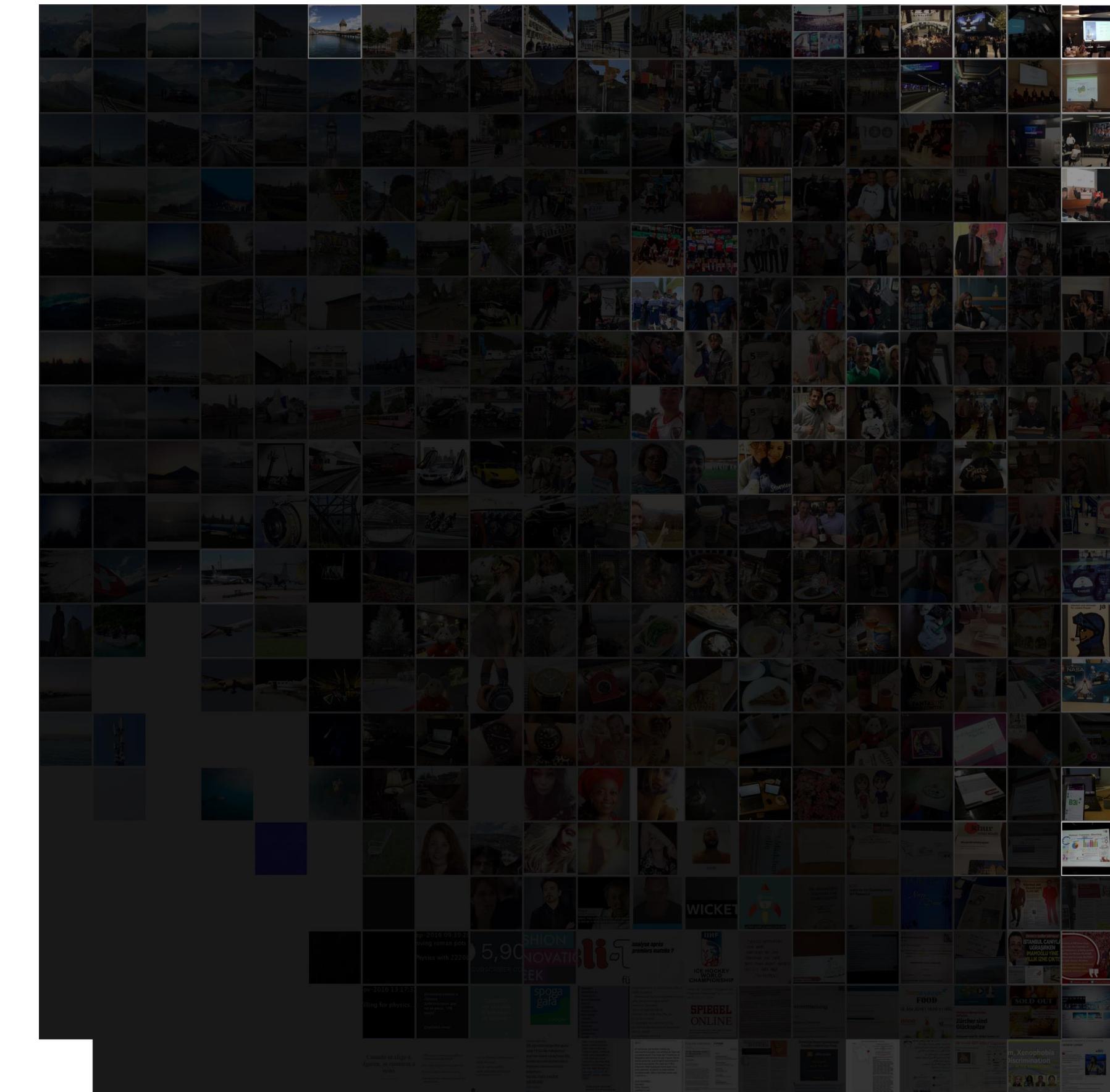
Tweets were collected based on locations (cities of Switzerland)



Highlight BMUs



Chur

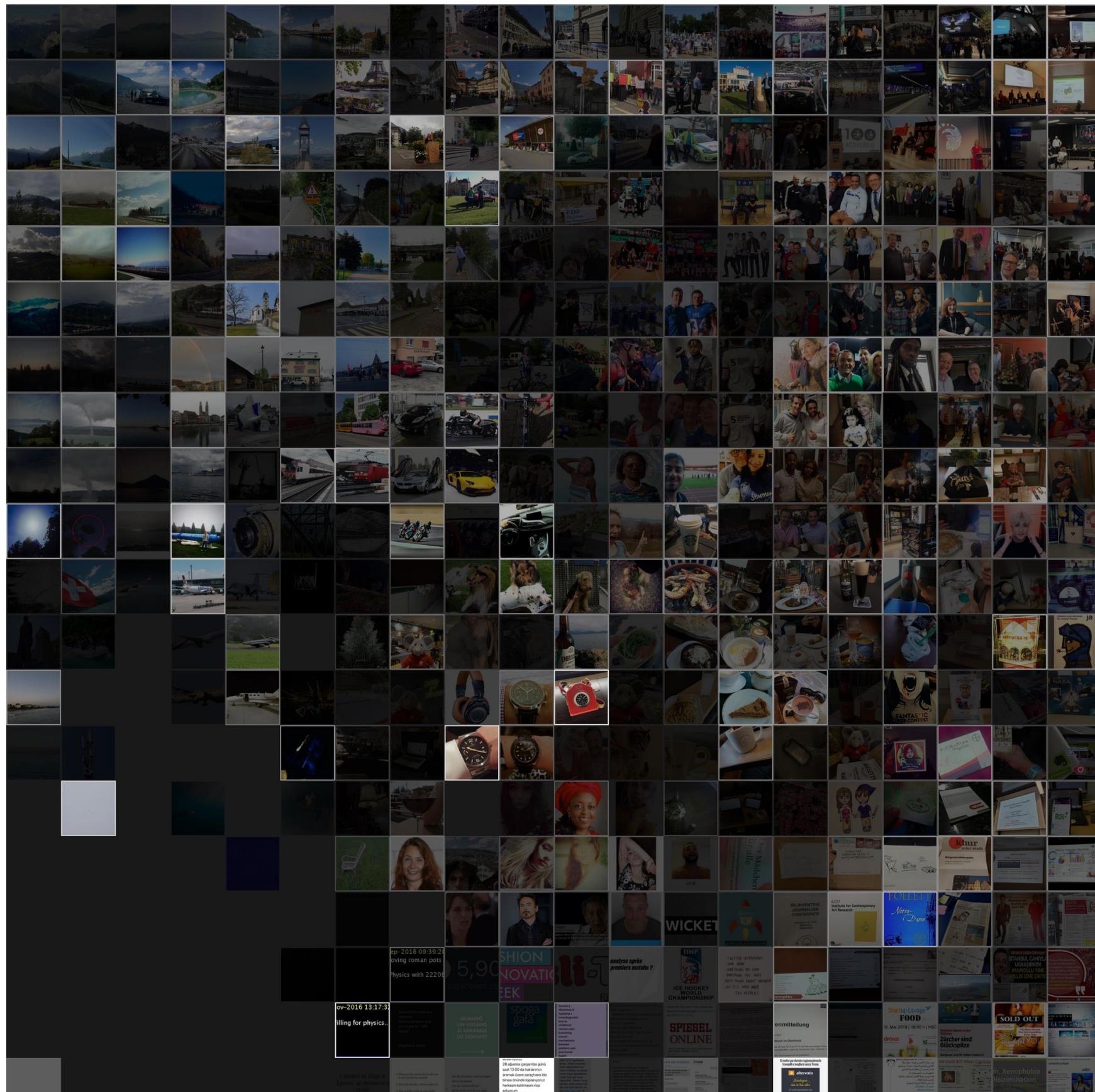


Zurich

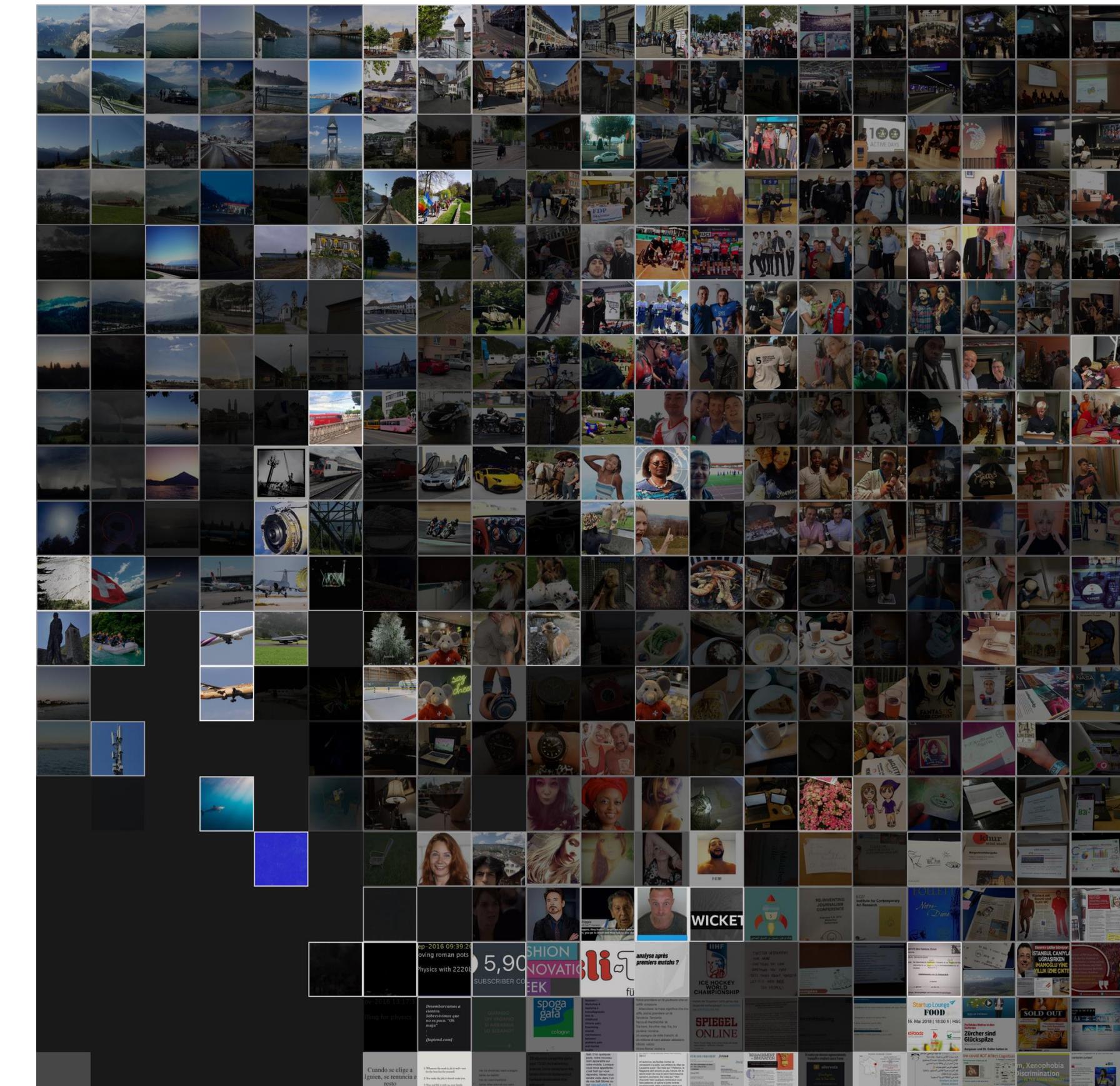
Retrieve the BMUs of the data from Chur and Zurich, and highlight these BMUs respectively

- College of Design Construction and Planning
- AI on the Built Environment
- DCP 4300
- Charles Wang
- Karla Saldana Ochoa

Highlight BMUs



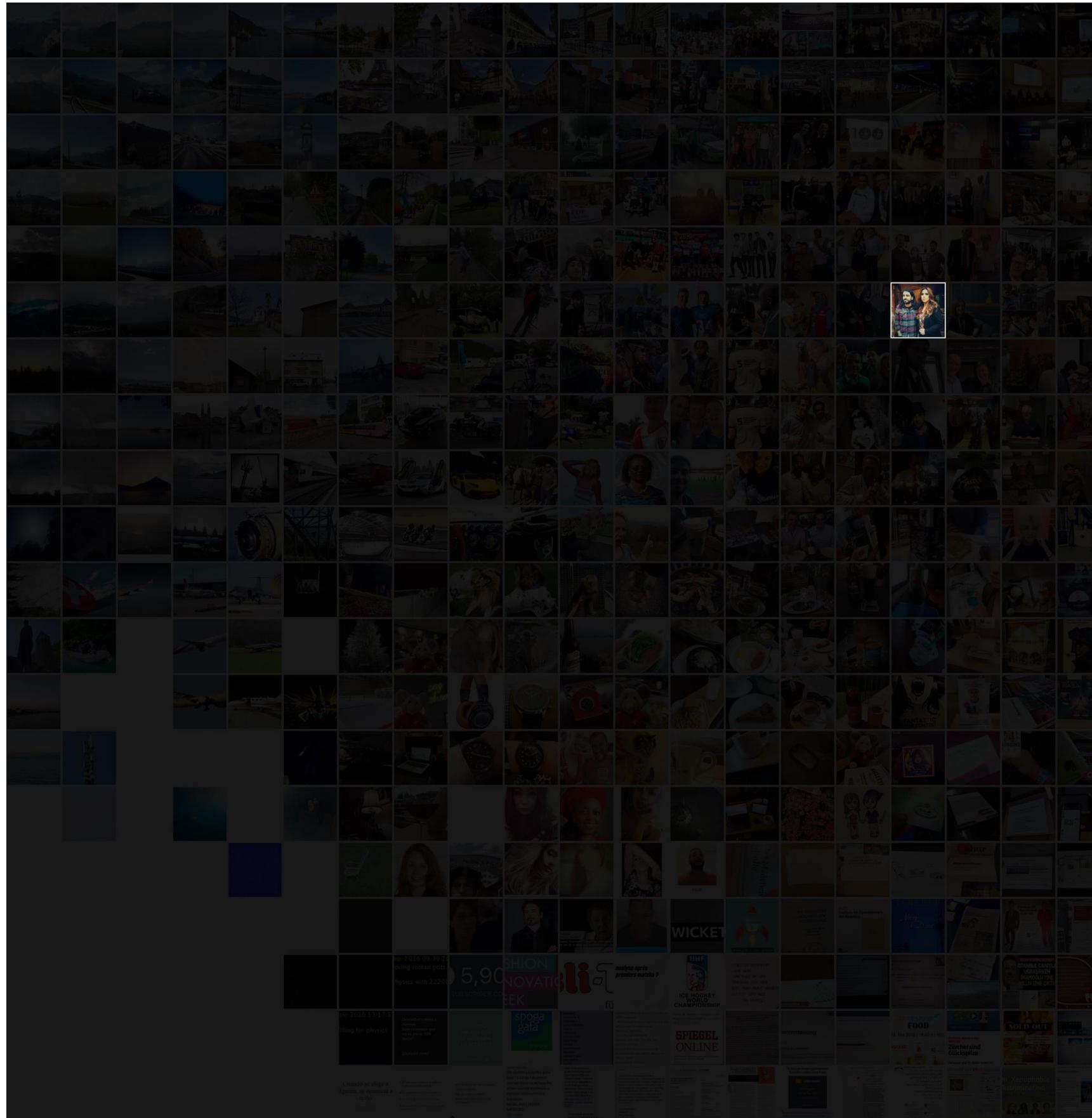
2015-2017



2017-2019

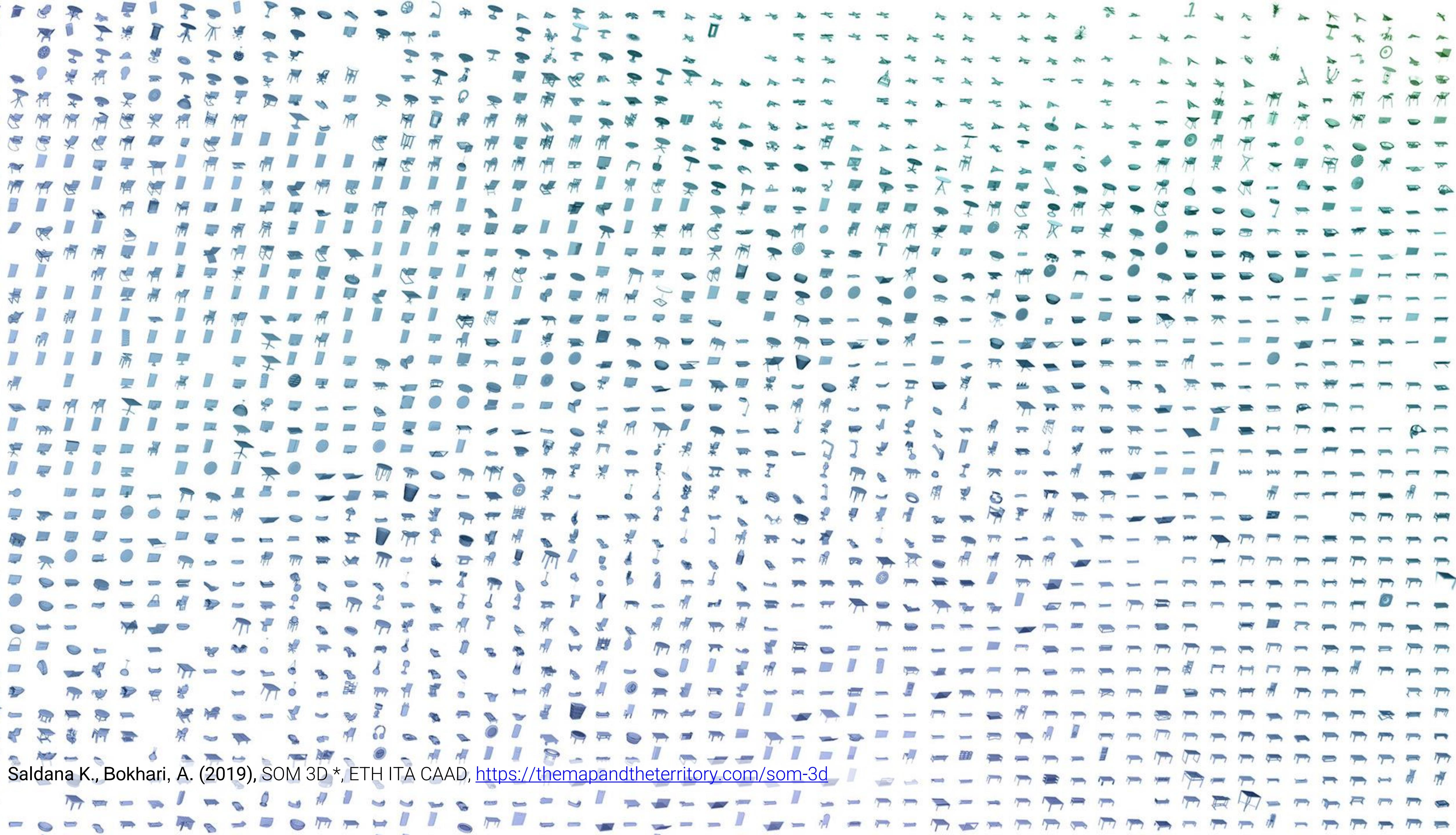
Or by different time period

- College of Design Construction and Planning
- AI on the Built Environment
- DCP 4300
- Charles Wang
- Karla Saldana Ochoa



EXAMPLES OF SOMS ON DIFFERENT TYPES OF DATA

We can render SOM cells by the items they contain



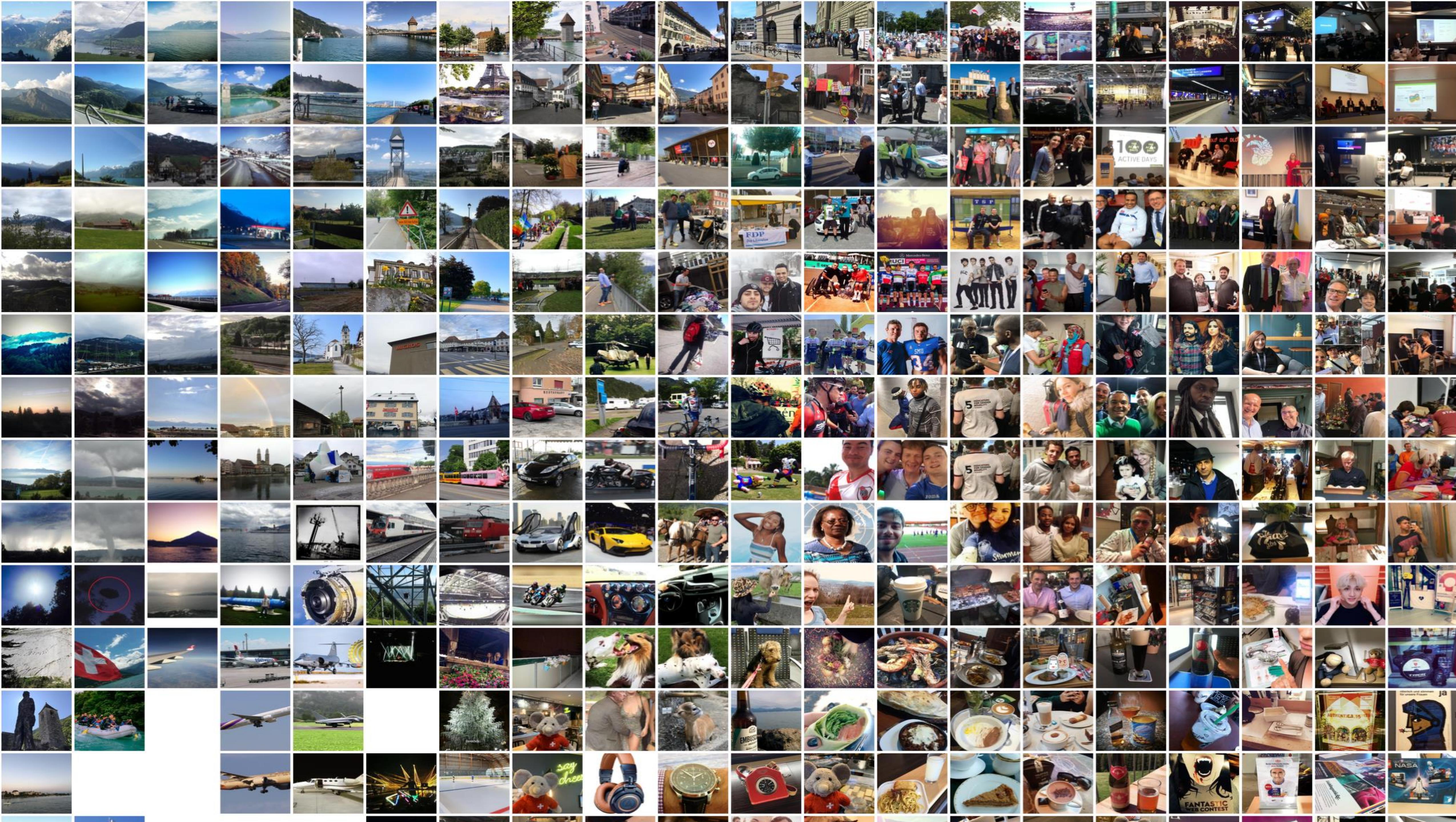
Saldana K., Bokhari, A. (2019), SOM 3D *, ETH ITA CAAD, <https://themapandtheterritory.com/som-3d>



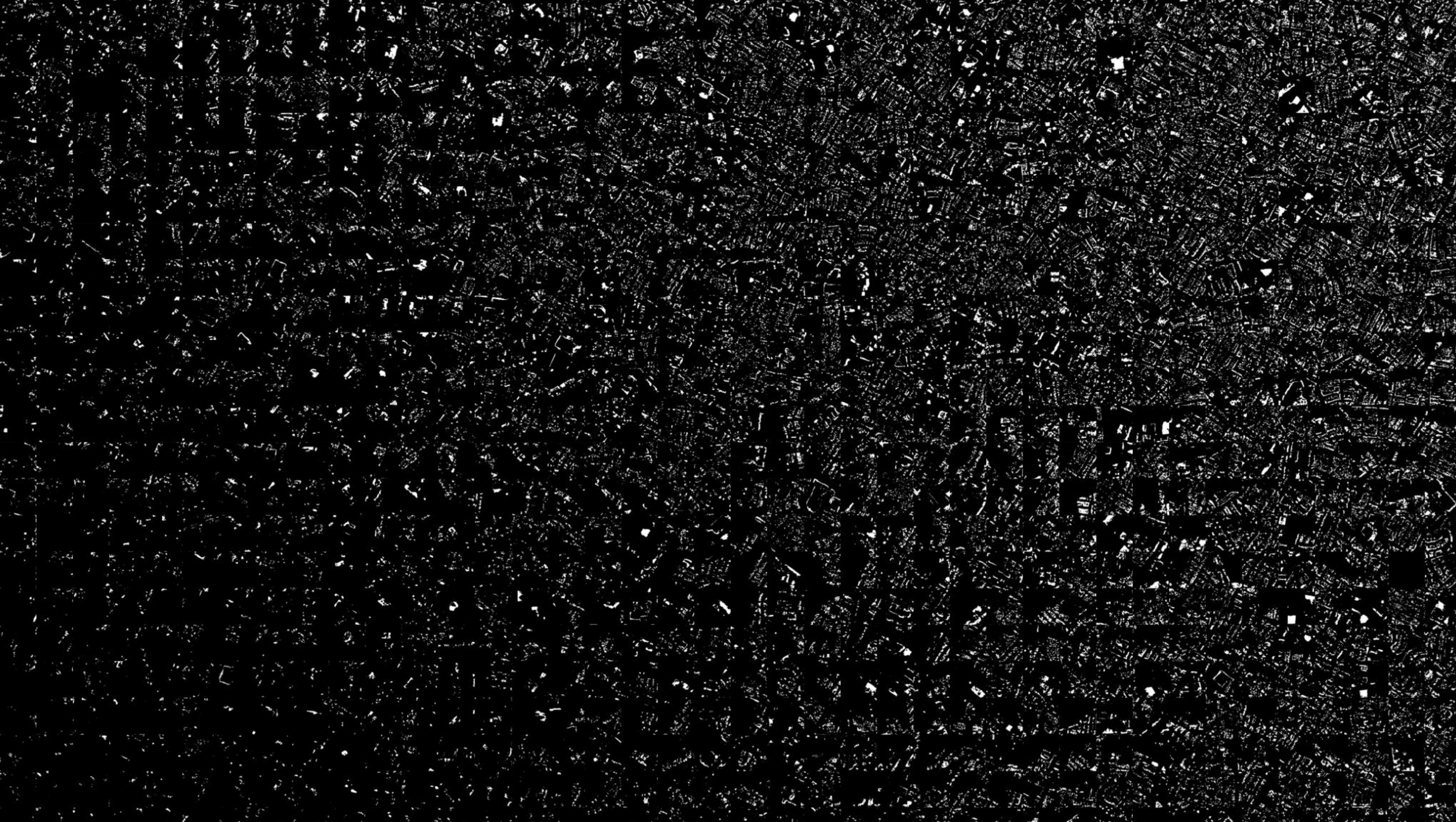
Alvarez D., Saldana K., (2017), City of indexes, Elective course 2017, ETH ITA CAAD Praxis 2018



Alvarez D., Saldana K., (2017), City of indexes, Elective course 2017, ETH ITA CAAD Praxis 2018

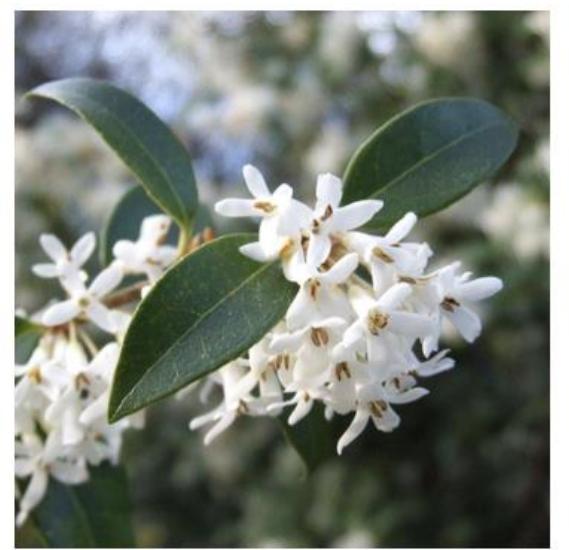


program developer and researcher	researcher and academic peers	local economic development	campus culture	research student	campus university	student	development and journalism	academic publications network	Health safety	Human rights	strategizing development and communication strategy	other	context world research need	program	video need population right	organized local government	development and world member communities	project	
education model school	community foundation religious hub	president university	community	research	student school	participate space club activity	policy	report re national lab	disaster program safety emergency	ts government protection	house persons	right people advocacy street	world people community	contact participation network of life	education women foundation people	social community work	marketing people house owned	development and expertise community value	
student center	and day dormitories	project support students	learning world journey education	outlook college program	university research	science	terrorism issue employee health	program	organizat on state	army local based upper	country age experience	social	community	support help	program	health care	method name basic tool	people	
scholar	don and student found	out division workplace mount	center	school	education student school social	gallery charity diversified annual	research round table study	report news	capacity building sector magazine	challange award life provide	mapping middle impact aim	policy dialogue networks environment	development and	climate smart program	organized local	community program school development and	health development and		
scholar high student		community development and disaster board	program introduce report middle	work contact case author	world	undergrad uate student opportunity know	news	worker rights resistance human	information and development and system	world work organizat	institute state peace conflict	national publication need resistance	right health care child univer	poverty group	work case community basic program	community service	medical work		
water power engin center office	project	university student research	community general price staff	human	skilled job learn news	building reset create study	program basic	advocacy prevention forest service	following red river values	new service family war	new	affiliates population poor patient	service funding social contact	work people partner	community project research team	program	development and provide	organized local	
organized on community programs	development and education	project community programs	program research group work	aviations programs injury	community	general	leads child most year		policy refugee trainee training	contact human today agency	people country base	population development and community work	world	organized on refugee	organized on life	leadership donation urban attend	community value	service value	
child programs development center	organized	high school	innovate	young	work	state country development and agency	project area	country	development and information manager	Humanitair	world Humanitair	cofound	work	development and organization	work	country	humanity community effort	Humanitair work	
work team	community service	time solution change team	member people organization	women youth working difference	organized	health care	partner organized	information work	development and	training	country people disaster	people	work connection	project education state opportunity	board support Humanitair on director	state health aid event	organized on memory aid program	personnel people related transport	service case
education school center	organized	organized	outlook promote women group		work	religions	workshop project	connect people need real	school center character	local people culture organized	Health work people labor	holiday vacation residence apply	support connect cult region	work society		life community	support progress	resource education foundation aid	world
political campaign	political	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	politics	



SOM ON IMAGE DATA

Demonstration with the previous collected tweets

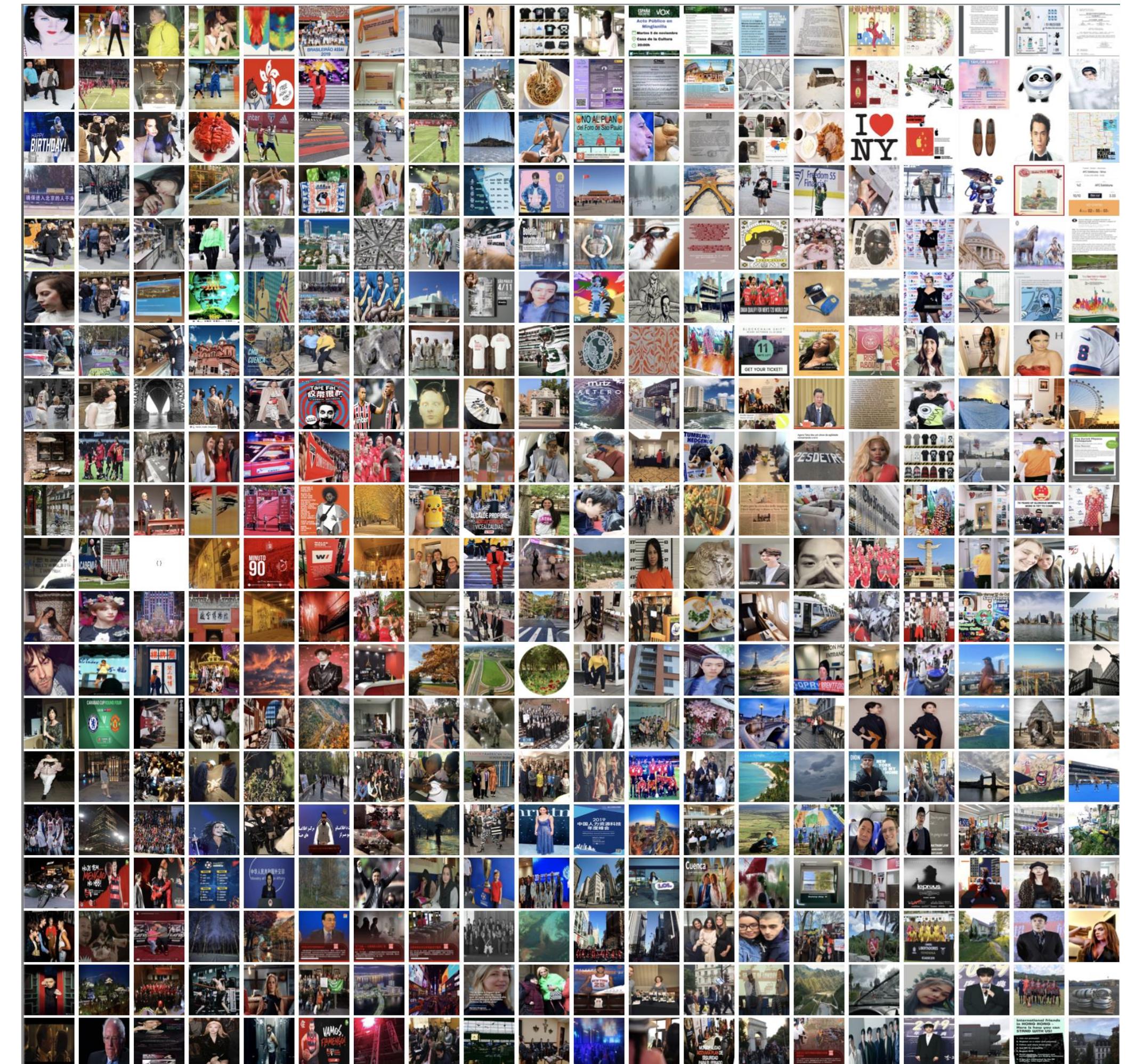


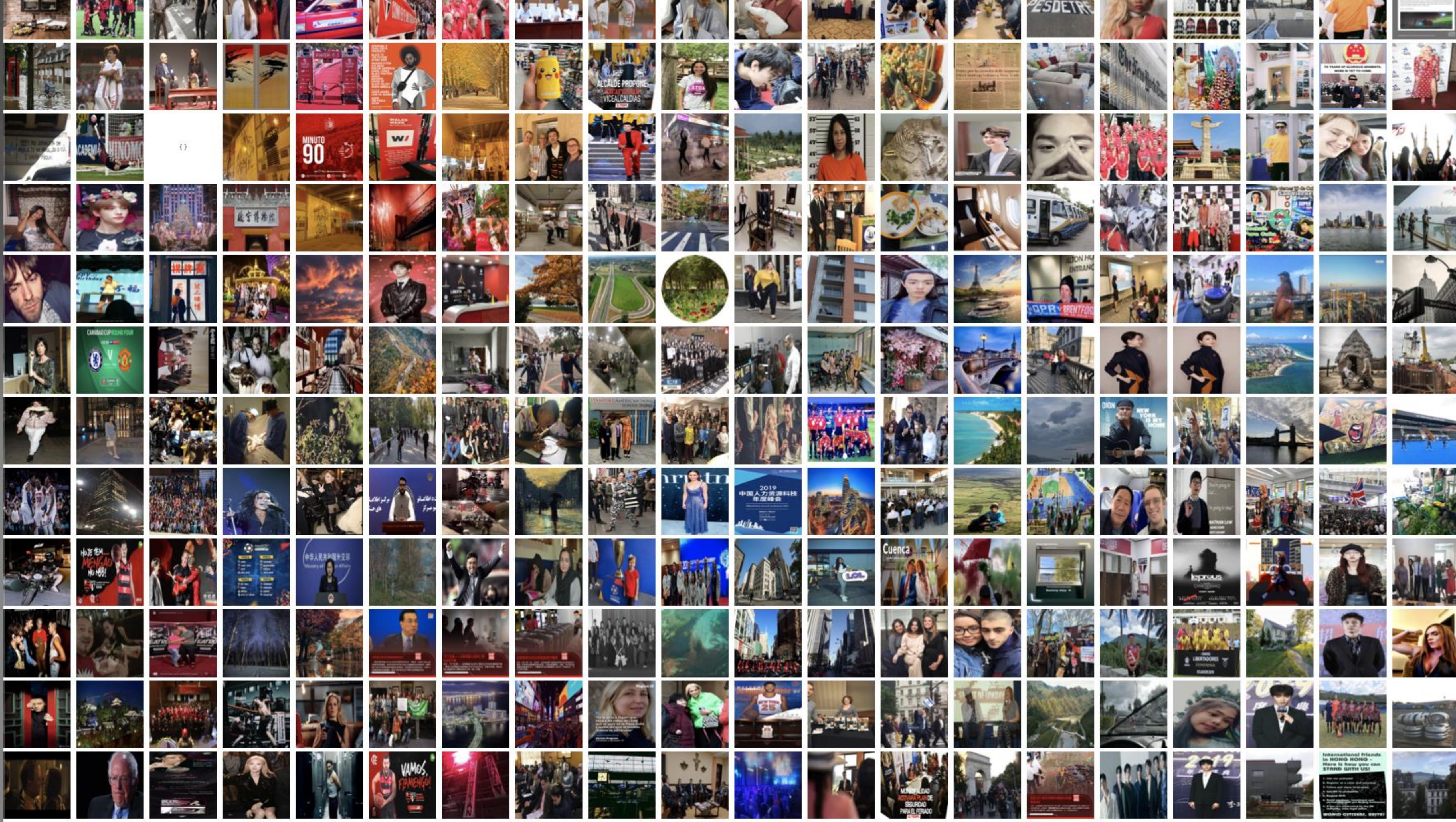
image

-> "colors"



1600	0	1600	0	1600
0	1600	0	1600	0
1600	0	1516	84	1536
64	1600	0	1562	38
1477	123	1494	106	1558
42	1600	0	1600	0
1600	0	1600	0	1512

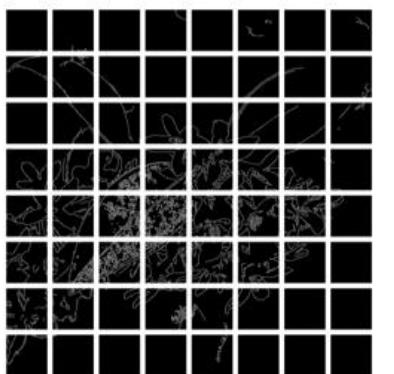




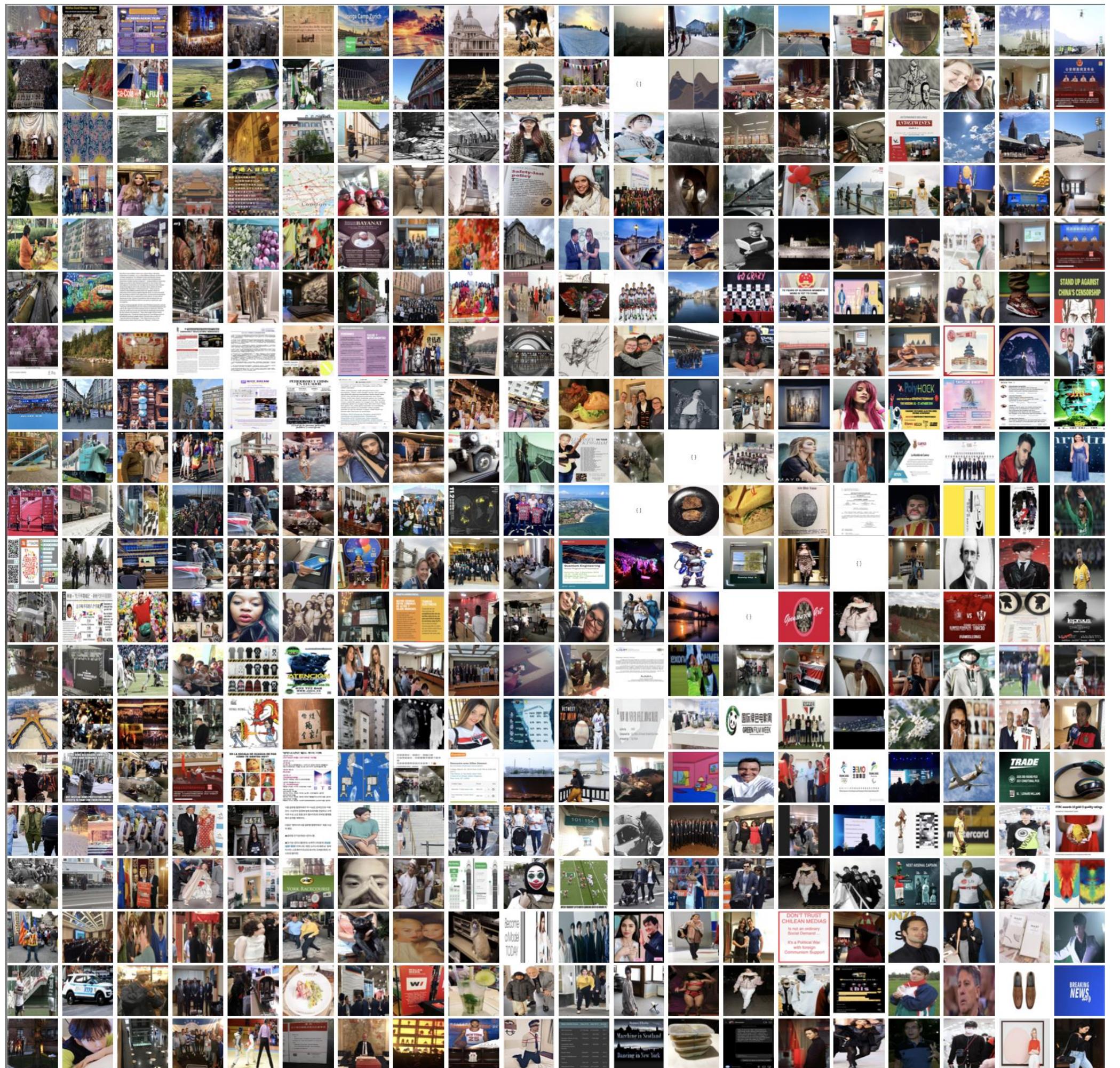


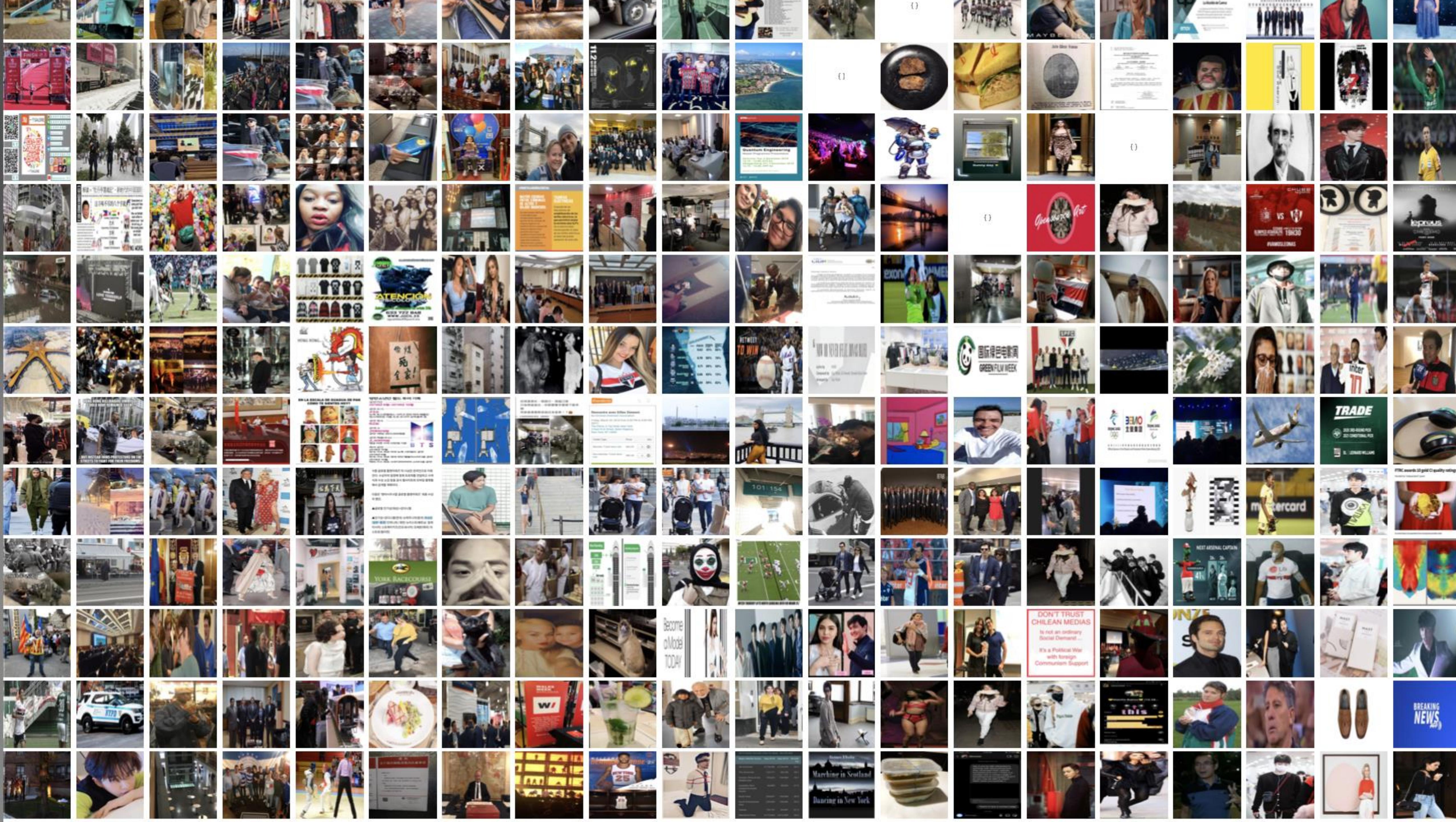
image

-> "edges"

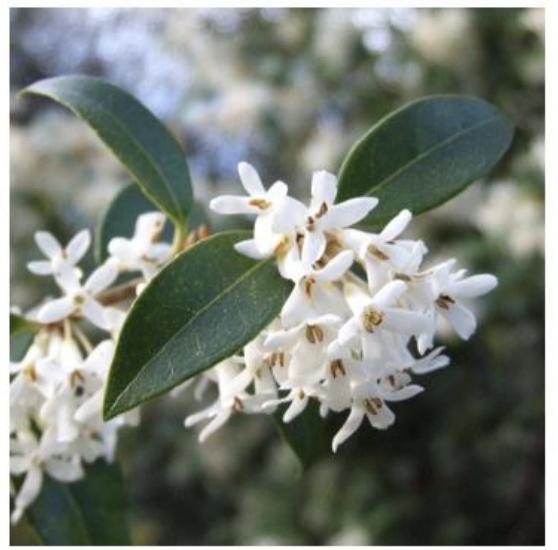


0.439216 0.470588 0.541176
0.694118 0.733333 0.862745
0.780392 0.811765 0.898039
0.733333 0.741176 0.74902
0.462745 0.490196 0.458824
0.505882 0.533333 0.458824
0.662745 0.694118 0.701961

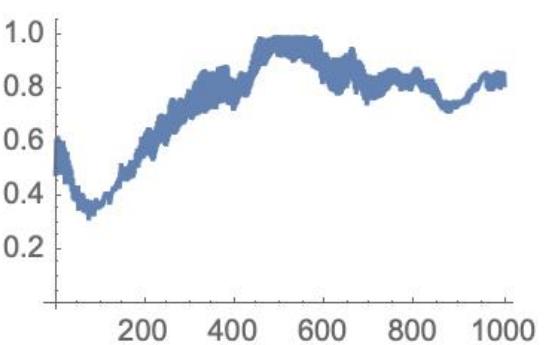




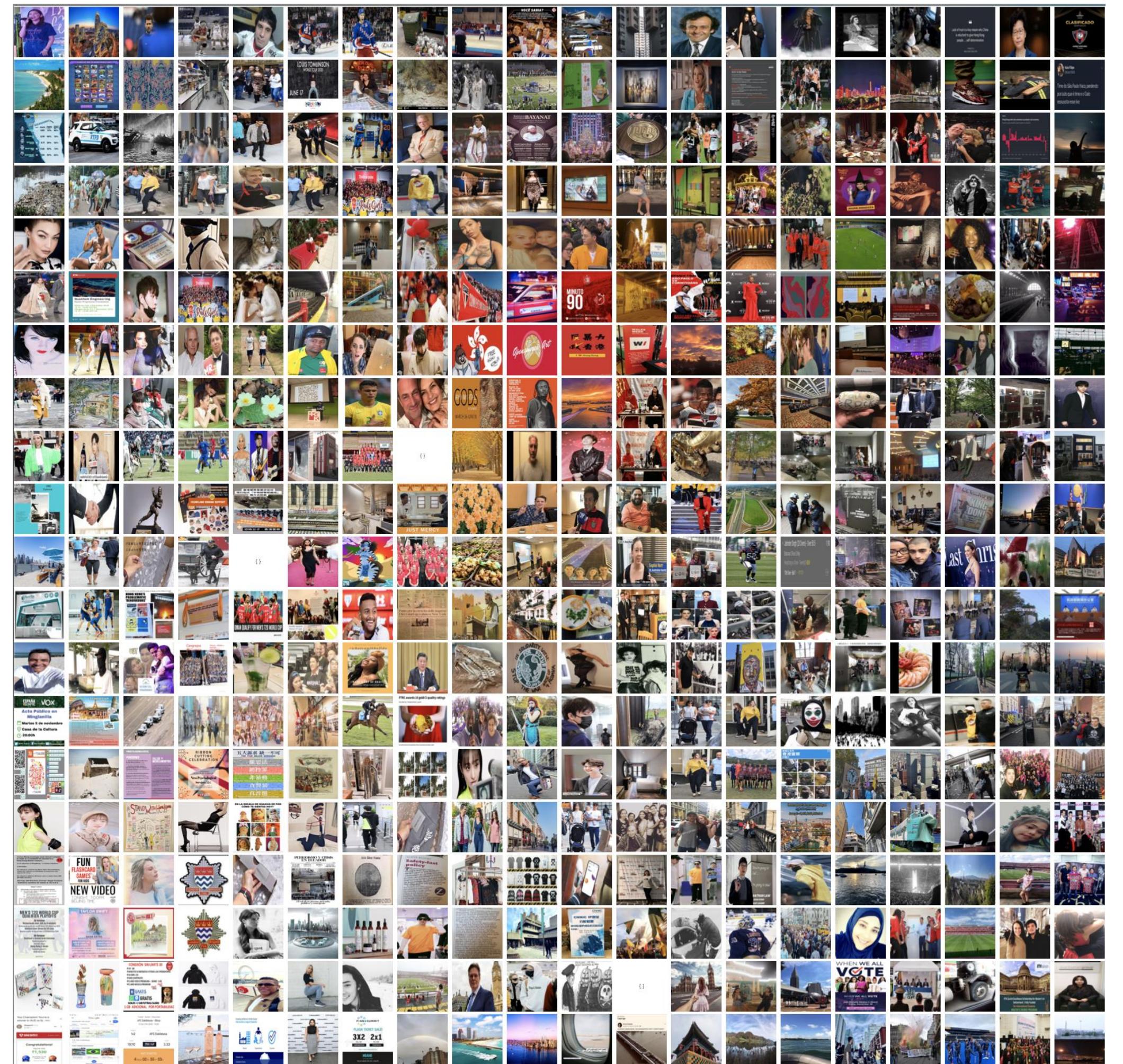
image

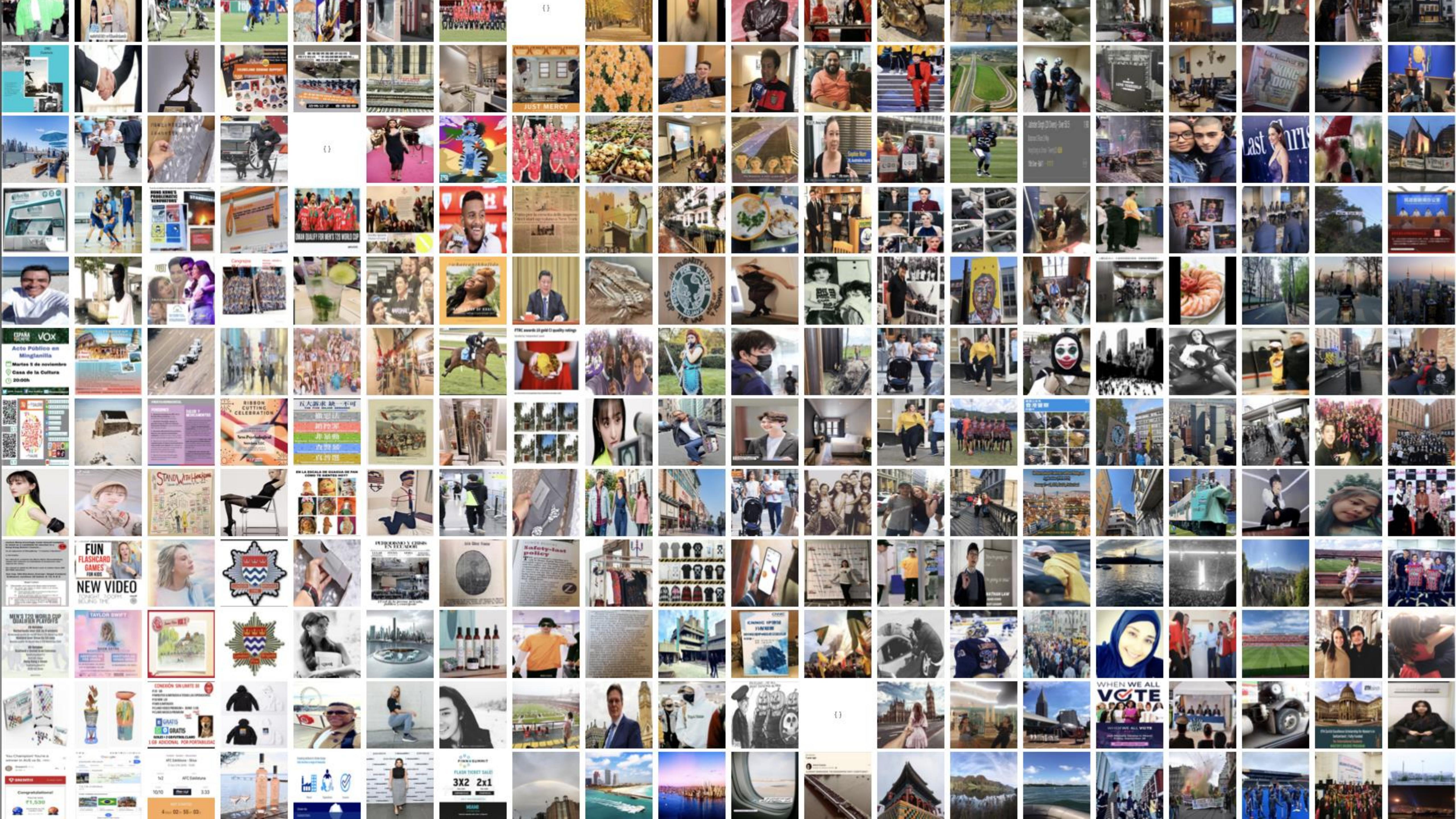


-> "fourier"



$$\begin{array}{ll} 311.196 + 0. \text{i} & -2.844 \\ -2.8447 - 8.53134 \text{i} & -18.802 \\ 0.0507741 - 1.67722 \text{i} & -0.85581 \\ 11.2859 + 32.356 \text{i} & 2.20171 \\ 1.98793 + 0.293197 \text{i} & -2.4941 \\ 1.08693 - 0.0374585 \text{i} & -0.72863 \\ -7.28062 + 7.17637 \text{i} & 0.61670 \end{array}$$





image



-> "feature extraction"

common privet

common jasmine

laurel

California laurel

fruit tree

pride-of-rochester

8.22561	-8.62608	28.0713
-3.54004	12.2321	3.18221
-6.41089	1.24627	-2.62163

