

# Vectors





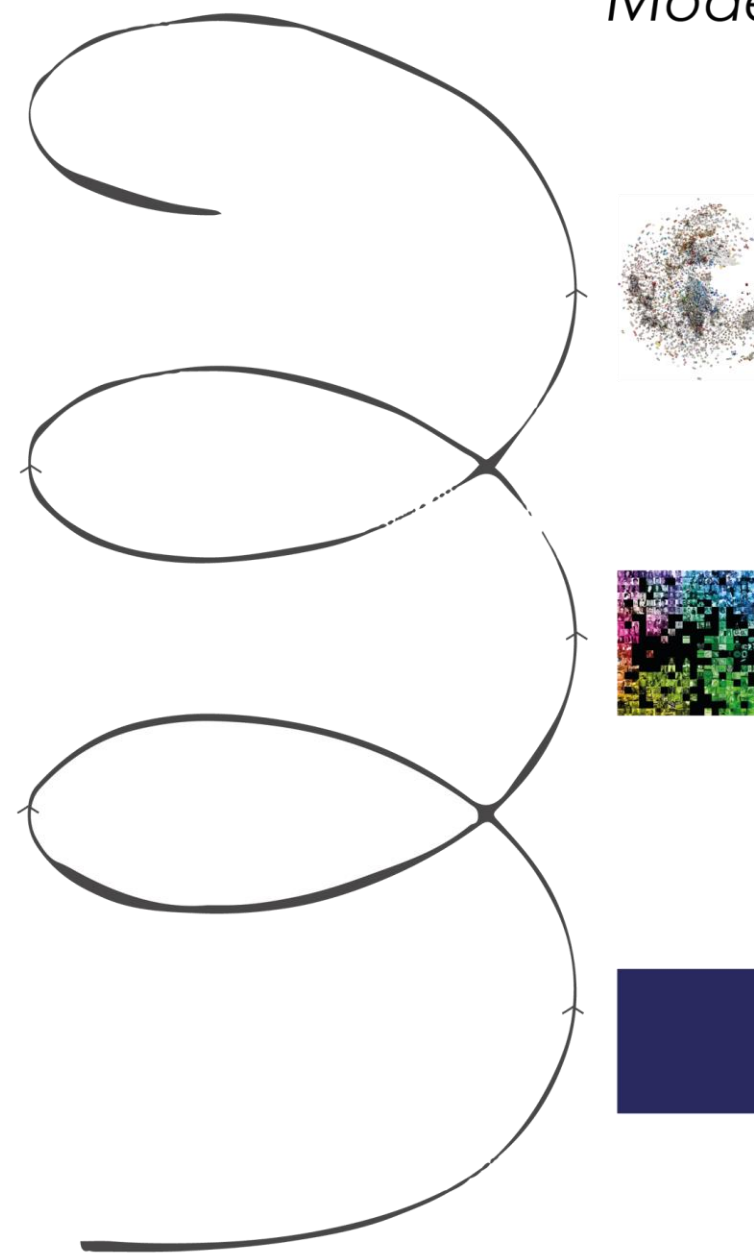
Map

Model

{72},{73},{172},{230}  
,{273},{274},{275},{2  
76},{277},{278},{279  
,{294},{295},{296},{  
438},{519},{520}

0101010101  
0010101010  
1001010101  
010101

41°24'12.2N  
2°10'26.5 E

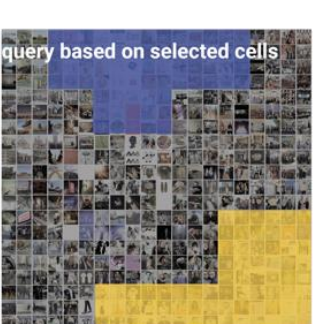




**Transform one of the two formats to its numerical representation**



### Train and render the SOM



**Choose one way of filtering the SOM**



# VECTORS

A vector is a list of numbers



# Vectors

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

An example in 2 dimensions

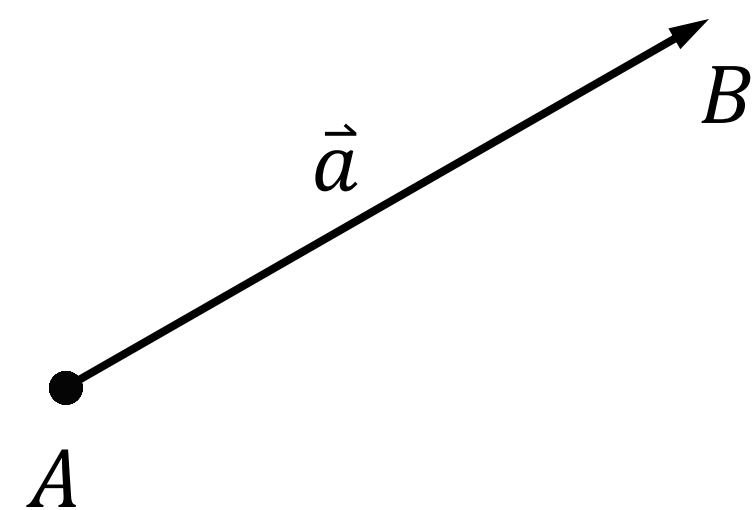
$$\vec{a} = (a_1, a_2, \dots, a_n)$$

Generalize to n-dimensional Euclidean space

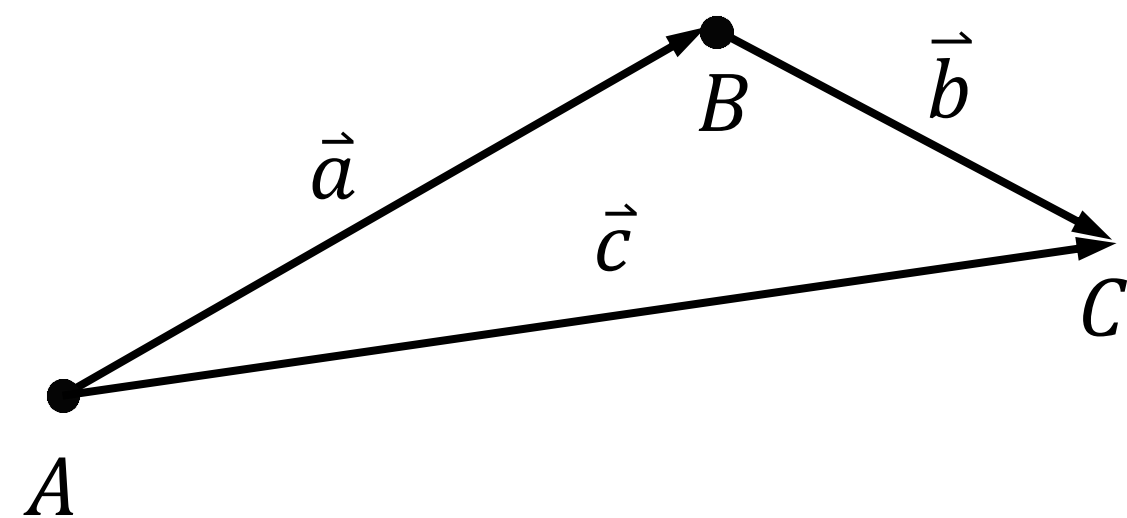
$$\|\vec{a}\| = \sqrt{a_1^2 + a_2^2 + \dots + a_n^2}$$

Magnitude (length, or norm) of a vector

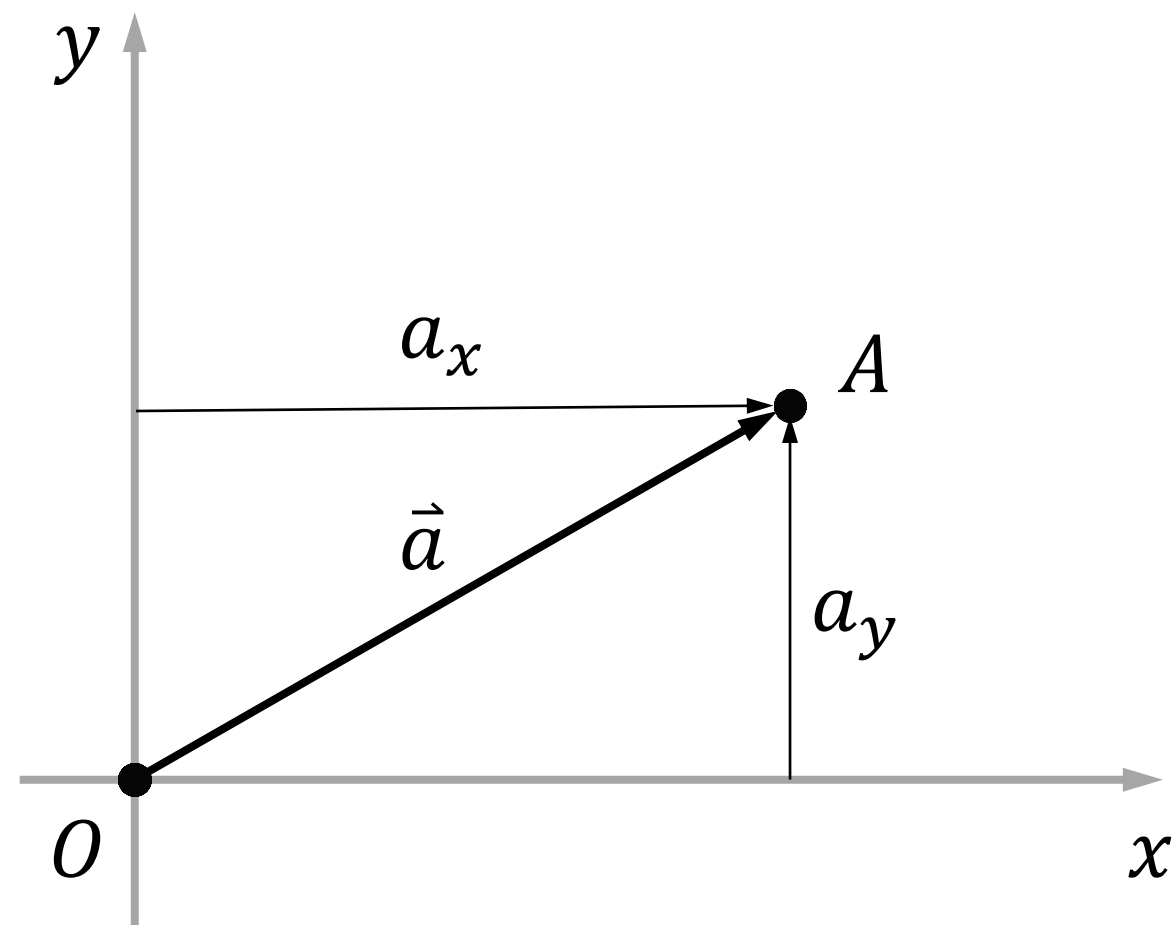
Vectors in geometry



A vector pointing from point A to B



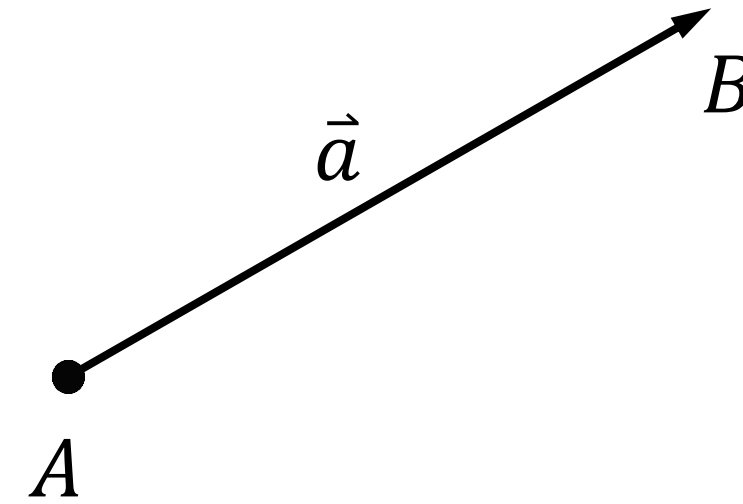
Addition and subtraction



Represent the coordinate of a point in Cartesian coordinate system

## Euclidean distance

distance between two points in Euclidean space



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

# FEATURE VECTOR

In the context of machine learning vectors are called feature vectors  
as each of these values corresponds to some features



# Examples of Feature Vector

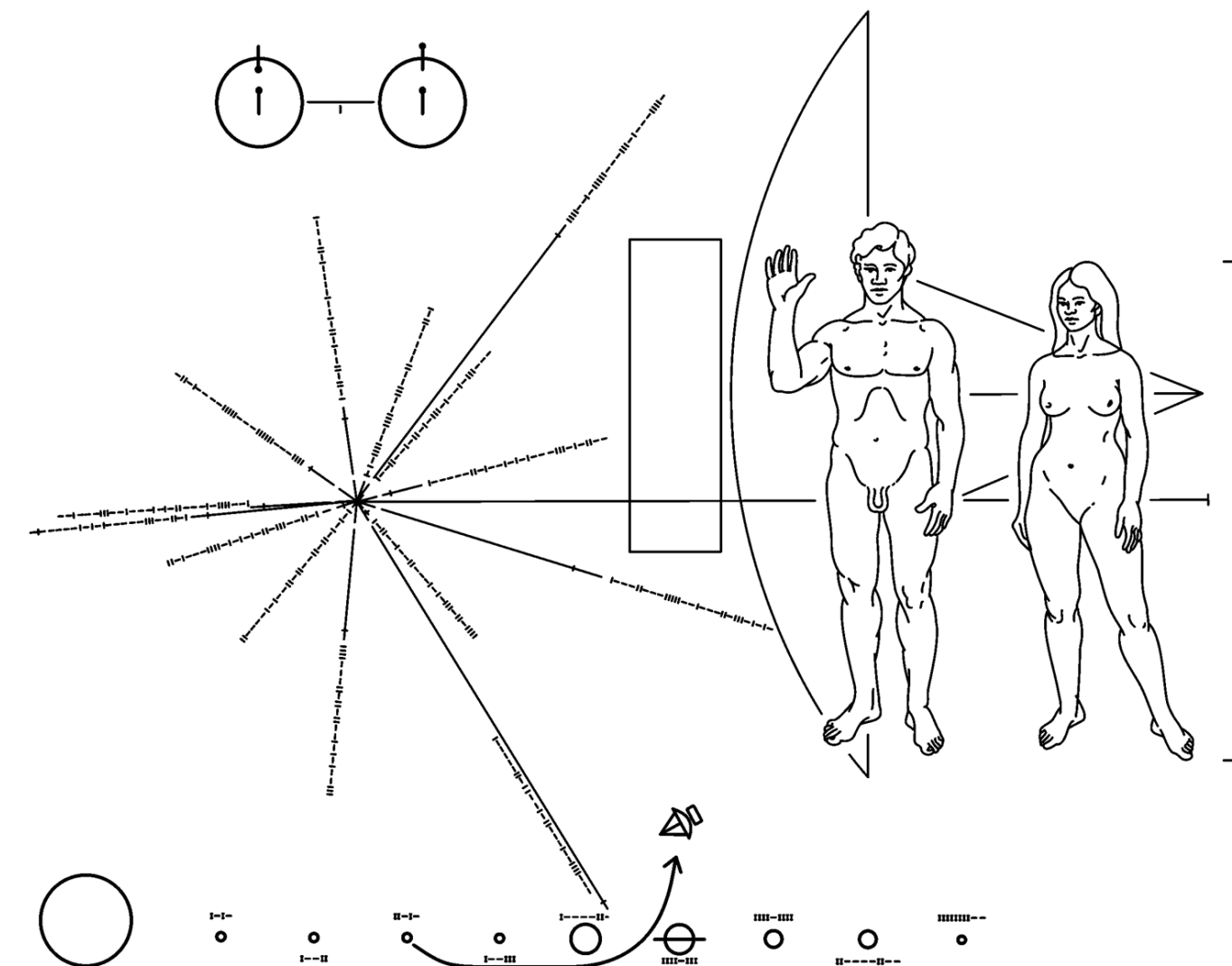
Numerical features that represent some object



An apple

(color, size, weight, sweetness)

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



(sex, age, weight, height)

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

@Pioneer plaque

A person

## Feature Vector + Euclidean Distance

A Common Ground for Comparing Objects



A

(color, size, weight, sweetness)

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



B

(color, size, weight, sweetness)

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

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

# Cross Dimensionality

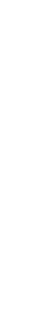
Communication between Euclidean spaces of different dimensionality

$$\begin{bmatrix} a_1 & a_2 \end{bmatrix} \begin{bmatrix} b_{1,1} & b_{1,2} & b_{1,3} \\ b_{2,1} & b_{2,2} & b_{2,3} \end{bmatrix} = \begin{bmatrix} c_1 & c_2 & c_3 \end{bmatrix}$$



(color, size, weight, sweetness)

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



(price, do I like it?)

(0.75 Fr, 1 yes)

There are operations allow us to project from one dimensionality to another



Map and Models



(color, size, weight, sweetness)

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

Features

Model

Values

Map

# Map and Models

Pixel values (obtained by digital camera)

255	127	...	133
132	86	...	144
...	...	...	...
178	254	...	233

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

Map

Digital photograph



(color, size, weight, sweetness)

Model

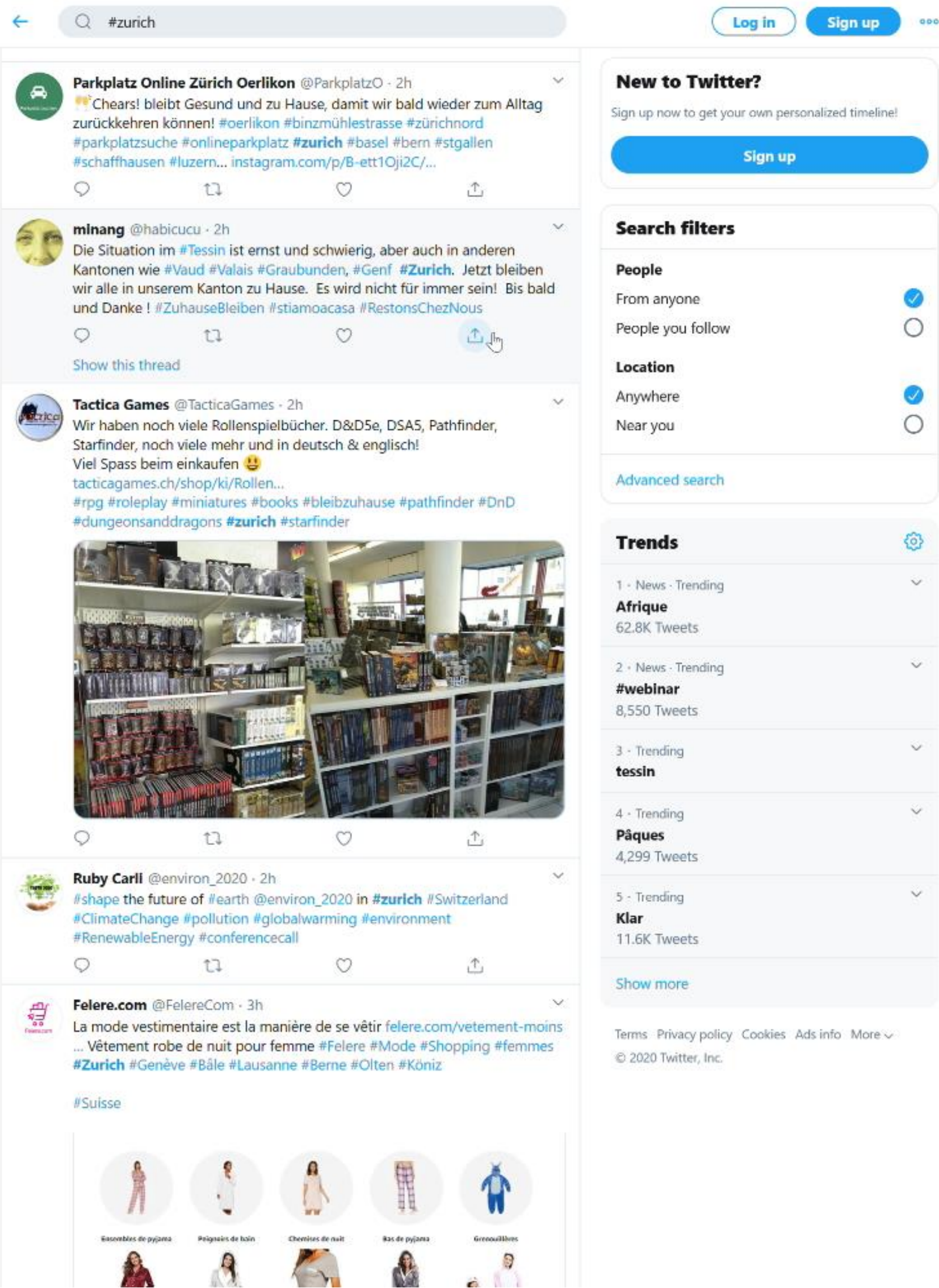
# FEATURE VECTOR FOR DIGITAL OBJECTS

Models of Map



# Images and Texts

Models that talk about the word



# Feature Vectors for Digital Objects

Models of Map

255 127 ... 133  
132 86 ... 144  
... ... ...  
178 254 ... 233

Image (Pixel values)

Map



Colors, Objects, Edges in the Image, ...

Model

4.3, 7.5, 2.2, 1.7, 0.8, .....

Feature Vector

Map

# WHY ?

As images are already numbers, why do we convert them to some other numbers?



## An Example with Images

Group by interior / exterior photos



?



?





```
EuclideanDistance[
  Flatten@ImageData@ImageResize[#1, {32, 32}],
  Flatten@ImageData@ImageResize[#2, {32, 32}]] & @@
```



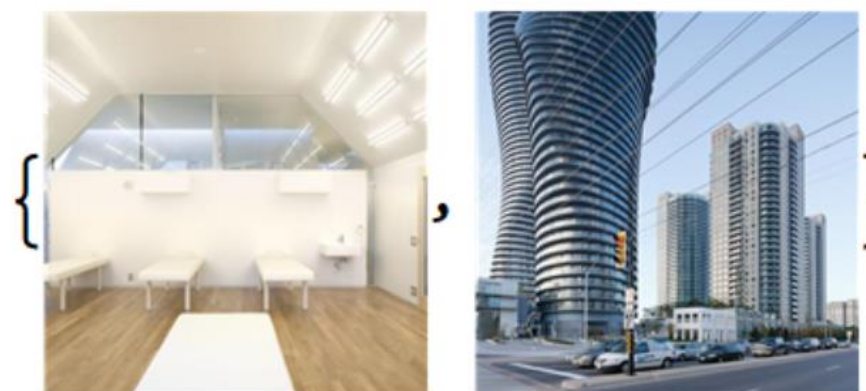
Out[2]= 21.6916

```
EuclideanDistance[
  Flatten@ImageData@ImageResize[#1, {32, 32}],
  Flatten@ImageData@ImageResize[#2, {32, 32}]] & @@
```



Out[3]= 16.6223

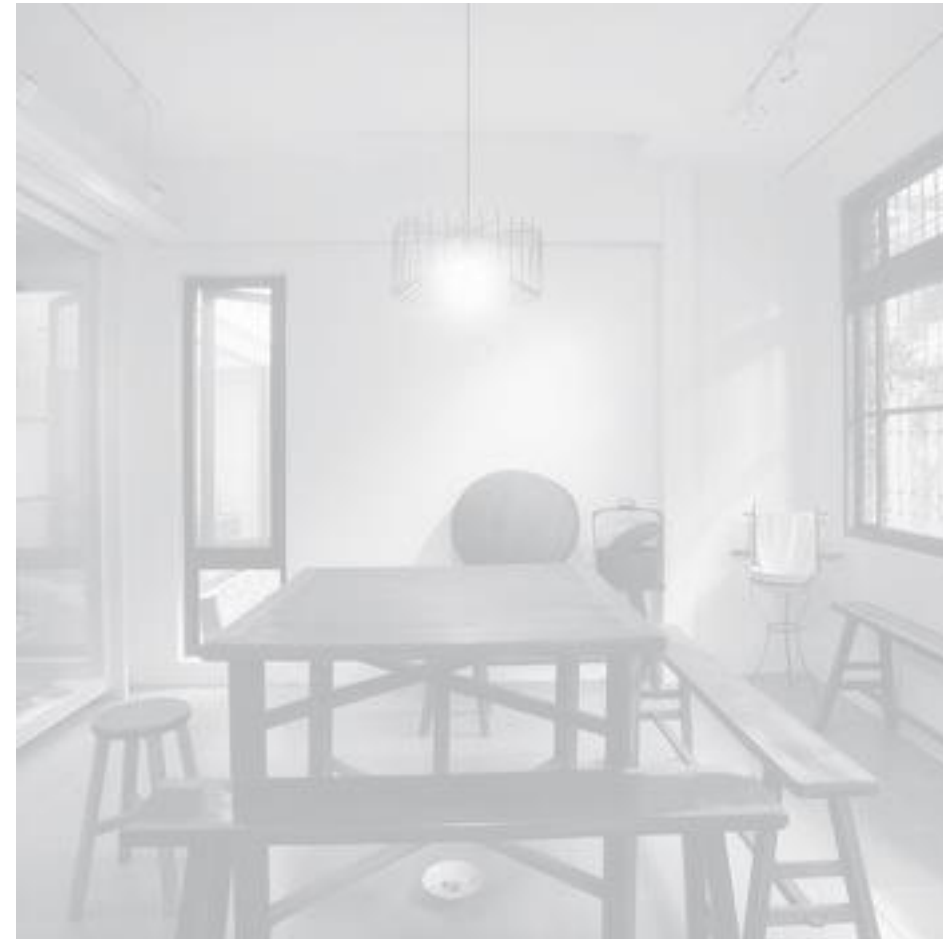
```
EuclideanDistance[
  Flatten@ImageData@ImageResize[#1, {32, 32}],
  Flatten@ImageData@ImageResize[#2, {32, 32}]] & @@
```



Out[4]= 19.1647

# An Example with Images

Group by interior / exterior photos



Colors sometimes cannot get what we want



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

# FEATURE EXTRACTION

Computational mechanism for getting feature vectors



## Non-probabilistic

Edge Detection

Fourier Transform

Hough Transform

...

## Probabilistic (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 Histogram

...

Word2Vec (Word Embedding)

Sentiment Analysis

...

# FEATURE EXTRACTION

Demonstration with the previous collected tweets



image



-> "colors"

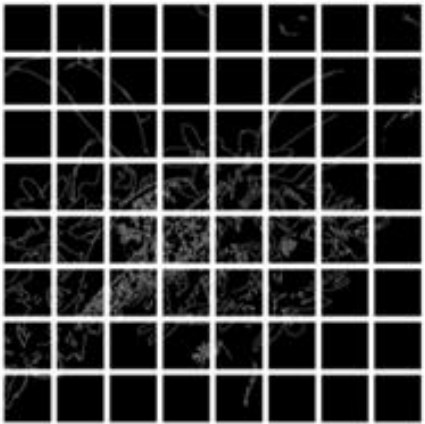


1600	0	1600	0	1600
0	1600	0	1600	0
1600	0	1516	84	1536
64	1600	0	1562	38
1477	123	1494	106	1558
42	1600	0	1600	0
1600	0	1600	0	1512

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



-> "feature extraction"

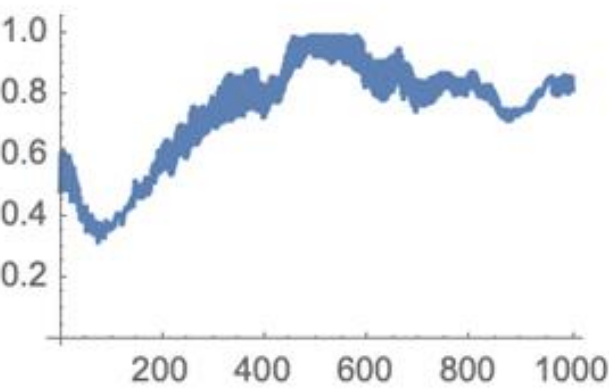
- common privet
- common jasmine
- laurel
- California laurel
- fruit tree
- pride-of-rochester

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

image



-> "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"

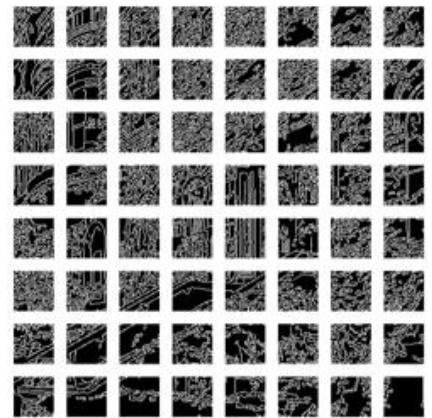


0.745098 0.741176 0.662745 0.694118 0.666667  
0.635294 0.705882 0.658824 0.627451 0.494118  
0.490196 0.423529 0.368627 0.427451 0.278431  
0.447059 0.517647 0.313725 0.34902 0.423529  
0.196078 0.203922 0.235294 0.133333 0.301961  
0.305882 0.196078 0.254902 0.282353 0.172549

image



-> "edges"



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

image



-> "feature extraction"

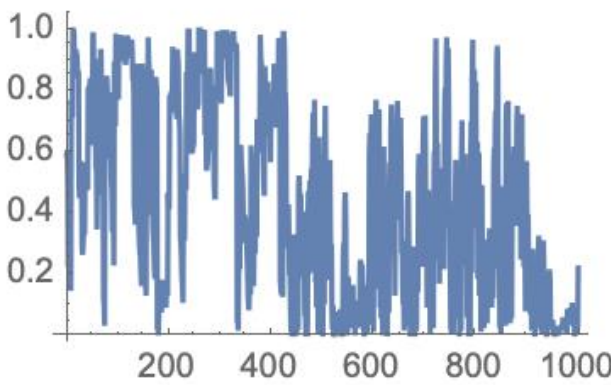
- Boston ivy
- vine
- vascular plant
- flora
- support
- stair

11.9924 5.44124 -2.30834  
0.115535 2.4649 4.43479  
5.21442 4.58633 -3.29425

image



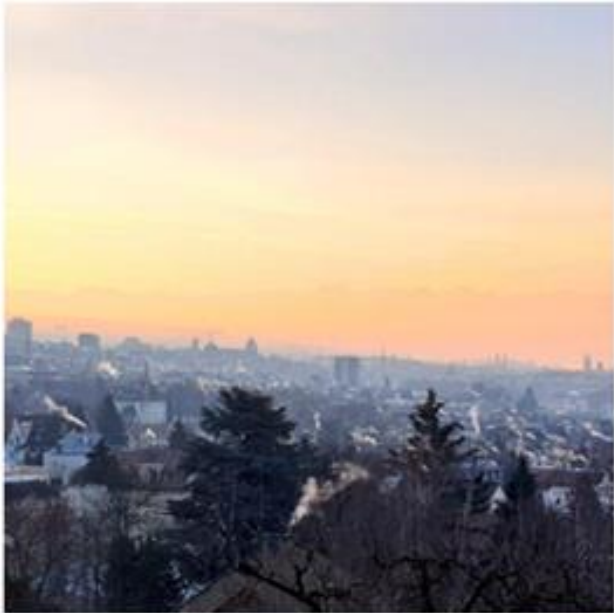
-> "fourier"



232.95 + 0. i 6.82914 + 15.0475 i



image

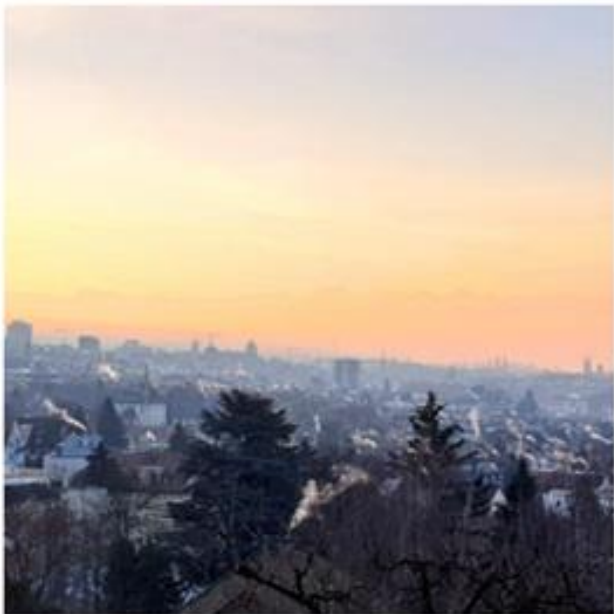


-> "colors"

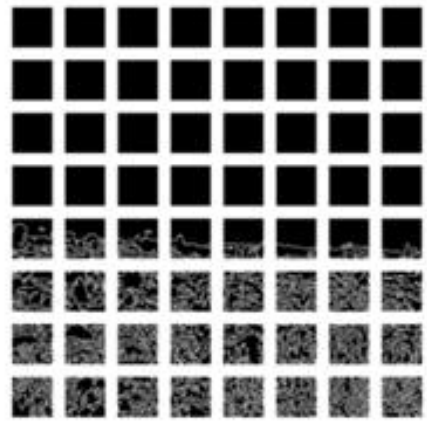


0.956863	0.901961	0.858824	0.92549	0.878431
0.854902	0.913725	0.870588	0.85098	0.905882
0.862745	0.85098	0.894118	0.85098	0.843137
0.866667	0.839216	0.839216	0.835294	0.823529
0.843137	0.811765	0.807843	0.85098	0.796078
0.803922	0.862745	0.776471	0.8	0.866667

image

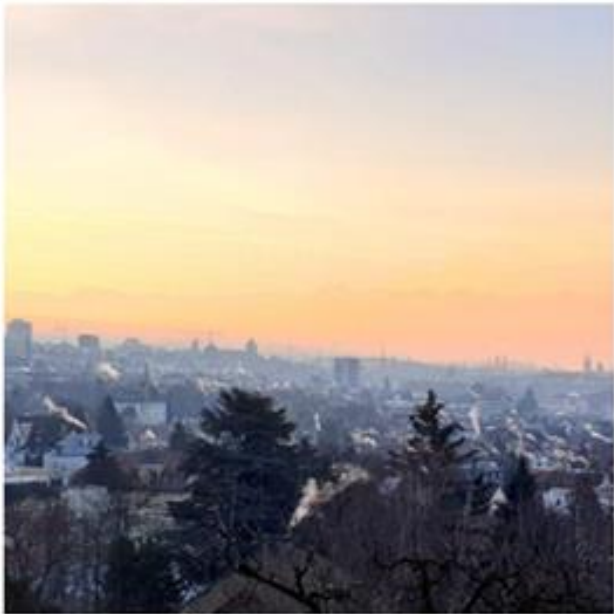


-> "edges"



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

image



-> "feature extraction"

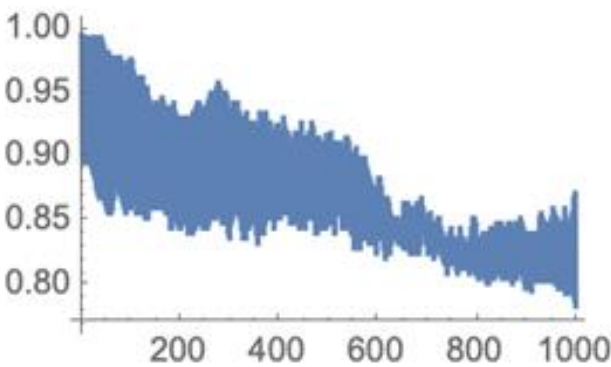
- atmospheric phenomenon
- physical phenomenon
- natural phenomenon
- cloud
- mount
- atmosphere

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

image



-> "fourier"



431.125 + 0. i 13.5396 + 6.74412 i



image



-> "colors"

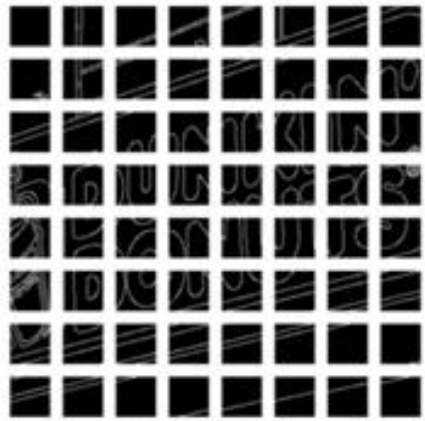


0.0352941	0.384314	0.47451	0.0784314	0.403922
0.490196	0.0431373	0.462745	0.537255	0.027451
0.462745	0.52549	0.0196078	0.439216	0.501961
0.	0.403922	0.470588	0.0392157	0.4
0.466667	0.172549	0.423529	0.505882	0.447059
0.443137	0.552941	0.745098	0.643137	0.72549

image



-> "edges"



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

image



-> "feature extraction"

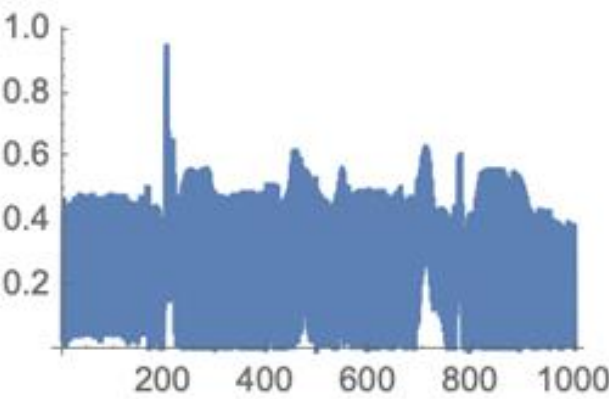
- casino
- grocery store
- supermarket
- self-propelled vehicle
- motor vehicle
- automobile

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

image



-> "fourier"



357.98 + 0. i 21.9133 - 10.4063 i



image



-> "colors"

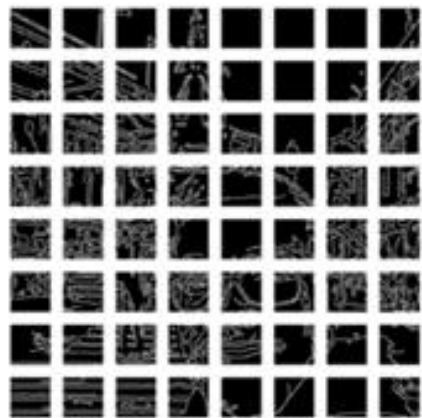


0.0588235	0.0627451	0.156863	0.	0.
0.117647	0.0666667	0.0196078	0.133333	0.0235294
0.00784314	0.117647	0.0666667	0.0745098	0.168627
0.0117647	0.0117647	0.12549	0.00392157	0.
0.121569	0.0117647	0.00784314	0.129412	0.
0.	0.0941176	0.160784	0.172549	0.239216

image



-> "edges"



1413	187	1525
75	1477	123
1585	15	1432
168	1600	0
1600	0	1600

image



-> "feature extraction"

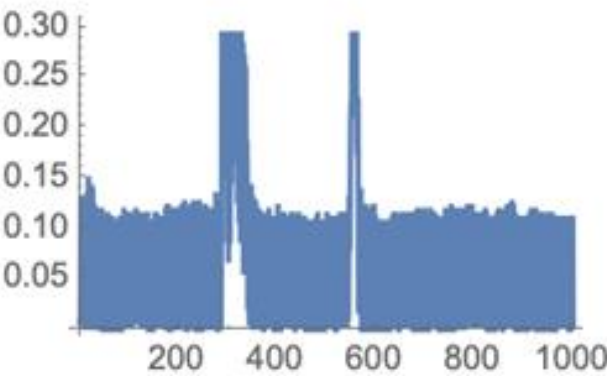
- person
- hominid
- primate
- mammal
- vertebrate
- anatomy

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

image



-> "fourier"



234.955 + 0. i 14.517 - 2.76679 i



image



-> "colors"

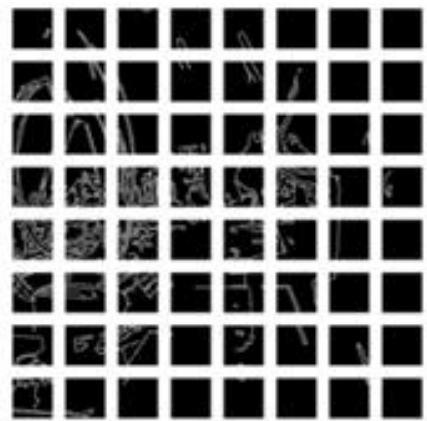


0.286275	0.0235294	0.0156863	0.337255	0.0196078
0.0156863	0.384314	0.00784314	0.0117647	0.443137
0.0117647	0.0117647	0.294118	0.0117647	0.0156863
0.407843	0.0156863	0.0117647	0.396078	0.00392157
0.0117647	0.227451	0.00392157	0.0117647	0.152941
0.0117647	0.00784314	0.117647	0.00784314	0.00784314

image



-> "edges"



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

image



-> "feature extraction"

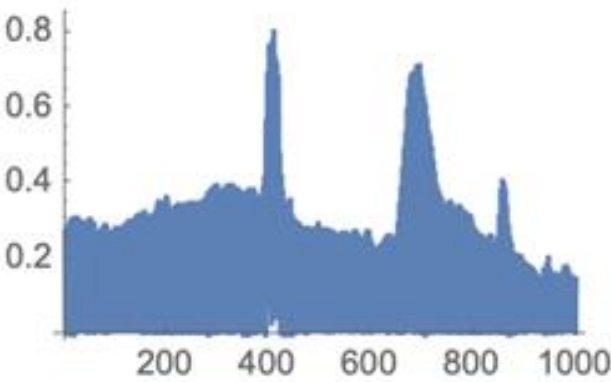
- laser
- primate
- hominid
- person
- light source
- fairy light

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

image



-> "fourier"



141.403 + 0. i 74.3727 + 10.9785 i



image



-> "colors"

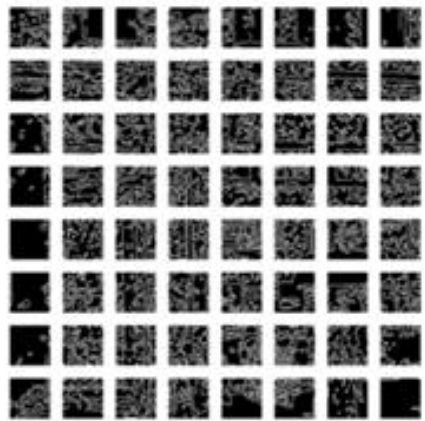


```
0.513725 0.556863 0.470588 0.52549 0.560784
0.478431 0.784314 0.776471 0.662745 0.65098
0.627451 0.513725 0.639216 0.619608 0.533333
0.721569 0.709804 0.643137 0.568627 0.552941
0.501961 0.533333 0.509804 0.443137 0.682353
0.67451 0.619608 0.54902 0.537255 0.482353
```

image



-> "edges"



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

image



-> "feature extraction"

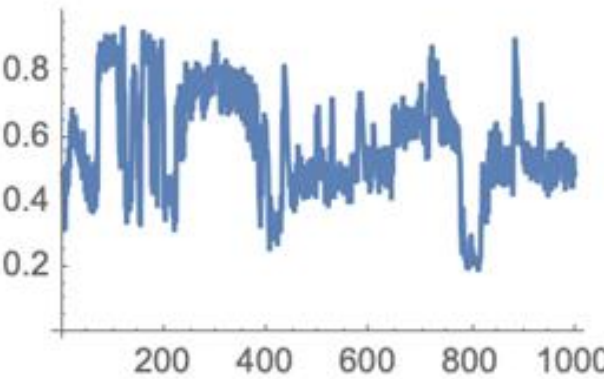
- sprinkler
- crucifix
- lock
- padlock
- cockpit
- abacus

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

image



-> "fourier"



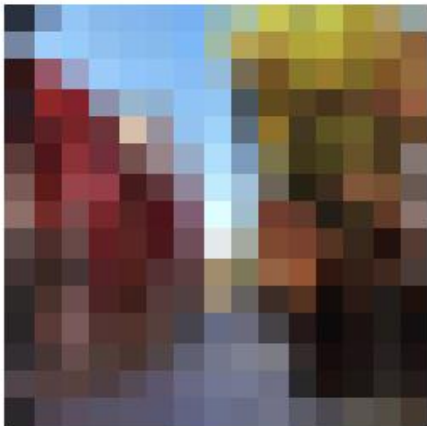
```
381.644 + 0. i 5.46611 + 14.145 i
```



image



-> "colors"

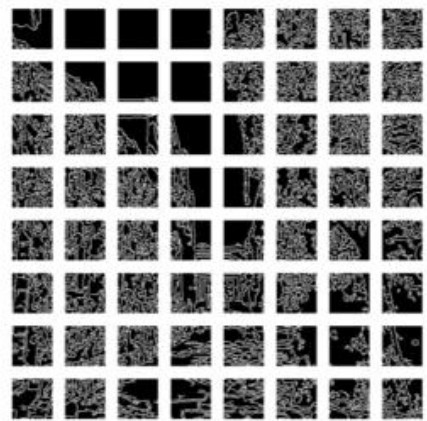


0.298039	0.392157	0.494118	0.541176	0.792157
1.	0.498039	0.737255	0.94902	0.454902
0.713725	0.956863	0.45098	0.709804	0.917647
0.666667	0.74902	0.560784	0.737255	0.713725
0.231373	0.713725	0.717647	0.172549	0.690196
0.592157	0.141176	0.592157	0.572549	0.486275

image



-> "edges"



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

image



-> "feature extraction"

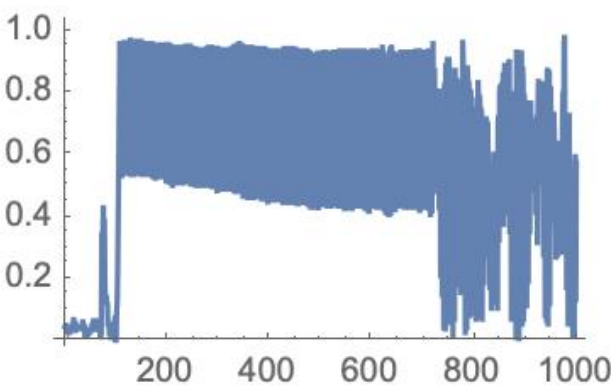
- Boston ivy
- tree
- flowering tree
- maple tree
- boxelder
- California box elder

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



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	0.2325780.9080240.0687178				
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?	-> "Word2Vec"	Qualifying text by it's content with word-embeddings	0.68047	-0.039263	0.30186	-0.17792	0.42962
				0.032246	-0.41376	0.13228	-0.29847	-0.085253
				0.17118	0.22419	-0.10046	-0.43653	0.33418
				0.67846	0.057204	-0.34448	-0.42785	-0.43275
				0.55963	0.10032	0.18677	-0.26854	0.037334
				-2.0932	0.22171	-0.39868	0.20912	-0.55725
				3.8826	0.47466	-0.95658	-0.37788	0.20869
				-0.32752	0.12751	0.088359	0.16351	-0.21634
				-0.094375	0.018324	0.21048	-0.03088	-0.19722
				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	-0.039263	0.30186	-0.17792	0.42962			
				0.032246	-0.41376	0.13228	-0.29847	-0.085253			
				0.17118	0.22419	-0.10046	-0.43653	0.33418			
				0.67846	0.057204	-0.34448	-0.42785	-0.43275			
				0.55963	0.10032	0.18677	-0.26854	0.037334			
				-2.0932	0.22171	-0.39868	0.20912	-0.55725			
				3.8826	0.47466	-0.95658	-0.37788	0.20869			
				-0.32752	0.12751	0.088359	0.16351	-0.21634			
				-0.094375	0.018324	0.21048	-0.03088	-0.19722			
				0.082279	-0.09434	-0.073297	-0.064699	-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 bodkin	-> "Sentiment Analysis"	Qualifying text by positive, neutral or negative	0.232578	0.908024	0.0687178		
				0.68047	-0.039263	0.30186	-0.17792	0.42962
				0.032246	-0.41376	0.13228	-0.29847	-0.085253
				0.17118	0.22419	-0.10046	-0.43653	0.33418
				0.67846	0.057204	-0.34448	-0.42785	-0.43275
				0.55963	0.10032	0.18677	-0.26854	0.037334
				-2.0932	0.22171	-0.39868	0.20912	-0.55725
				3.8826	0.47466	-0.95658	-0.37788	0.20869
				-0.32752	0.12751	0.088359	0.16351	-0.21634
				-0.094375	0.018324	0.21048	-0.03088	-0.19722
				0.082279	-0.09434	-0.073297	-0.064699	-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 bodkin	-> "Word2Vec"	Qualifying text by it's content with word-embeddings					



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	-0.17792	0.42962
				0.032246	-0.41376	0.13228	-0.29847	-0.085253
				0.17118	0.22419	-0.10046	-0.43653	0.33418
				0.67846	0.057204	-0.34448	-0.42785	-0.43275
				0.55963	0.10032	0.18677	-0.26854	0.037334
				-2.0932	0.22171	-0.39868	0.20912	-0.55725
				3.8826	0.47466	-0.95658	-0.37788	0.20869
				-0.32752	0.12751	0.088359	0.16351	-0.21634
				-0.094375	0.018324	0.21048	-0.03088	-0.19722
				0.082279	-0.09434	-0.073297	-0.064699	-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	-> "Word2Vec"	Qualifying text by it's content with word-embeddings					