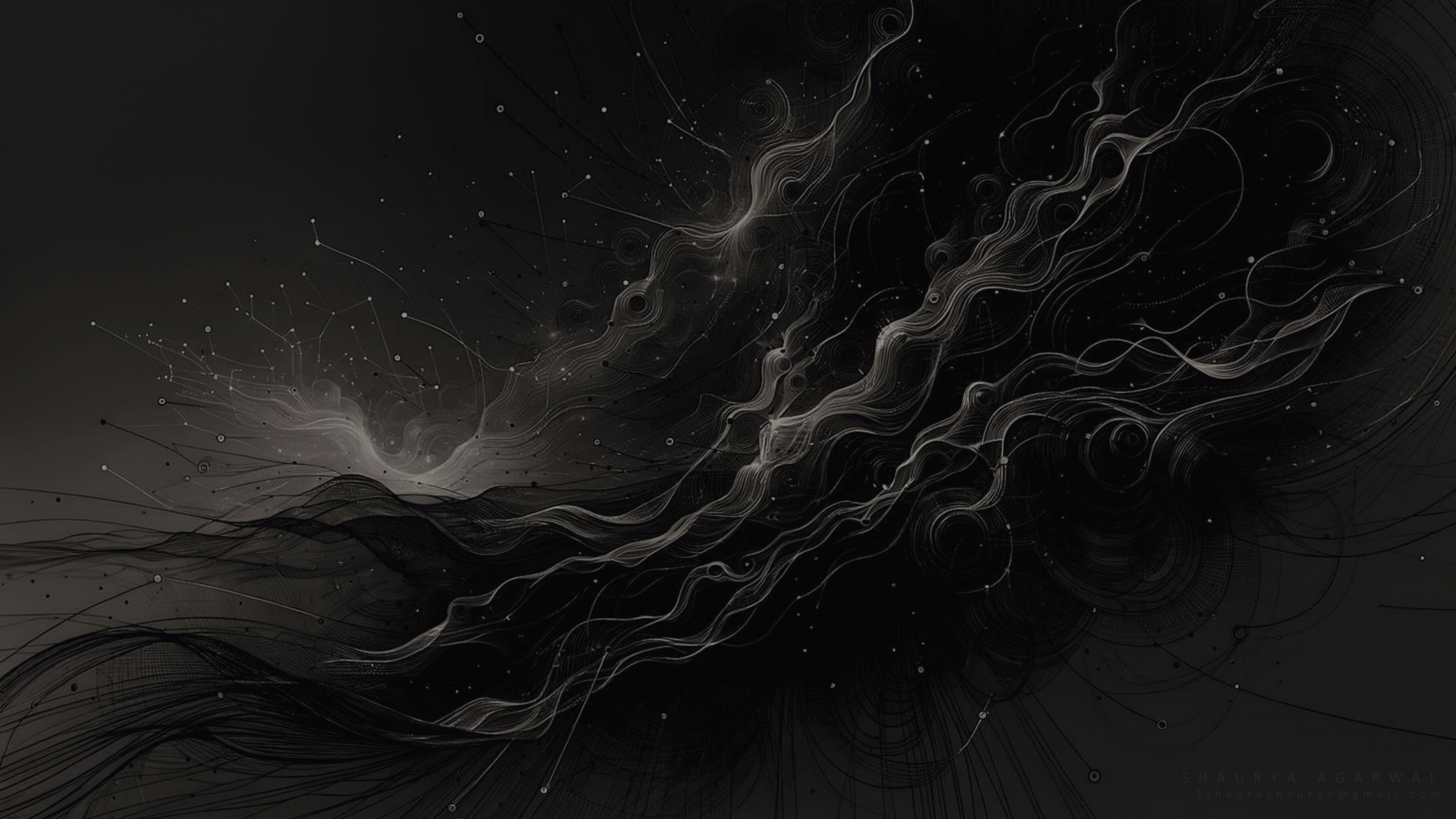
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K-MEANS & FRIENDS

EXPLORING CLUSTERING WITH PHOTOGRAPHS

shaurya agarwal

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Outline

- motivation
- movie
- math
- method
- more

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motivation

what are we talking about again?

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quantization, clustering, k-means and friends

Image Compression, Customer Segmentation, Document Clustering, Anomaly Detection, Feature Learning and Dimensionality Reduction, Medical Imaging, Genomics and Bioinformatics, Speech Recognition, Astronomical Data Analysis, Pattern Recognition and Classification, even enabling efficient training for LLMs

...and unusually enough, a movie

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movie

cinematography: a rather unusual use case for k-means

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i got to do this

cinematography

on

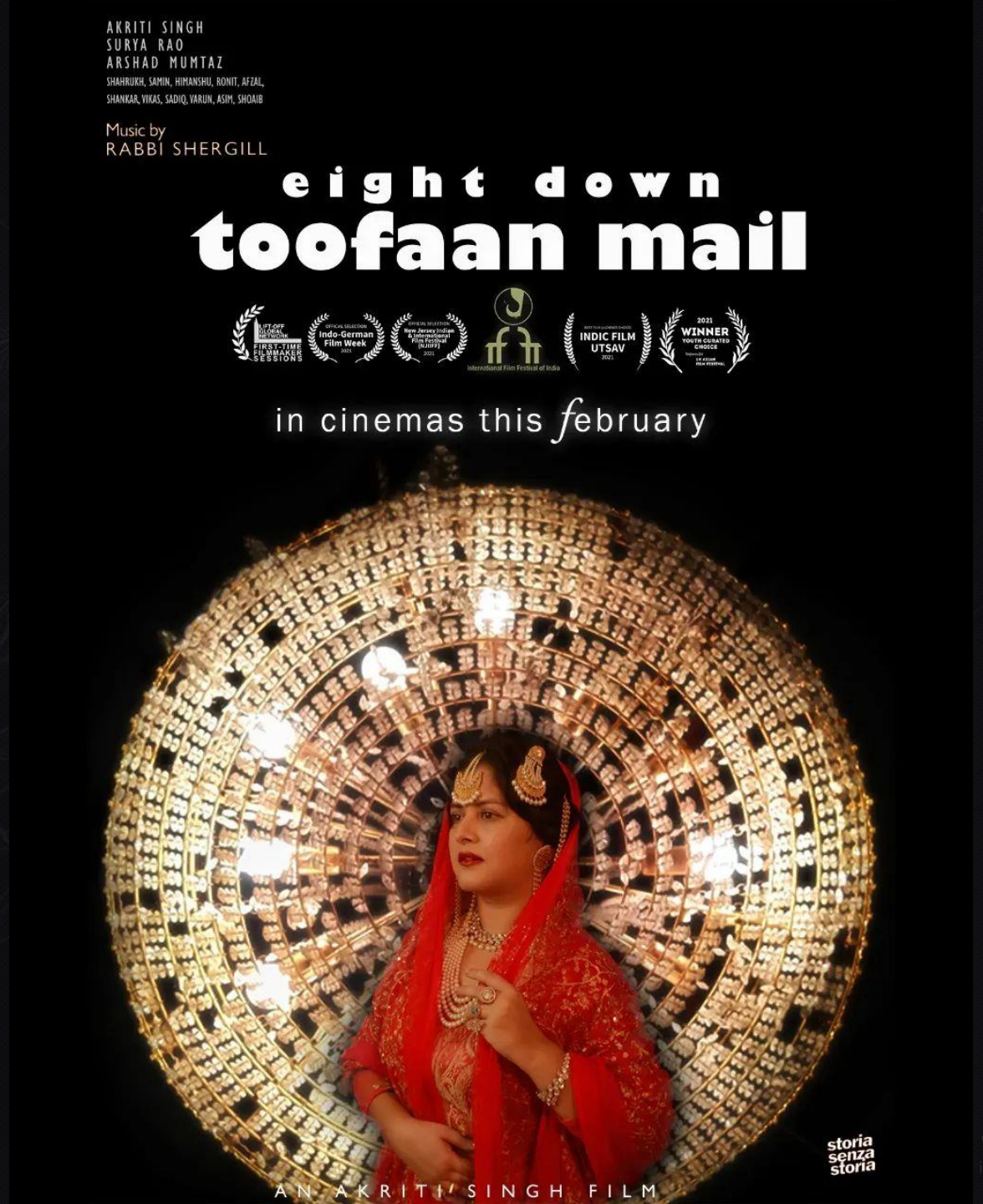
a

budget

powered

by

python



first principles

the best cinematography has exceptional control on color

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first principles

showcase what inspired the film’s cinematography

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first principles - colors

- one, or two or a few

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first principles - colors

- one, or two or a few but no more

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first principles - colors

the director ascribes meaning to these one, two or a few to tell the story

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first principles - colors

these colors must remain (approximately, perceptually) consistent

throughout the process, across all devices and screens

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pre-production

or else*

* I had a **great** director and a very very dedicated team, use your imagination

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pre-production

there are expensive cameras and studio setup that offer great control over the process

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pre-production

a typical day may cost 100s of 1000s of $$$ for camera and lighting

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pre-production

but for a 10-day shoot, interior and exterior

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pre-production

we had USD 359 total

(yes, that’s three hundred and fifty-nine dollars, at the current exchange rate)

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key insight

light – waves – wavelength, wavelength, wavelength

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key insight

light – colors – long wavelength, medium wavelength, short wavelength

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how do you pick the colors?

I used k-means++ to do it

we'll cover K-means first, the ++ is a way to better select the initial conditions, you'll see

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let’s see how

there really is no math to it...

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math*

how clustering works

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naïve explainer

imagine you have a bunch of marbles of different colors, and you want to organize them into groups

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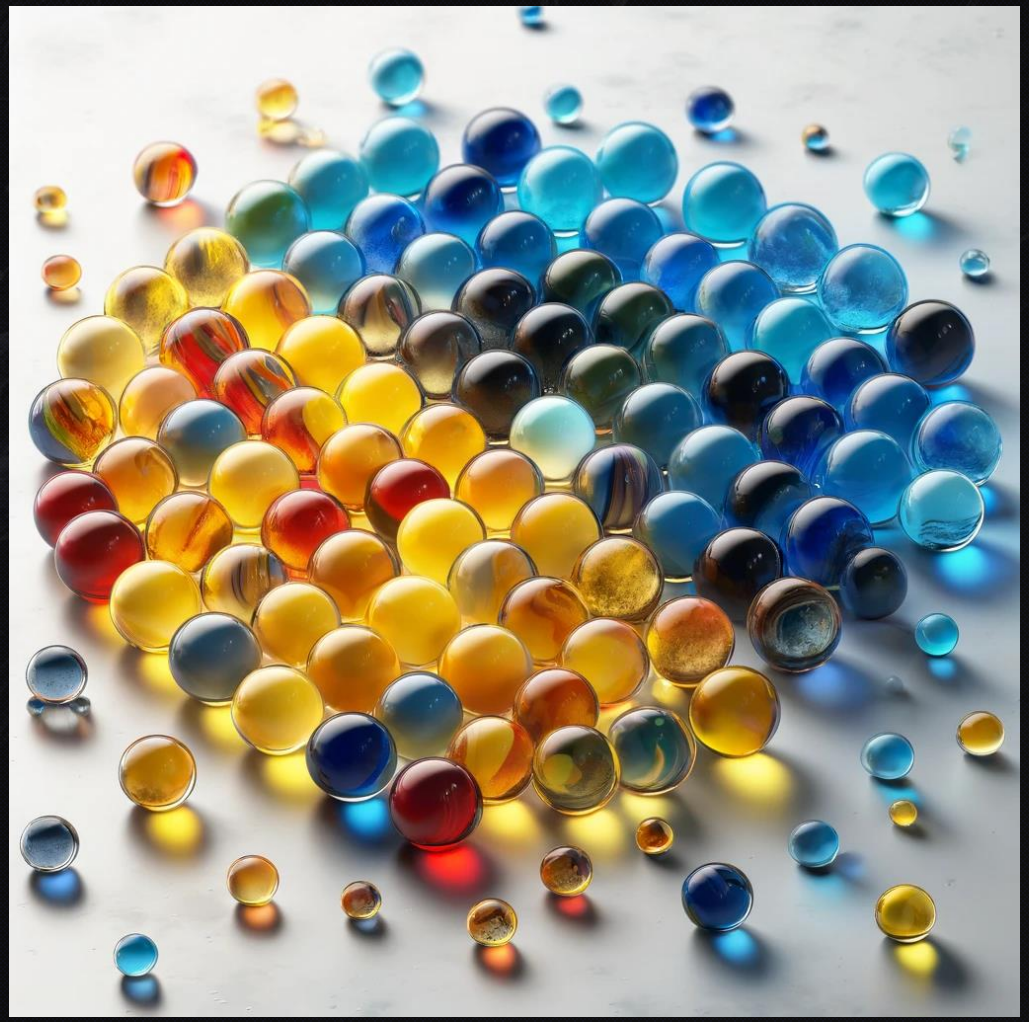
naïve explainer

the k-means method is like deciding to group the marbles

based on how close they are to each other (in color)



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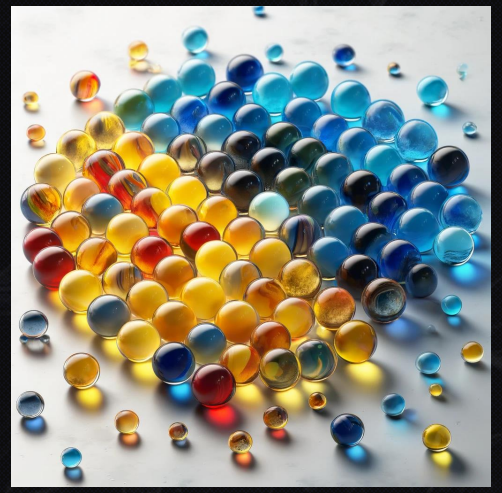
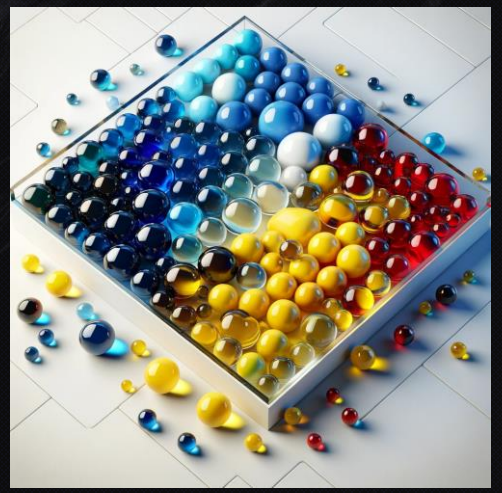
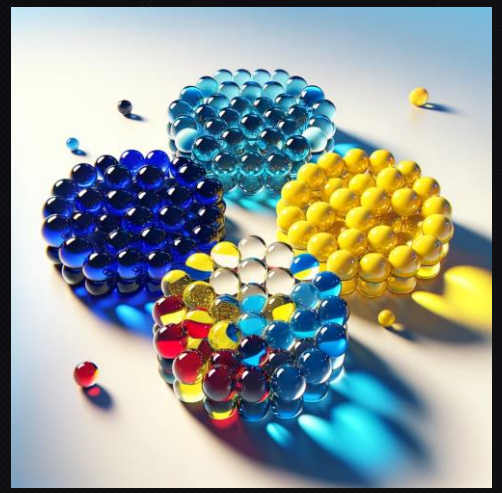
naïve explainer

the "k" in k-means is deciding how many groups you want







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steps

Initialize

Assign

Update

Repeat

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steps

Initialize

Start by selecting k initial centroids, where k is a predefined number of clusters

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steps

Initialize

Assign

Update

Repeat

Assign

each data point to the **closest** centroid,

creating clusters.

“distance” is how you find the closest centroid, define distance to mean the unit measure of the feature(s) you cluster on

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steps

Initialize

Assign

Update

Repeat

Update

Recalculate the centroids as the mean of all points in each cluster

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steps

Repeat

the assignment and update steps until the centroids no longer change significantly, indicating convergence

Initialize

Assign

Update

Repeat

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steps

Initialize

Assign

Update

Repeat

Limit

Limit

Often the centroids do not seem to converge, but dance around the convergence points, this is when we stop the algorithm by specifying the maximum number of iterations

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framework

Representation

Distance Measure

K

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framework

Representation

feature comes in focus

unit distances mean the same thing everywhere.

Representation

Distance Measure

K

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framework

Distance Measure

Cartesian, Manhattan, Cosine or custom based on the feature(s) you want to use to create the clusters.

Representation

Distance Measure

K

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The Right K: Elbow Method

Plot the cost (e.g., within-cluster sum of squares) against different k values. The "elbow" point, where the rate of decrease sharply changes, can indicate a good k value.

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The Right K: Silhouette Score

Measure how similar an object is to its own cluster compared to other clusters. A high silhouette score suggests the object is well matched to its own cluster and poorly matched to neighboring clusters. The k that maximizes the average silhouette score may be chosen.

Representation

Distance Measure

K

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framework

The Right K: Gap Statistic

Compares the total within intra-cluster variation for different values of k with their expected values under null reference distribution of the data. The k with the highest gap statistic suggests the optimal clustering.

Representation

Distance Measure

K

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how?

let’s see this in action

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method

let’s look at some code

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tech stack

this is compute intensive

we leverage vectorized, just-in-time approach

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tech stack

JAX parallelizes and optimizes the compute DAG over NumPy

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code

switch to code

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MORE

JOIN THE DISCUSSION, GITHUB, MAKE THIS BETTER

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open-source

Eight Down Toofaan Mail is now on YouTube

https://www.youtube.com/watch?v=VnHPtozfhRU

this project on GitHub: https://github.com/shauryashaurya/kandinsky

join me

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