Lecture 17: Clustering and density estimation

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What is unsupervised learning?

Unsupervised Learning

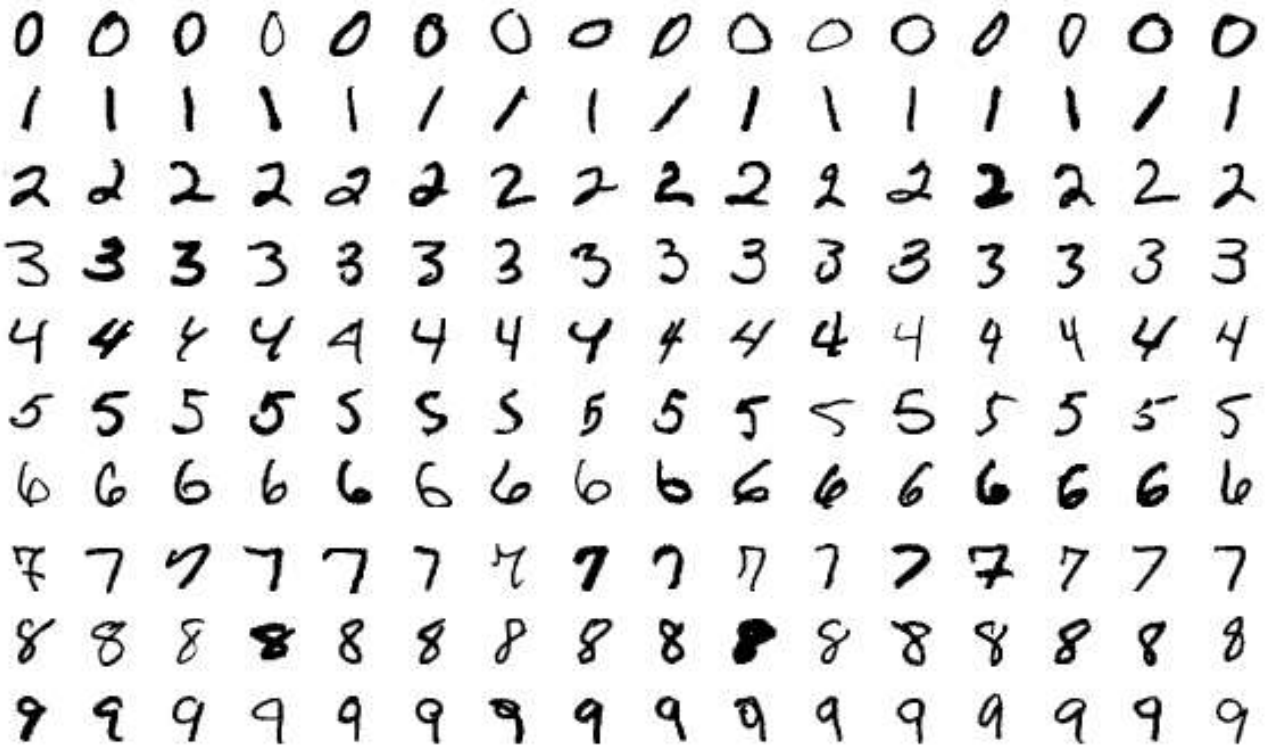
Your are given n observations:

$$\mathbf{x}_{1:n} = \{\mathbf{x}_1, \ldots, \mathbf{x}_n\}$$

(inputs, features, …)

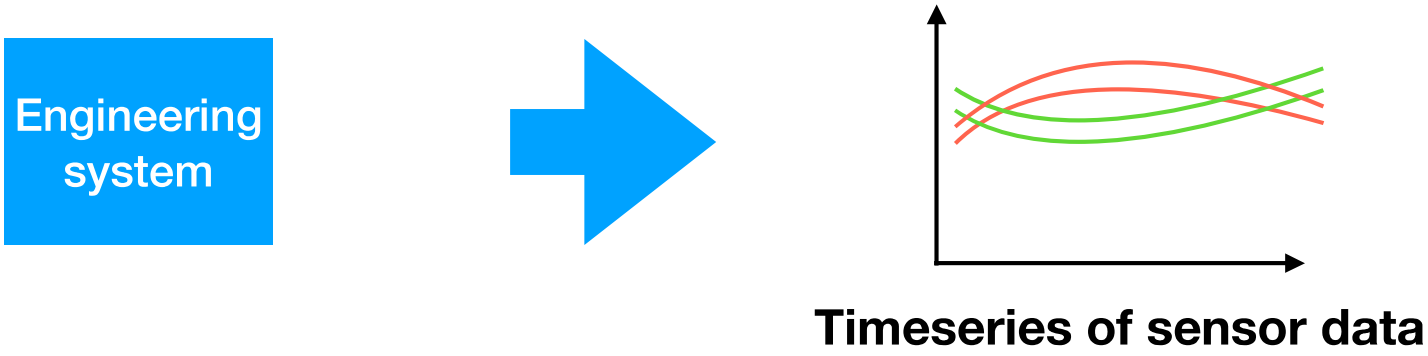
Problem: Find patterns/structure in the data.

Classic clustering example: MNIST dataset without labels



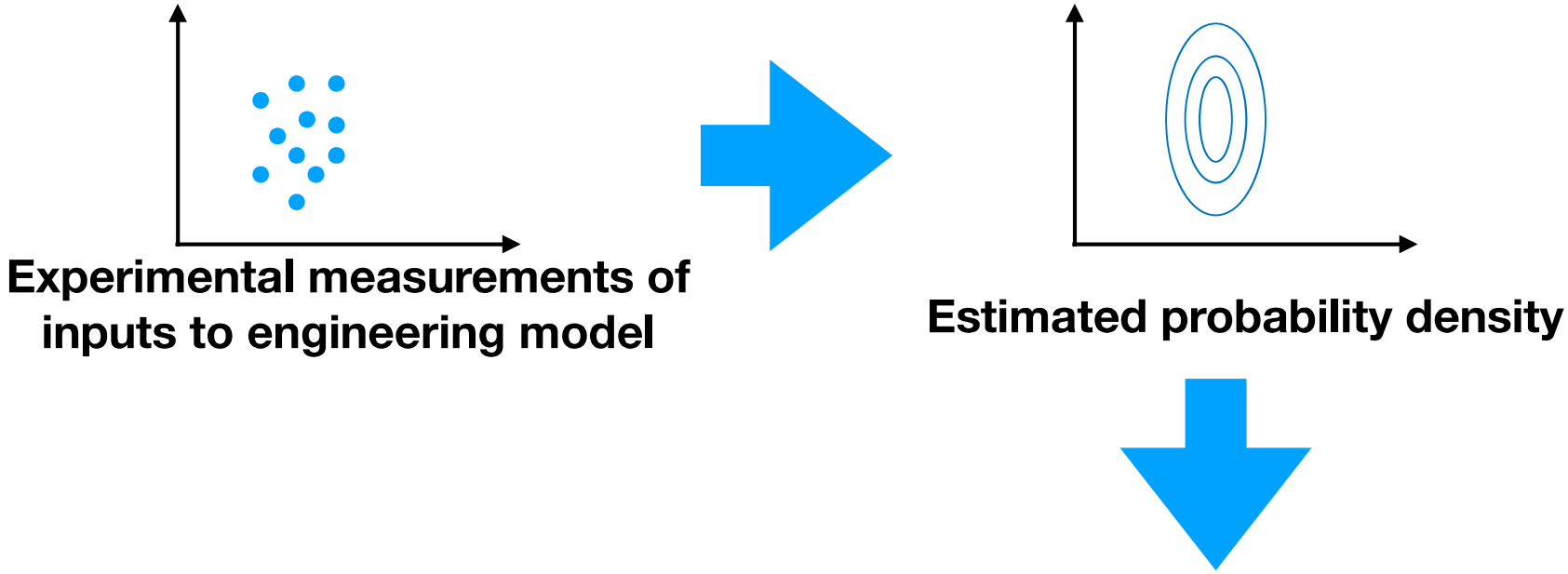
https://en.wikipedia.org/wiki/MNIST_database#/media/File:MnistExamples.png

Example of unsupervised learning in engineering context



How many different operating faults can occur?

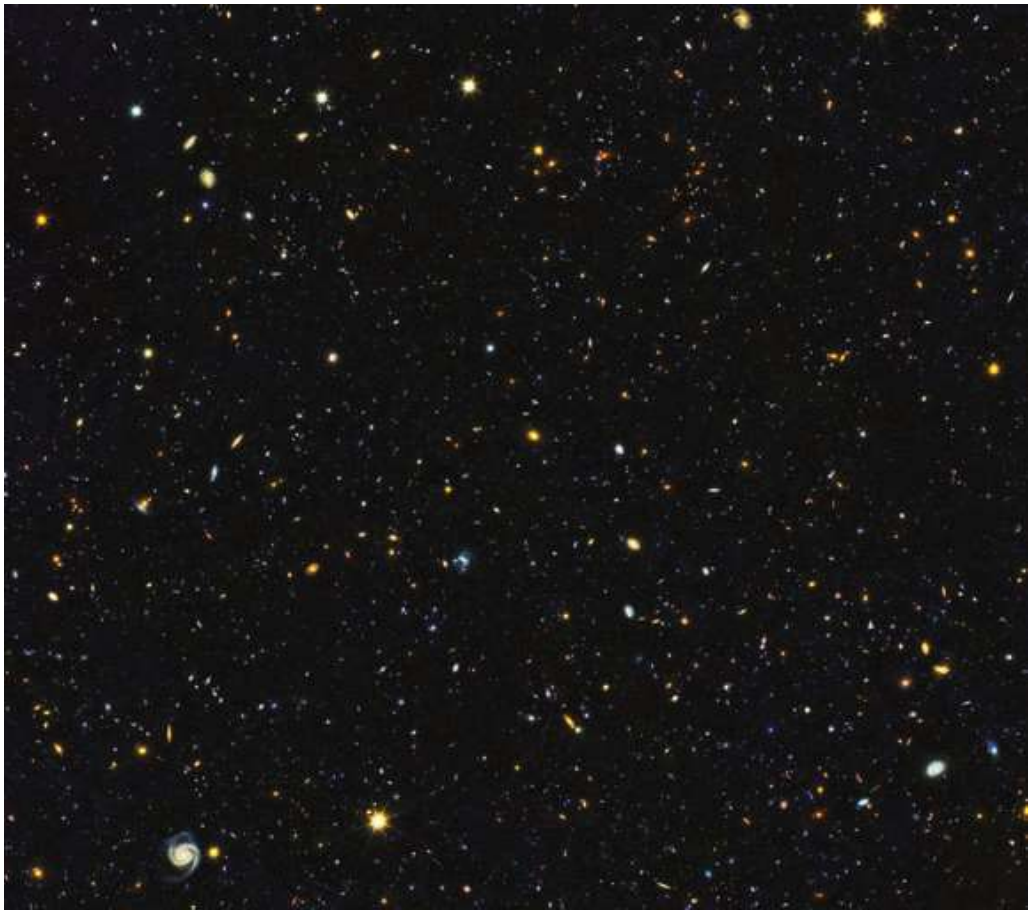
Example of density estimation in engineering/scientific context



Uncertainty propagation through engineering/scientific model.

Example of clustering in scientific context

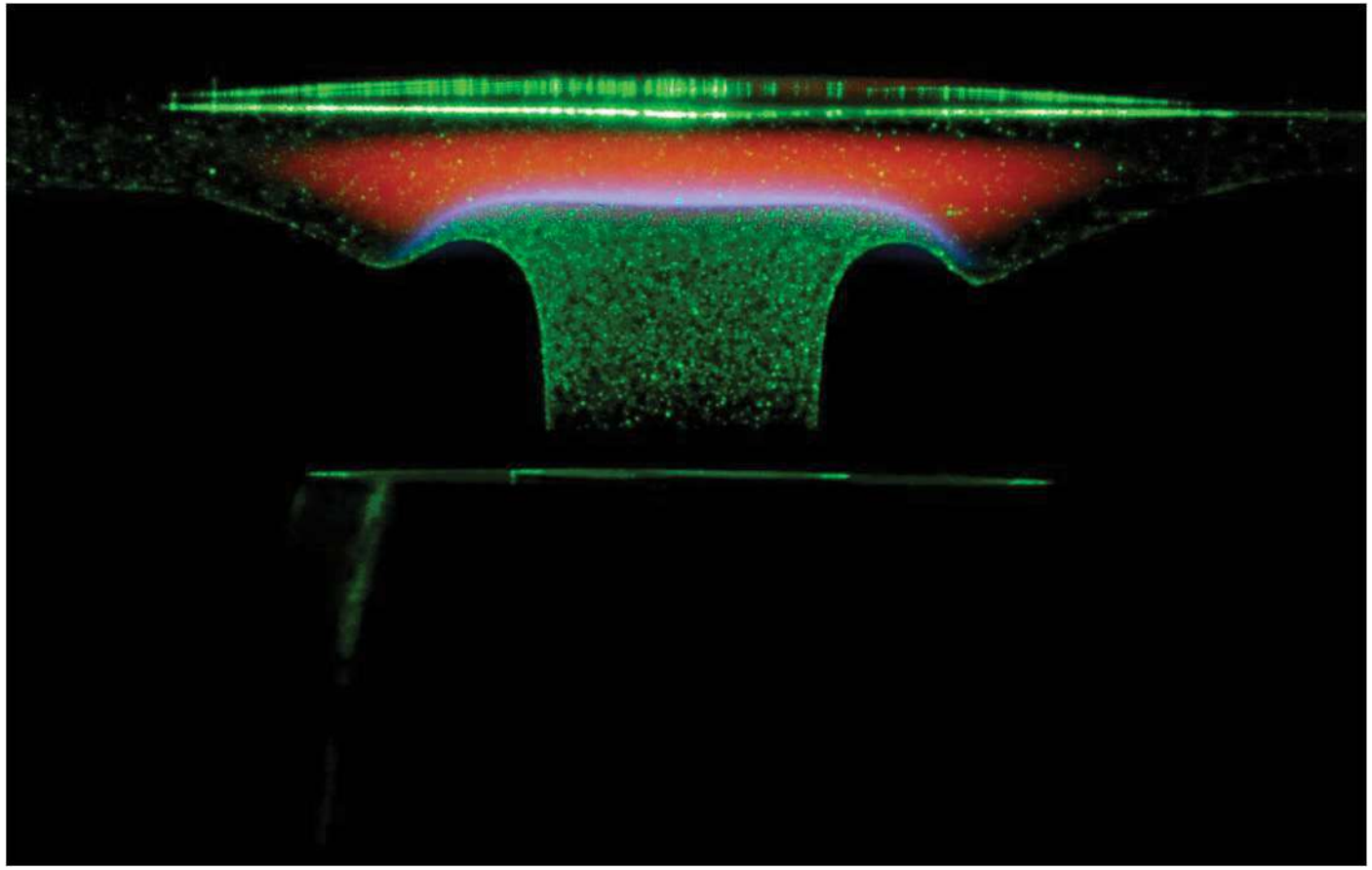
How many different galaxies are there in this picture?



https://astrobiology.nasa.gov/news/15000-galaxies-in-one-image/

Particle identification

What are the locations of the particles?



https://en.wikipedia.org/wiki/Particle_image_velocimetry#/media/File:PIV_through_stagnation_flame.jpg

A methane stagnation flame; flow seeded with 1 micron Al2O3 particles, illuminated by green light sheet (wavelength 532 nm) for particle image velocimetry.