Carnegie Mellon University
HeinzCollege

95-865 Unstructured Data Analytics

Recitation: More on PCA & manifold learning

Slides by George H. Chen

2D PCA Plots

Demo

t-SNE Interpretation

https://distill.pub/2016/misread-tsne/

Dimensionality Reduction for Visualization

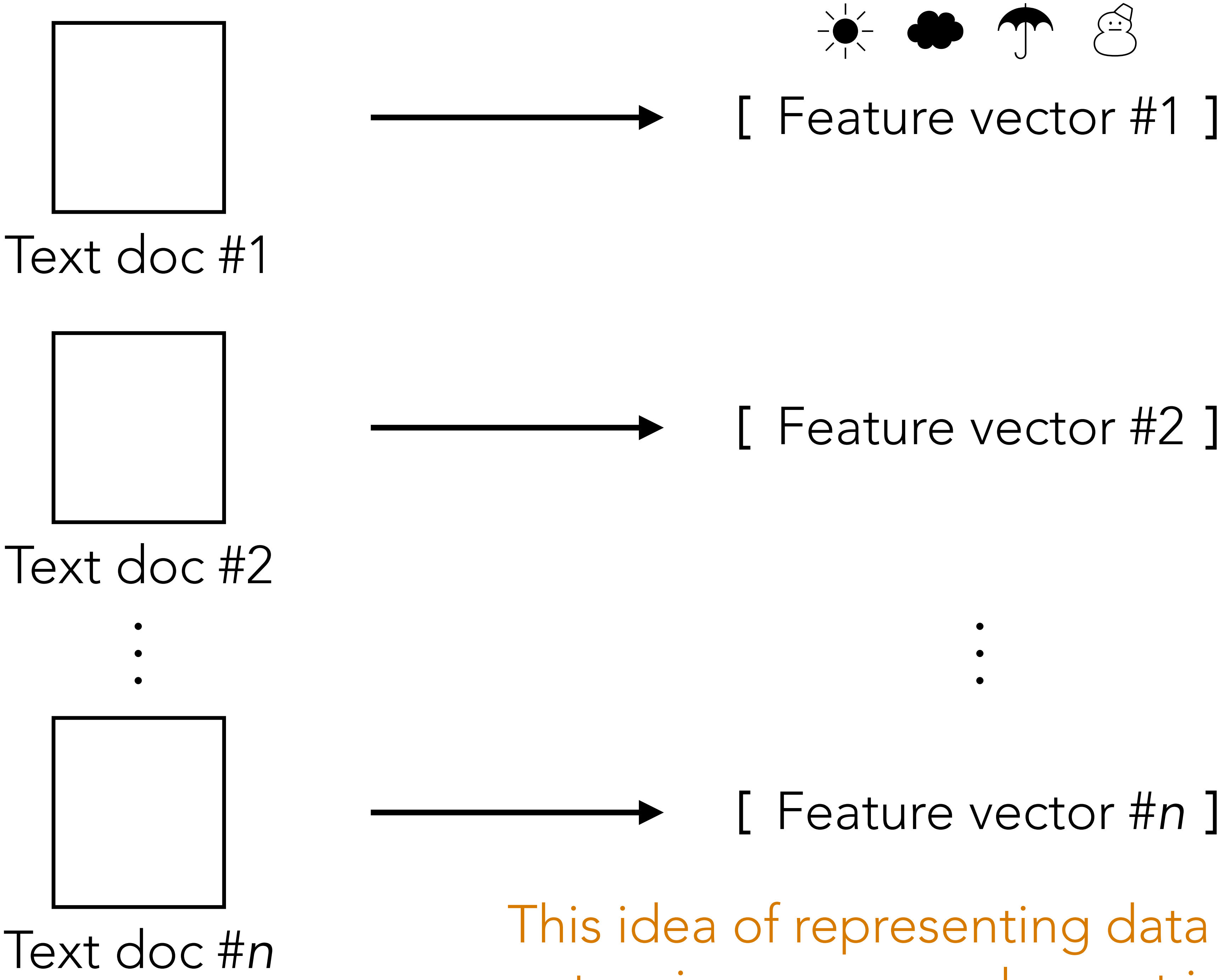
- There are *many* methods (I've posted a link on the course webpage to a scikit-learn example using ~10 methods)
- PCA is very well-understood; the new axes can be interpreted
- Nonlinear dimensionality reduction (manifold learning):
  new axes may not really be all that interpretable
- PCA is good to try first (look at plot & explained variance ratios)
  - If PCA works poorly, then t-SNE could be a good 2nd thing to try
- If you have good reason to believe that only certain features matter, of course you could restrict your analysis to those!
- t-SNE can be annoying to use but is still very popular
  - Promising recently developed alternative: PaCMAP (Wang et al 2021) accounts for local and global structure simultaneously and also uses "mid-near" neighbors of points — link on course webpage

Let’s look at images

(Flashback) Multiple Documents

Choose a common vocabulary to use across all documents

☀ ☁ ☂ ☃



Text doc #1 → [Feature vector #1]

Text doc #2 → [Feature vector #2]

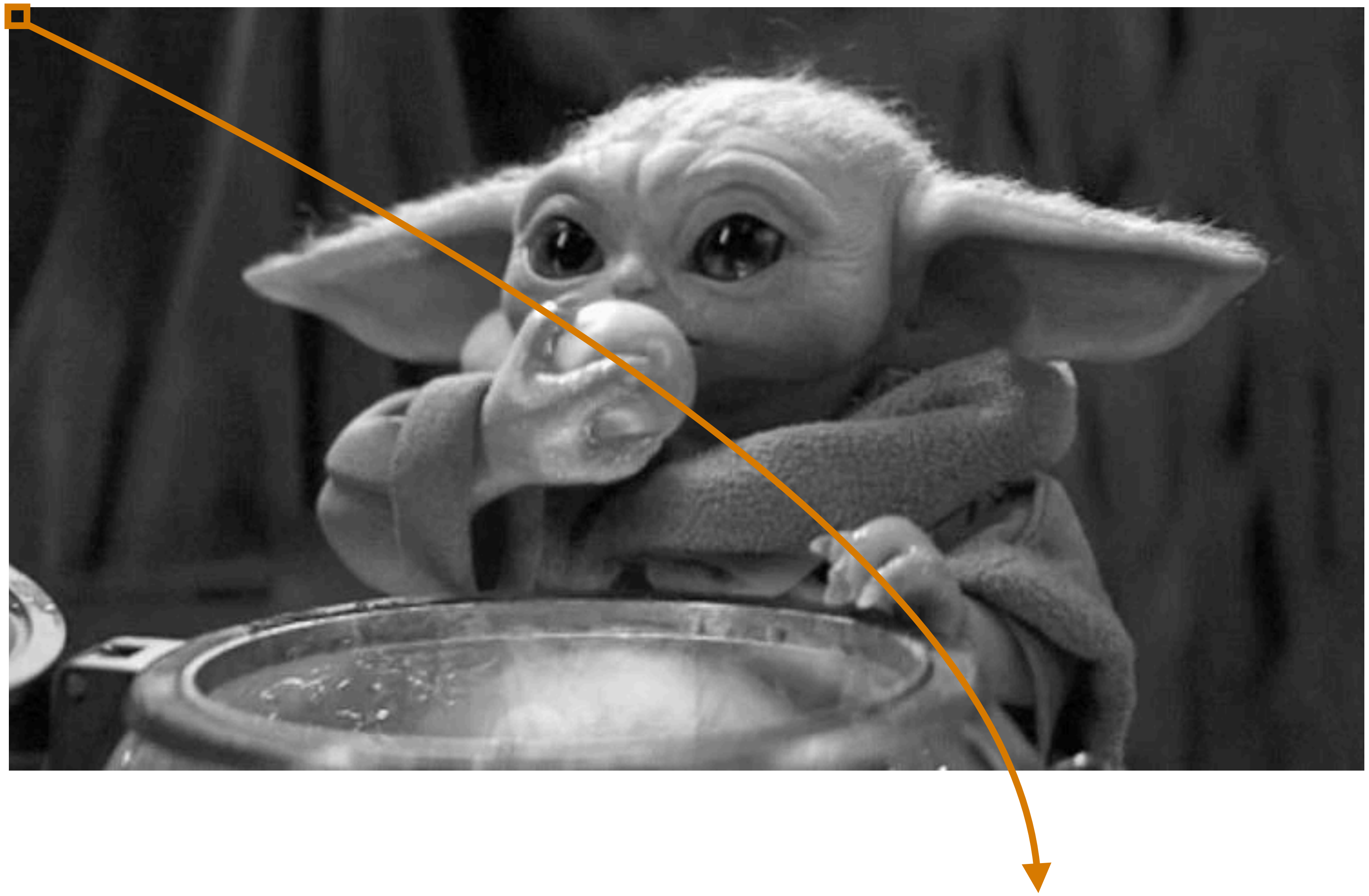
⋮

Text doc #*n* → [Feature vector #*n*]

This idea of representing data as feature vectors is very general — not just for text!

Example: Representing an Image

Go row by row and look at pixel values



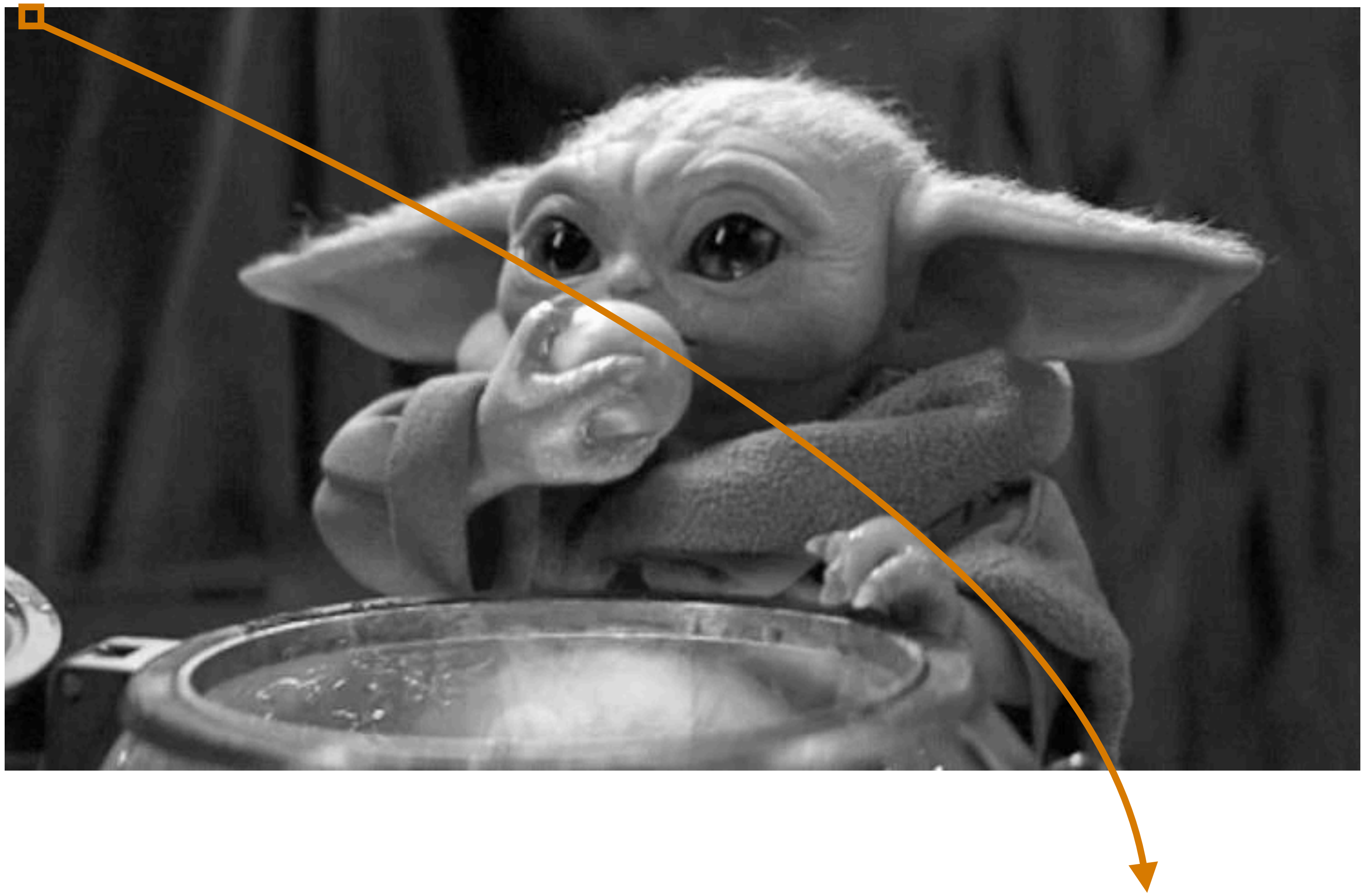
1: black
0: white

[1]

Image source: The Mandalorian

Example: Representing an Image

Go row by row and look at pixel values



1: black
0: white

[1   0.9   ]

Image source: The Mandalorian

Example: Representing an Image

Go row by row and look at pixel values

1: black
0: white

$$[\ 1 \quad 0.9 \quad \cdots \quad 0.1 \qquad\qquad]$$

Image source: The Mandalorian

Example: Representing an Image

Go row by row and look at pixel values

1: black
0: white

$$[\ 1 \quad 0.9 \quad \cdots \quad 0.1 \quad \cdots \quad 0.9\ ]$$

# dimensions = image width × image height

Image source: The Mandalorian

Very high dimensional!

Terminology Remark

$$[\;1 \quad 0.9 \quad \cdots \quad 0.1 \quad \cdots \quad 0.9\;]$$

⚠ We use “dimension” to means two different things:

- number of axes we can index into for a table/array (e.g., 2D means there are rows & columns)

# dimensions = 1

- total number of entries in the table/array

# dimensions = image height × image width

Dimensionality Reduction for Images

Demo