# CS/ECE/ME 532
# Matrix Methods in Machine Learning

*Welcome!*

# Seeing your assessment

- Today in class/after class
- During in-person office hours
- Make an appointment by email with me or the TAs
  - Note: if you emailed me and  not received a response, let me know if class today!

# About sklearn…

- sklearn is great!
- However:
  - The focus of this course is on the MATH behind ML
  - sklearn makes grading difficult and uneven
  - Therefore:

**Do not use sklearn for 532**

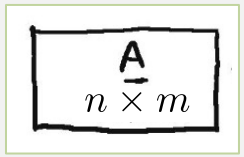
**(unless otherwise specified)**

# Activity 13

Hint for 1c: $||\boldsymbol{A}||_2 = ||\boldsymbol{A}||_{OP} = \max_{\boldsymbol{x}\neq 0} \frac{||\boldsymbol{A}\boldsymbol{x}||_2}{||\boldsymbol{x}||_2} = \sigma_1$

**Recall:**

$$\boldsymbol{A} = \boldsymbol{U}\boldsymbol{\Sigma}\boldsymbol{V}^T$$




SVD gives the ***best*** rank-r approximation:

$$\boldsymbol{A} = \sum_{i=1}^{n} \sigma_i \boldsymbol{u}_i \boldsymbol{v}_i^T \quad \rightarrow \quad \hat{\boldsymbol{A}} = \sum_{i=1}^{r} \sigma_i \boldsymbol{u}_i \boldsymbol{v}_i^T$$

## Applications of SVD

Image compression


Face recognition

[PDF] Face recognition using **eigenfaces**

M Turk, A Pentland - … . 1991 IEEE computer society conference on

We present an approach to the detection and identification of human f
working, near-real-time face recognition system which tracks a subjec
recognizes the person by comparing characteristics of the face to thos

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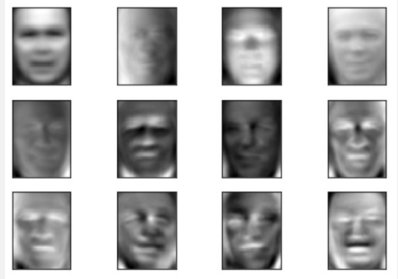

## Bias-Variance Tradeoff

How far off is $\hat{\boldsymbol{A}}$ ? $||\boldsymbol{A} - \hat{\boldsymbol{A}}||_F^2 = \sum_{i=r+1}^{n} \sigma_i^2$ *bias!*

*Sum of squares of the singular values left out of approx.*

What happens in the presence of noise?

$$\boldsymbol{A} = \boldsymbol{S} + \boldsymbol{N}$$ *noise often isotropic (singular values same)*

$$\sum_{i=r+1}^{n} \sigma_i^2 \quad \text{vs.} \quad rm\sigma_g^2$$