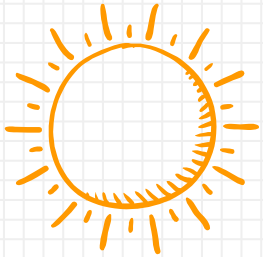
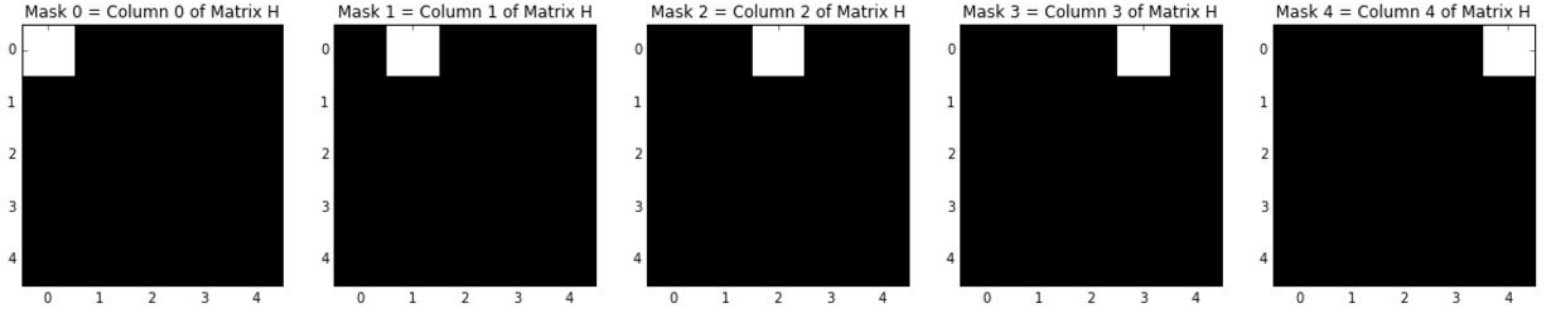


EE16A Imaging 3

Announcements

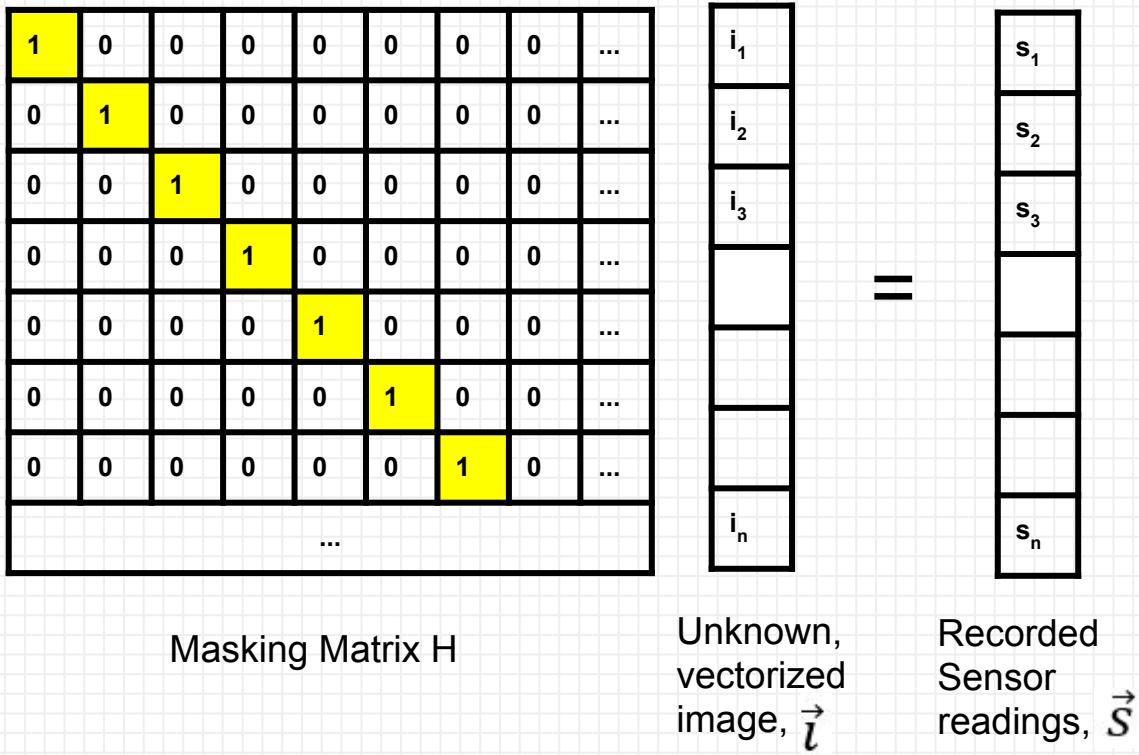
- Buffer Week Schedule on Piazza
  - Can make up any Imaging Lab (1, 2, or 3)
- Midterm 10/1 - study hard!
- This lab is conceptually very challenging
  - This presentation will help a lot :)
  - Also, there's a homework problem that is quite similar

Last week: Single-Pixel Scanning



- Setup a masking matrix where each row is a mask
  - Measured each pixel individually once

Last Week: SPS is Matrix-Vector Multiplication

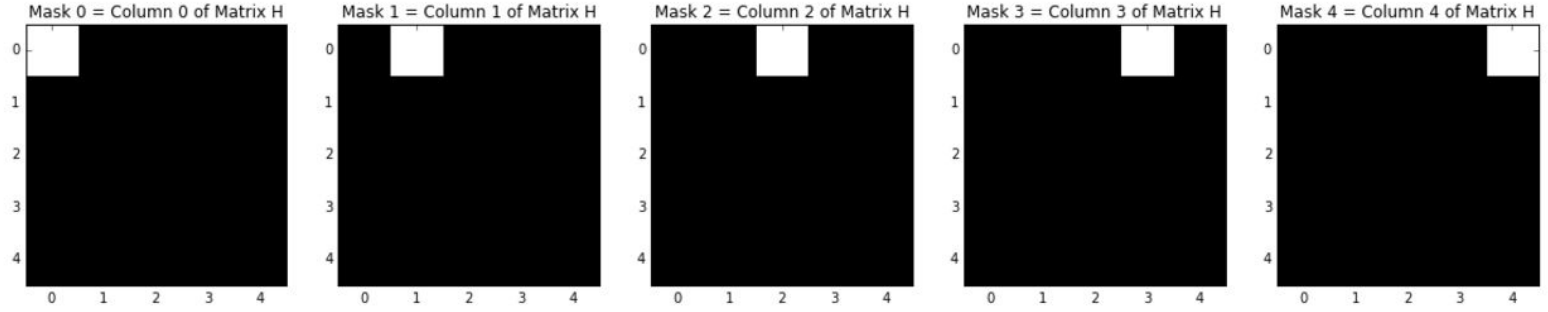


Masking Matrix H

Unknown, vectorized image, $\vec{i}$

Recorded Sensor readings, $\vec{s}$

Last week: Single-Pixel Scanning



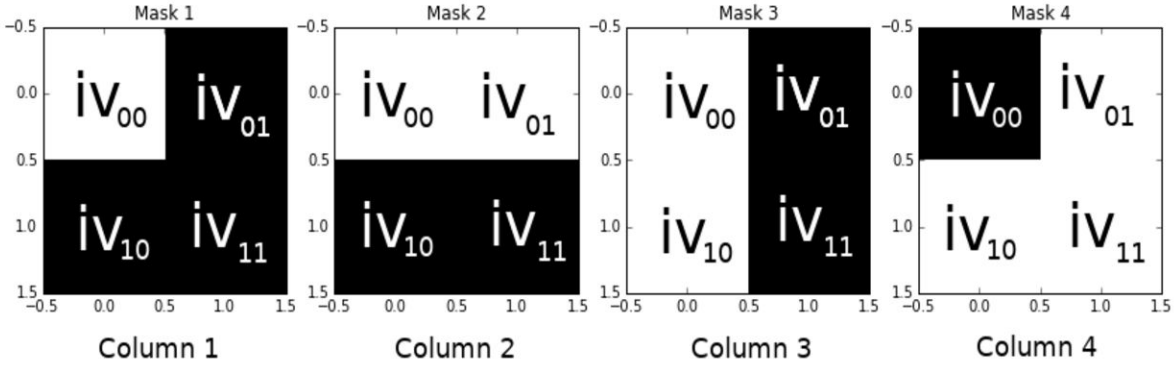
- Setup a masking matrix where each row is a mask
  - Measured each pixel individually once
- **How can we reconstruct our scanned image?**
- **What are the requirements of our masking matrix H?**

$$\vec{s} = H\vec{\imath}$$

Some questions from last week

- Are all invertible matrices equally good as scanning matrices?
- What happens if we mess up a single scan?

Today: Multi-Pixel Scanning



- **Can we measure multiple pixels at a time?**
  - Measurements are now linear combinations of pixels
- **How can we reconstruct our scanned image? Why?**
  - But there are still other things to be concerned about

Why do we care?

- We want to improve the quality of our images
- Fountain codes homework
  - The idea was good enough to get Qualcomm to buy the inventors' company
- Redundancy is always good
  - Averaging measurements is better than just keeping bad values

How do we do it?

- We need to change our masks to improve our SNR (signal to noise ratio)
  - Take smarter measurements
  - Measure linear combinations of pixels instead of a single pixel
  - Redundancy is key to getting good results
- Problems?
  - Our measurements are noisy
    - What is noise?
  - Noise can be amplified through inverting a matrix
    - How?

What is noise?

What is Noise?

0.4
0.95
2.1
.
.
.
9.8

$\vec{s}_{real}$

We can say that this vector is the ideal vector plus some vector of disturbances we call “noise,” represented by ω

=

0
1
2
.
.
.
10

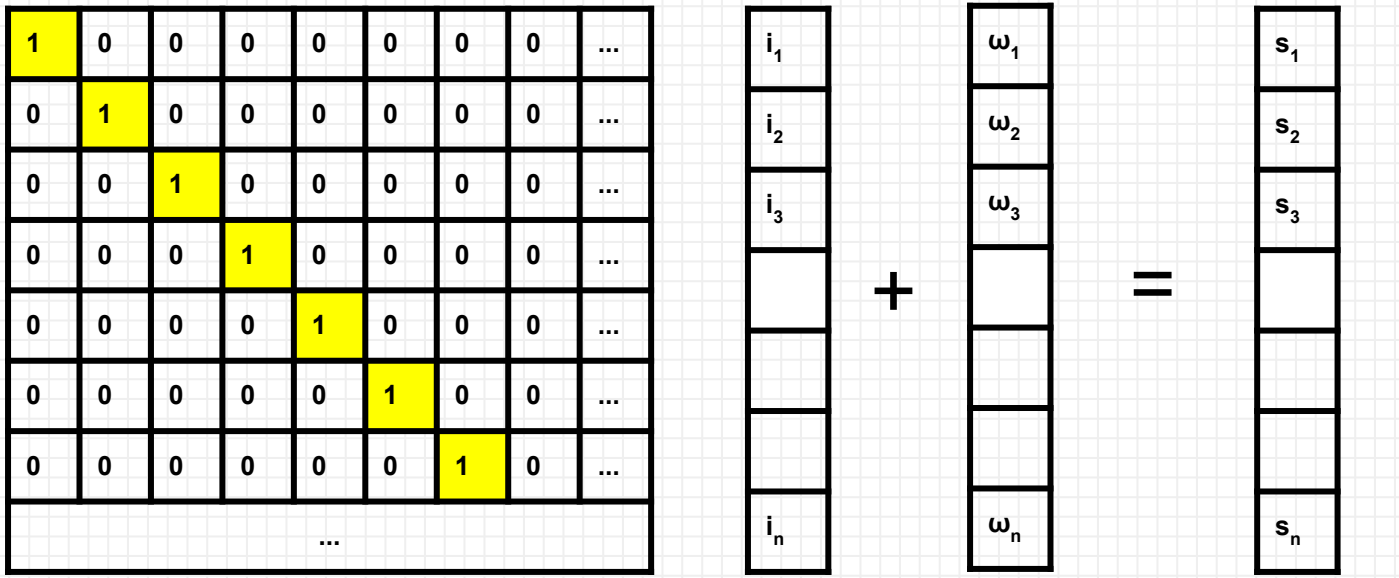
$\vec{s}_{ideal}$

+

0.4
-0.05
0.1
.
.
.
-0.2

$\vec{w}$

What is noise?



Masking Matrix **H**

Unknown, vectorized image, $\vec{i}$

Random noise vector, $\vec{w}$

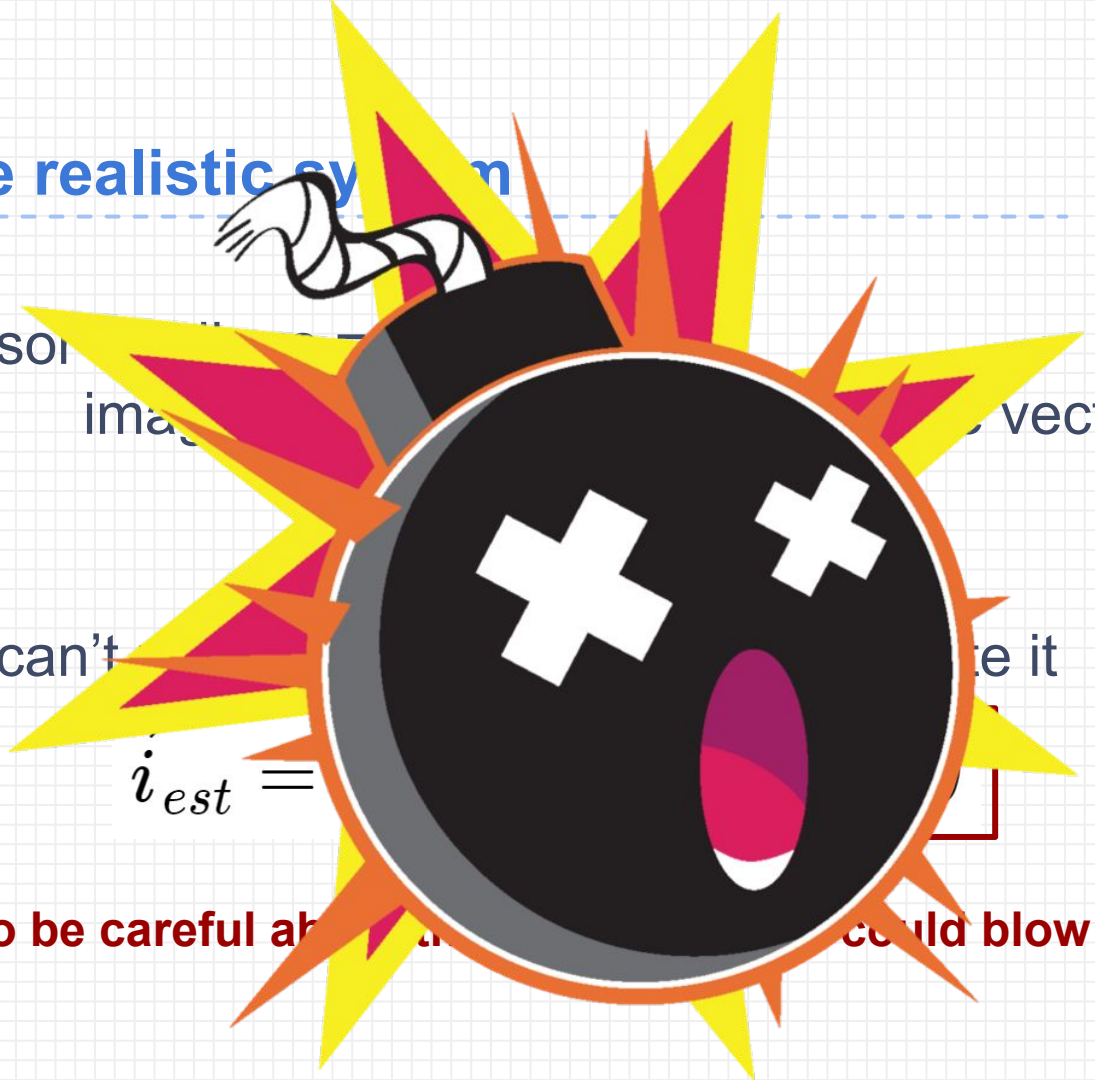
Recorded Sensor readings, $\vec{s}$

A more realistic sy m

- Sensor ... vector

- We can't ... e it

$$i_{est} =$$



We have to be careful ab ... could blow up !!

The Missing Link

- H Is an NxN matrix that we know is linearly independent (invertible).
  Therefore:
  - H has N linearly independent eigenvectors
  - N lin. ind. vectors can span $\mathbb{R}^N$
    - They span the noise vector
  - The inverse has eigenvalues $\frac{1}{\lambda_1}, \frac{1}{\lambda_2}, \ldots \frac{1}{\lambda_n}$

The Missing Link

Thus the noise term from before can be written as:

$$\vec{\omega} = \alpha_1 \overrightarrow{v_1} + \alpha_2 \overrightarrow{v_2} + \cdots \alpha_n \overrightarrow{v_n}$$

And:

$$H^{-1}\vec{\omega} = H^{-1}(\alpha_1 \overrightarrow{v_1} + \alpha_2 \overrightarrow{v_2} + \cdots \alpha_n \overrightarrow{v_n})$$

Finally

$$= \frac{1}{\lambda_1}\alpha_1 \overrightarrow{v_1} + \frac{1}{\lambda_2}\alpha_2 \overrightarrow{v_2} + \cdots \frac{1}{\lambda_n}\alpha_n \overrightarrow{v_n}$$

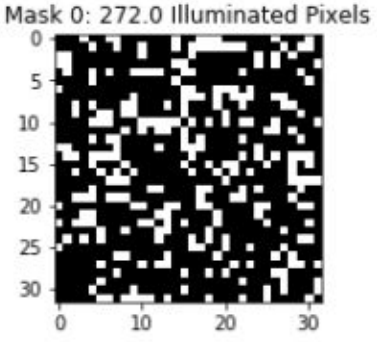
Linking it all together

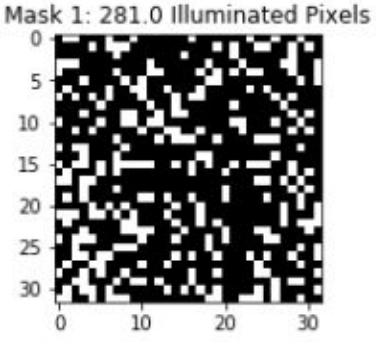
$$\vec{\imath}_{est} = H^{-1}\vec{s} + H^{-1}\vec{\omega}$$

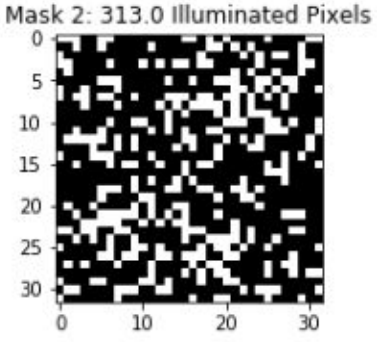
$$H^{-1}\vec{\omega} = \frac{1}{\lambda_1}\alpha_1\vec{v_1} + \frac{1}{\lambda_2}\alpha_2\vec{v_2} + \cdots \frac{1}{\lambda_n}\alpha_n\vec{v_n}$$

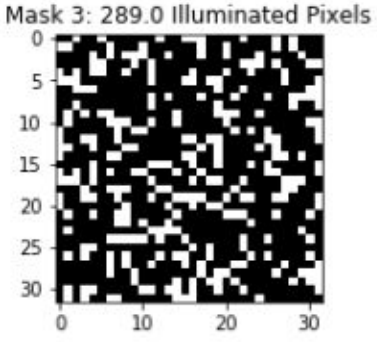
- The noise is directly related to the eigenvalues.
- We don't know what the alphas are, but we can reduce noise by choosing good eigenvalues
  - **What are good eigenvalues?**
- **What properties would a good H matrix have?**

Possible Scanning Matrix: Random







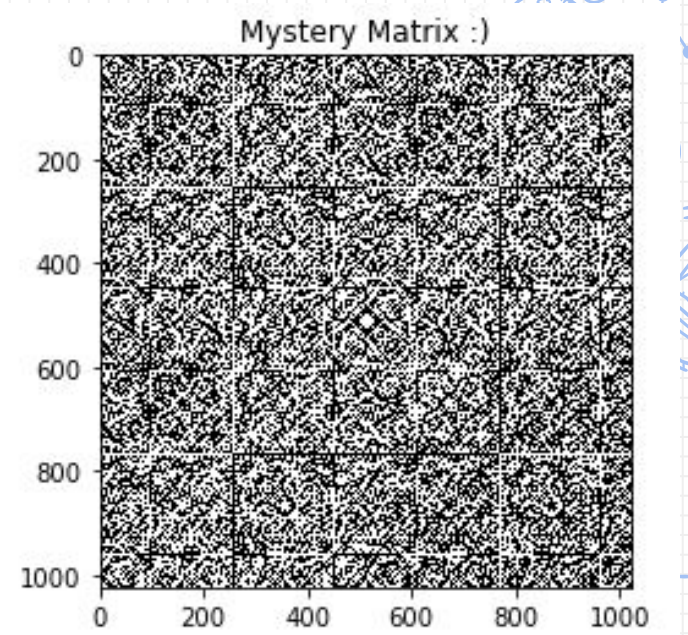


- Illuminate ~300 pixels per scan
  - *Usually* invertible
  - But what are its eigenvalues?

¯_(ツ)_/¯

A more systematic scanning matrix:

- Hadamard matrix!
- Constructed to have large eigenvalues
  - Just what we need!



Notes

- READ CAREFULLY - Very long lab with lots of reading; heavily tests understanding of eigen stuff
- Post check off link is optional but very cool
- Can adjust projector settings
  - Focus with dial on side
  - Brightness, contrast, sharpness
- If you aren’t checked off for Imaging 2, do so today