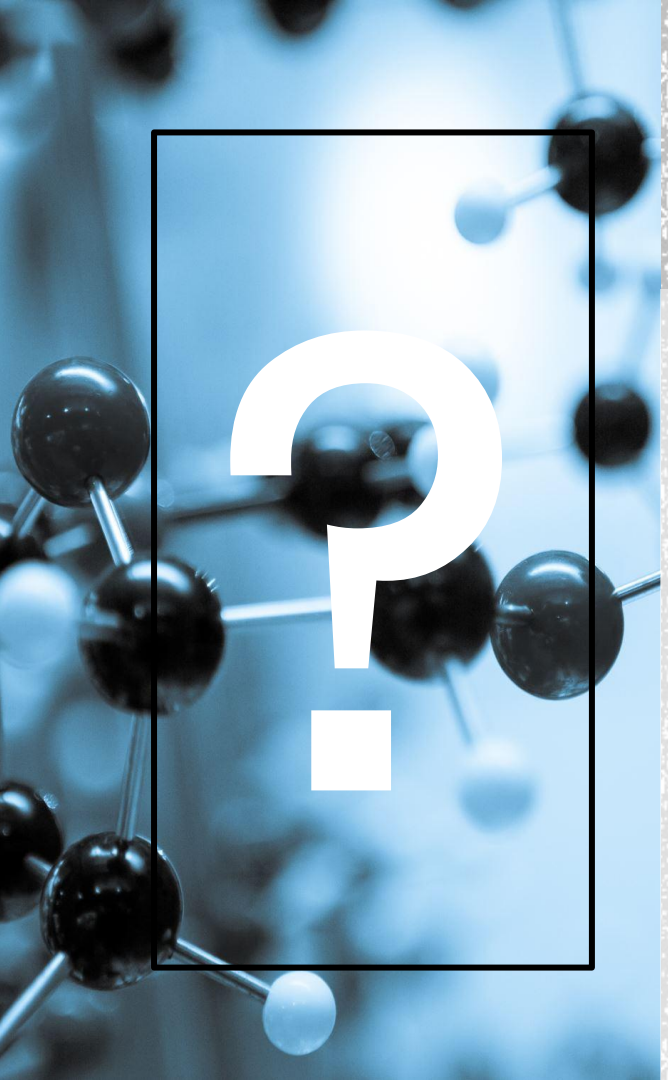
DETECTORS & GENERATORS: INTRO

Scott H. Hawley
Belmont University, Nashville TN

Faith & Science Symposium, Bethel University, St. Paul MN, April 6, 2024

CONTENT: METAPHORS IN FAITH⇔SCIENCE

- Not apologetics talks. (Apologetics is fine though!)
- They are reflections, *metaphors* between matters of science & faith
- Biblical content (proverbs, parables,…) was often in metaphors, so people back then could relate, e.g. farming metaphors. (1 Cor 9:9)
- Christian bookstores are full of metaphors involving sports, business,…?
- <u>Scientists are believers too!</u> We experience the world in unique ways, & can supply meaningful insights & realizations based on our perspectives
- Also: Science itself is a series of metaphors.
- My fields: Physics, Music, & Machine Learning/AI



CAVEATS

- While I draw comparisons with scripture, these metaphors are not 100% scriptural
- I am not a theologian
- They are just 'my' human-made metaphors
- They should carry as much weight as human-made metaphors drawn from golf, sportsball, birding, fashion, cake-baking, Baldur's Gate 3, or differential geometry.
- If they 'resonate' with you, great!
- If not, then ~~you're a bad, stupid person~~ use whatever you can & discard the rest.

STRUCTURE OF THESE TALKS: 2 MAJOR ML ("AI") CATEGORIES

1 "Discriminative AI": classifiers, recognizers, decision-makers, diagnosers

- "be able to recognize the times"
- "he who has ears to hear"
- noise, filters, damping - gravity wave detectors, kittens' eyes
- similarity

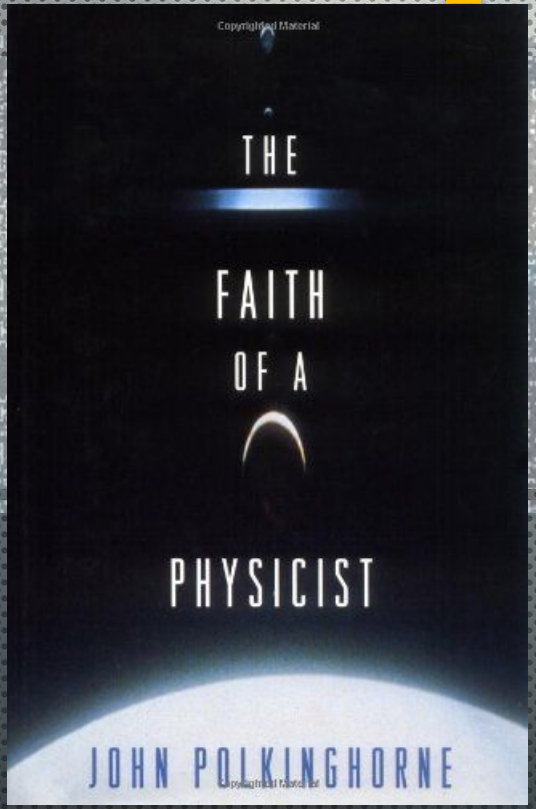
2 "Generative AI":

- "out of the overflow of the heart the mouth speaks"
- language models, image generation, audio generation
- shaping noise

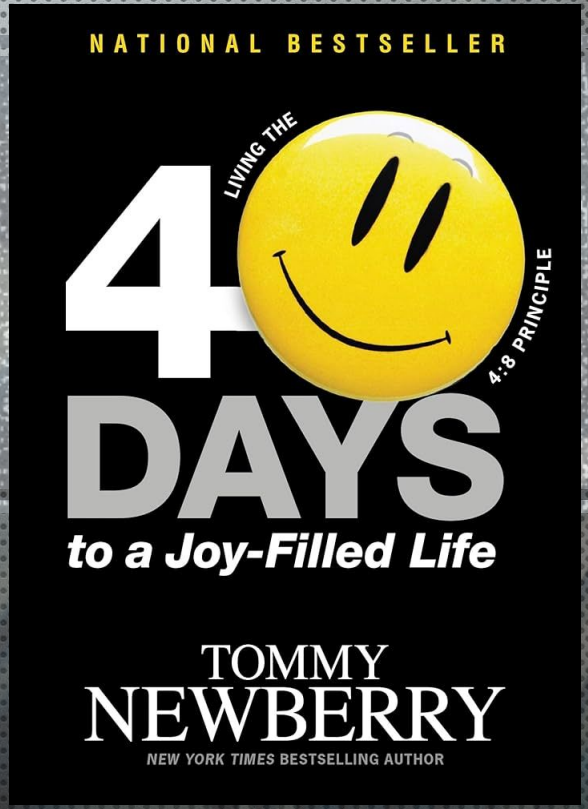
Dominant paradigm for the past 10 years: neural networks

- "...be transformed by the renewing of your mind [the weights in your internal neural network]"

Books On-Topic:



POLKINGHORNE



NEWBERRY

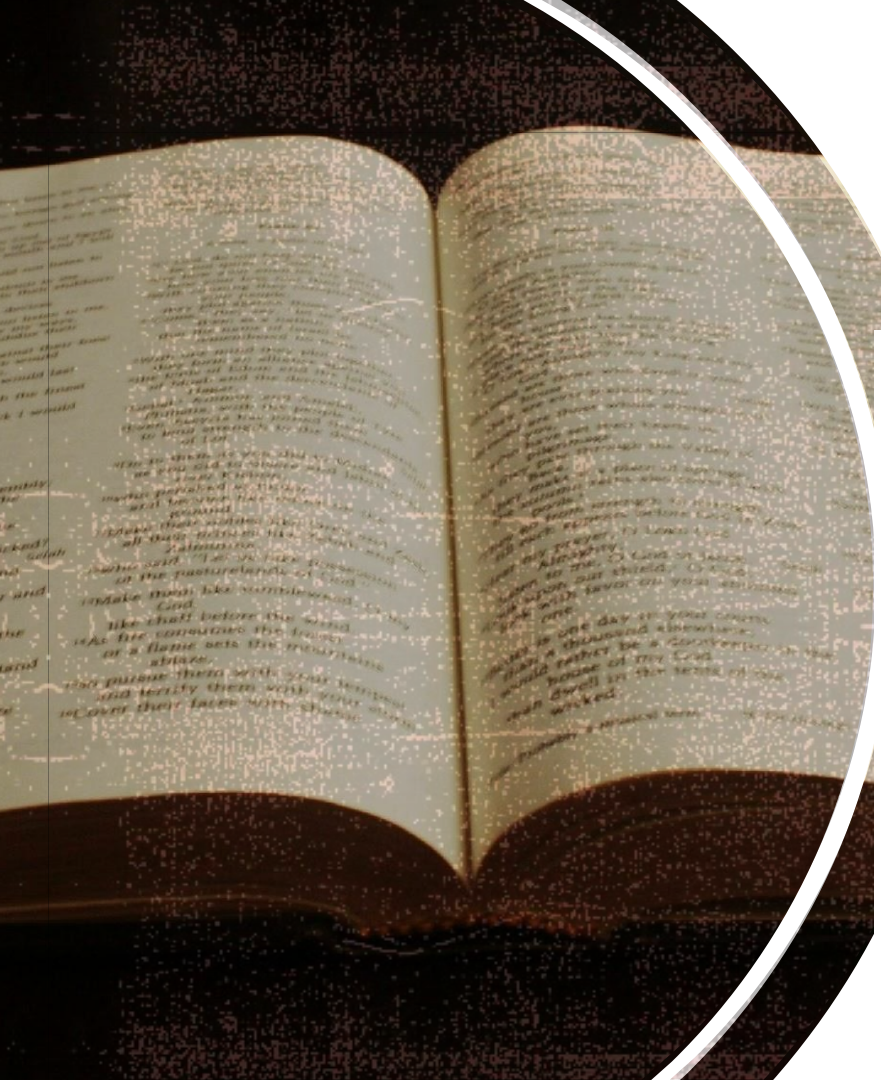
PART I: DETECTORS

Scott H. Hawley

EYES THAT SEE & EARS THAT HEAR

Detection, Filtering, & Classifying by Humans and Machines

@drscotthawley



BIBLE PASSAGE TO GET US STARTED: EPH 4:17-24

17 So I tell you this, and insist on it in the Lord, that you must no longer live as the Gentiles do, in the futility of their thinking.
18 They are darkened in their understanding and separated from the life of God because of the ignorance that is in them due to the hardening of their hearts.
19 Having lost all sensitivity, they have given themselves over to sensuality so as to indulge in every kind of impurity, and they are full of greed.
20 That, however, is not the way of life you learned
21 when you heard about Christ and were taught in him in accordance with the truth that is in Jesus.
22 You were taught, with regard to your former way of life, to put off your old self, which is being corrupted by its deceitful desires;
23 to be made new in the attitude of your minds;
24 and to put on the new self, created to be like God in true righteousness and holiness.

BIT MORE BIBLE

- 15 times in N.T: Whoever has ears, let them hear.
- Jeremiah 5:21: Hear now this, O foolish people, and without understanding; which have eyes, and see not; which have ears, and hear not
- Deut 29:3-4: With your own eyes you saw those great trials, those signs and great wonders. But to this day the Lord has not given you a mind that understands or eyes that see or ears that hear.
- Hebrews 5:14: But solid food is for the mature, who by constant use have trained themselves to distinguish good from evil.

DETECTION (+ID, CLASSIFICATION, RECOGNITION,...)

Fundamental to being human, increasingly performed by machines: "AI"

Detection: Realizing something is there

Identification: What thing is this?

medicine, law, … ethics,...

Often via measure of *similarity* to what's expected

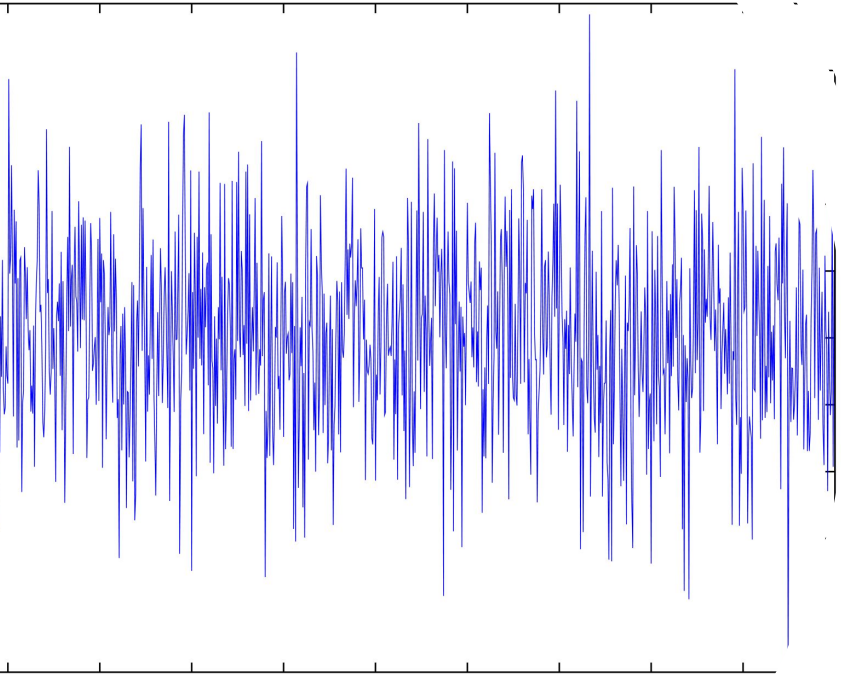
"Classification problems" are very prevalent in Machine Learning

- Automating decisions, which are typically discrete.
- Bureaucracies run on classifications
- Applications: Speech-to-Text, Loan approval, Object detection / Image segmentation, Content moderation (hate speech / fake news), Gunshot detection, Criminal risk assessment
- $$ to be made

Example: IID in Field Biology

- "Individual ID" = not just what *kind* of bird/whale/bat we see it, but which *individual* – "that spotted warbler who's named Steve"
- …quote paper

SKIPPING…



~NOISE~

- makes it hard to detect stuff
- what kinds of noise are in your life?
- (Noise will reappear in Part II as a key part of generative models)

product endorsement

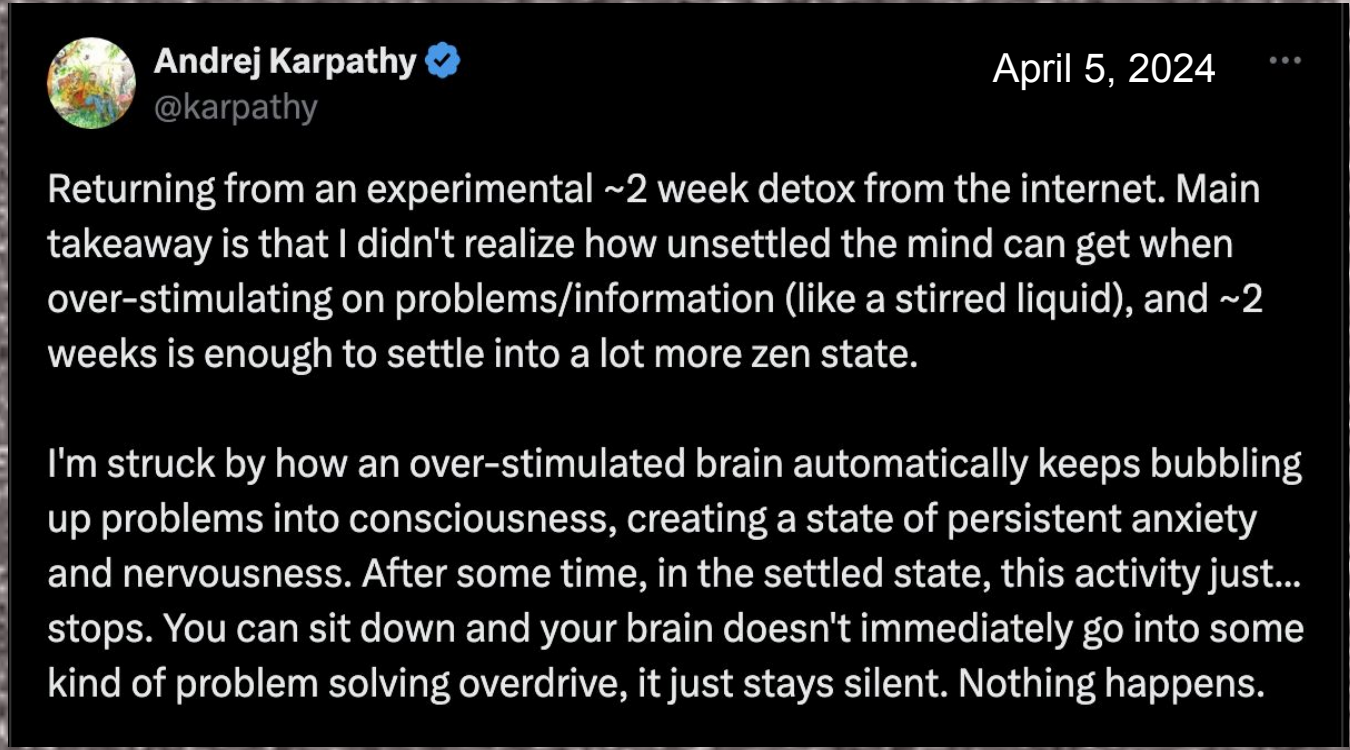
Bose QuietComfort Ultra Wireless Noise Cancelling Earbuds 👍

Classic way to deal with noise

Get distance:

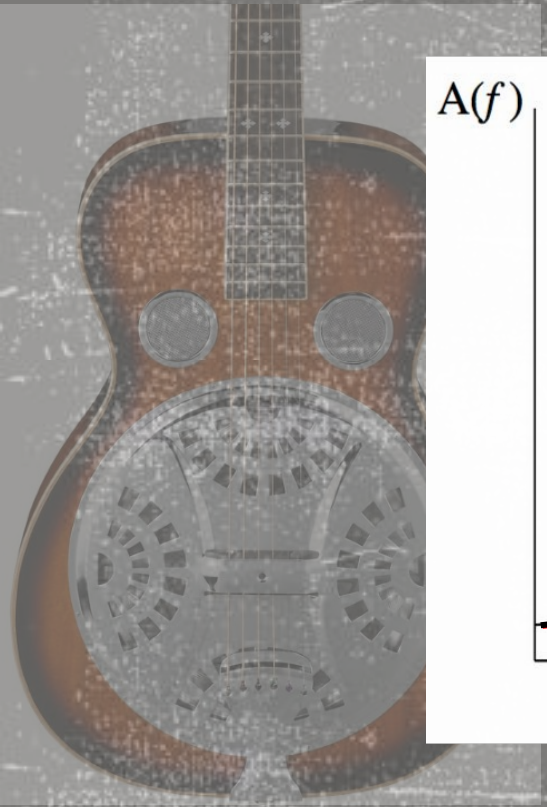
Retreat / Isolate

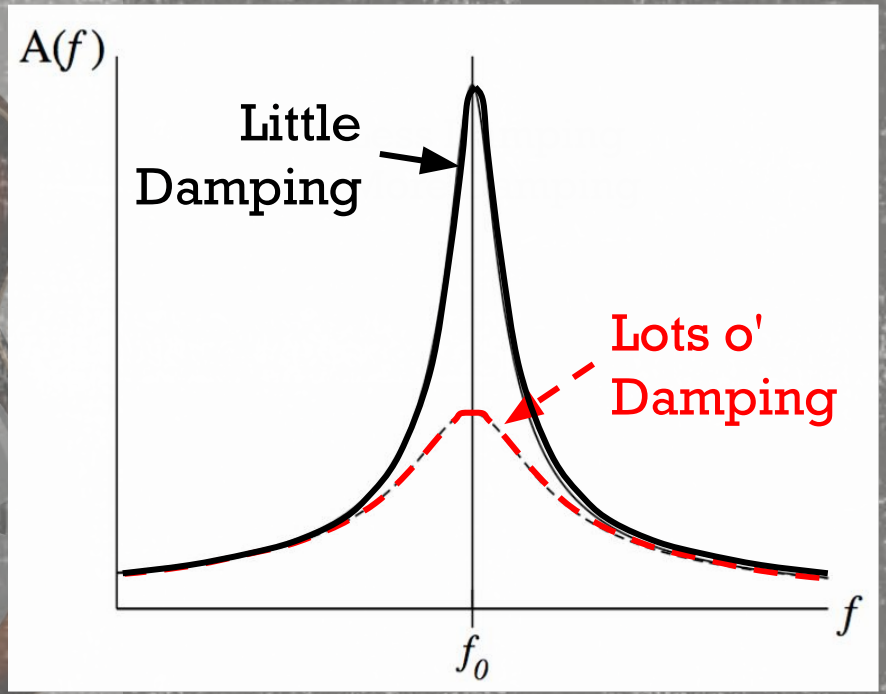
Meditate

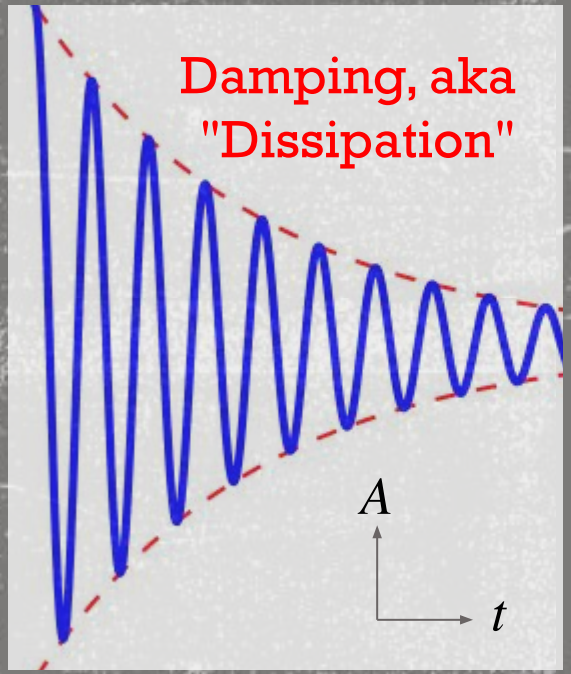


Another way: Filters, e.g. Resonance...

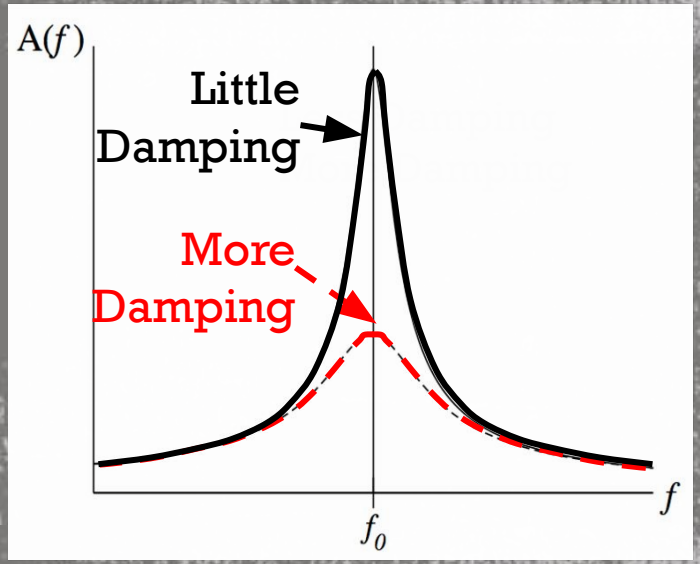
RESONANCE & DAMPING

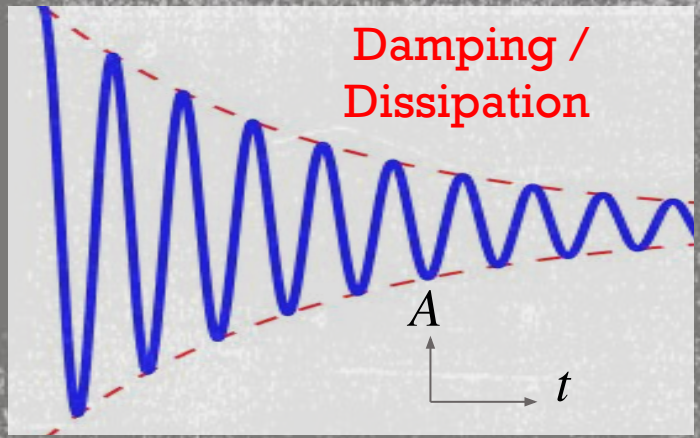






Interactive Demo





Devotional Reflections

Less Damping ⇒More finely tuned, more sensitive

More damping⇒Less responsive

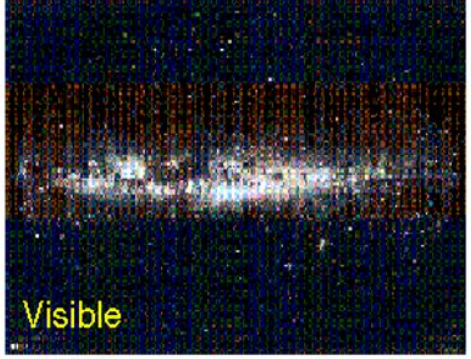
"But their minds were made **dull**, for to this day the same veil remains when the old covenant is read. It has not been removed, because only in Christ is it taken away." 2 Cor 3:14

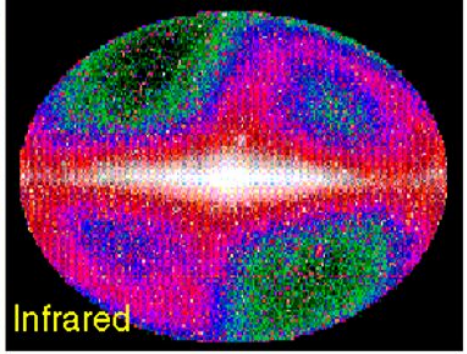
"Be careful, or your hearts will be weighed down with **dissipation**, drunkenness and the anxieties of life, and that day will close on you unexpectedly like a trap. For it will come upon all those who live on the face of the whole earth." Luke 21:34-35 NIV

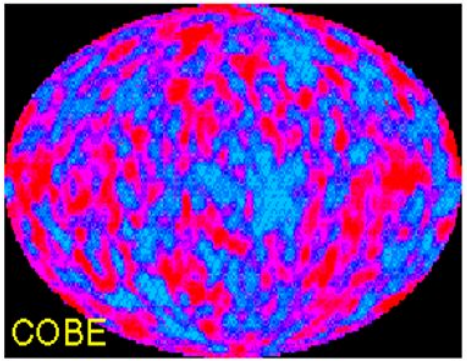
Signals pass through us all the time

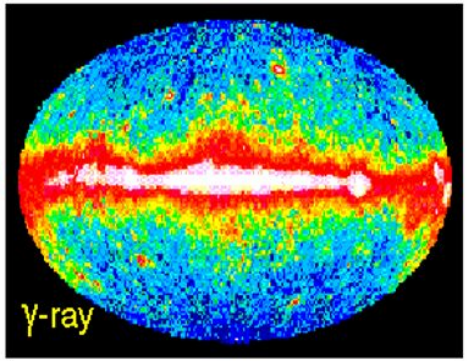
- How well are our detectors tuned?
- What's our noise background?
- Are we even sensitive to the right *band* of signals?

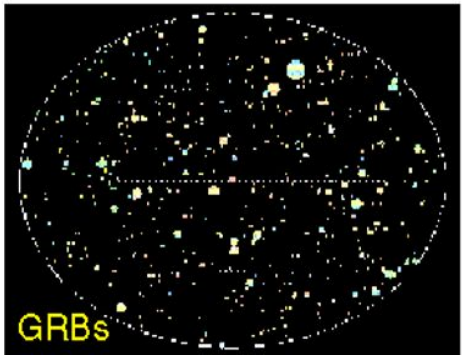
Consider *gravity waves…*





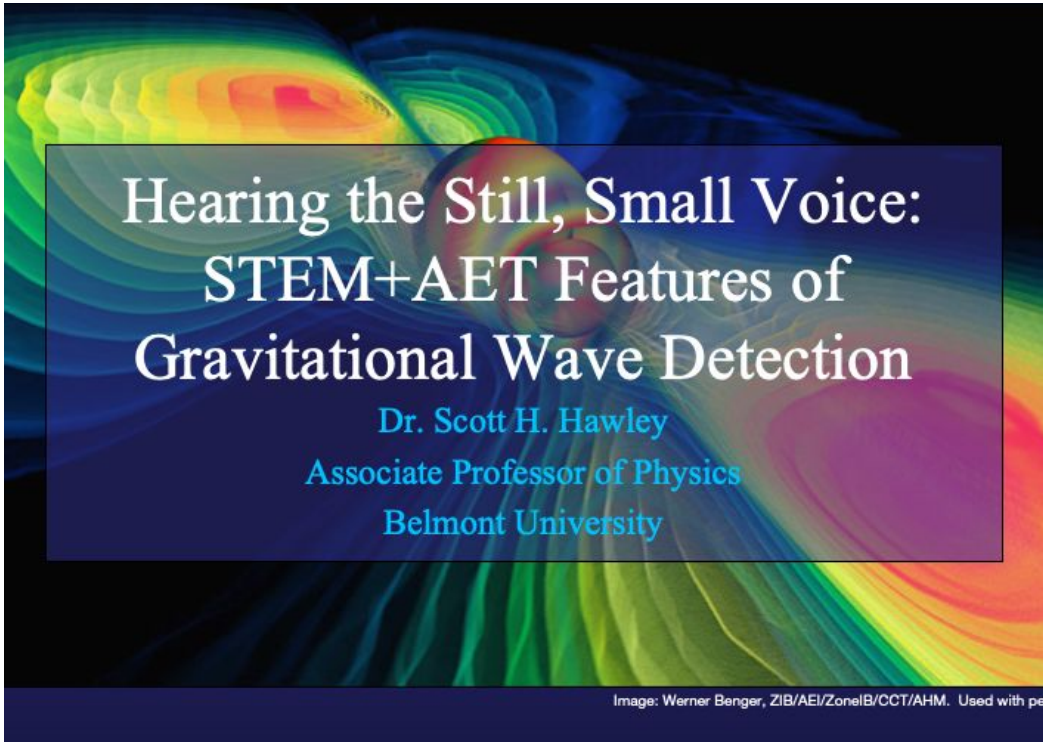






GWs
(ripples in
spacetime)

L.I.G.O: RESONANCE & PATTERN-MATCHING

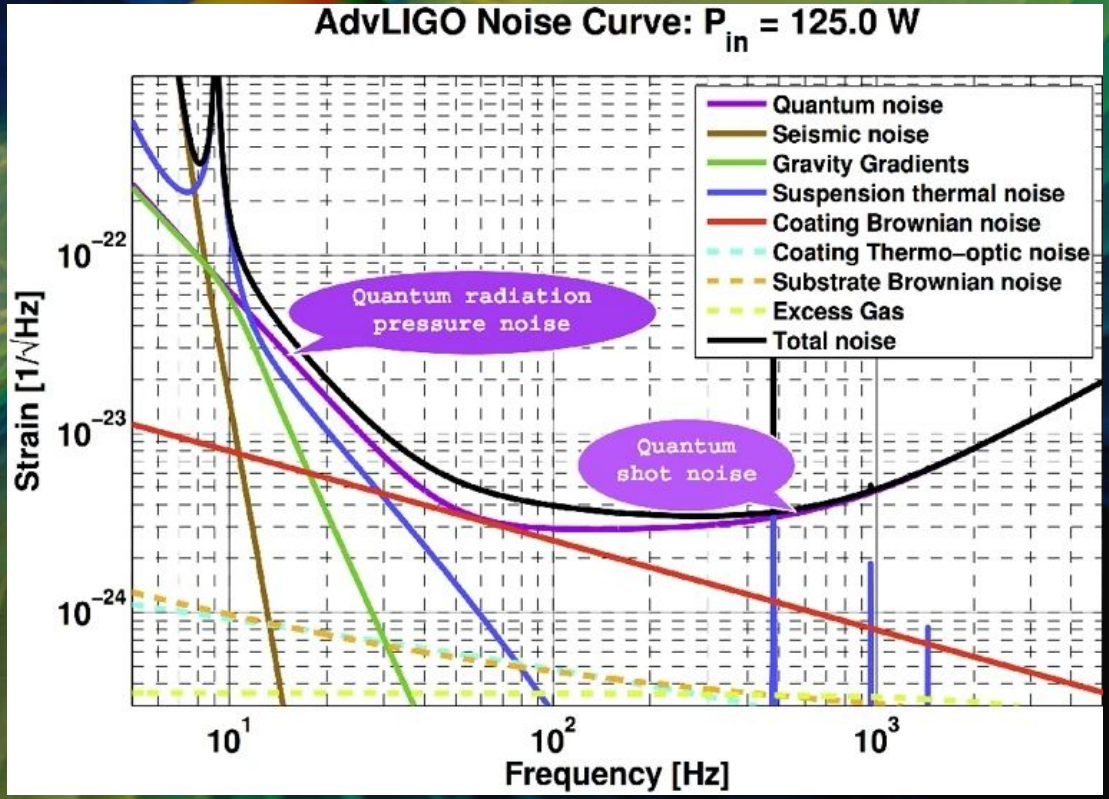


"Shazam for Space"

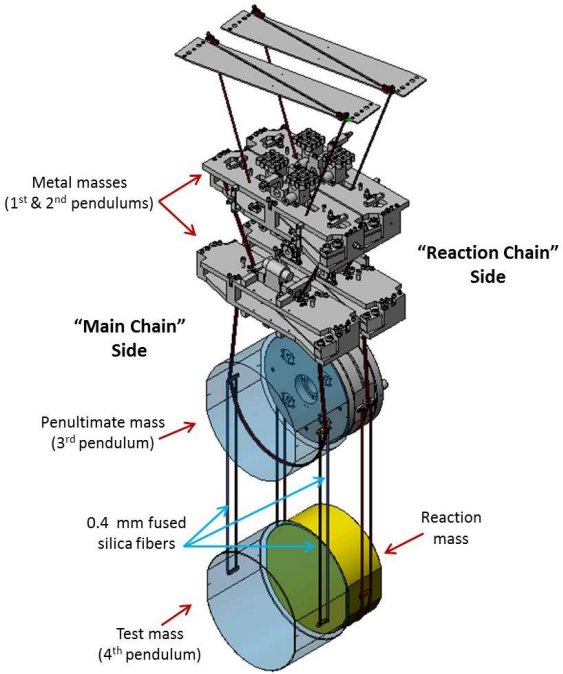
PRE-LIGO: RESONANT BAR GW DETECTOR

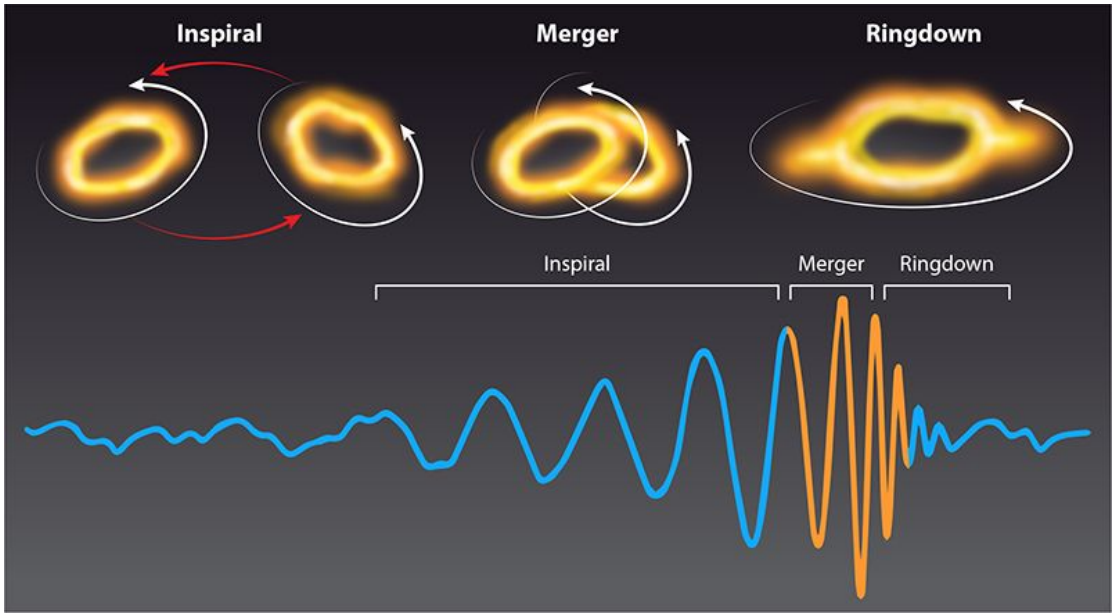
Photo of Joseph Weber, courtesy
AIP Emilio Segrè Visual Archives

LIGO DETECTORS

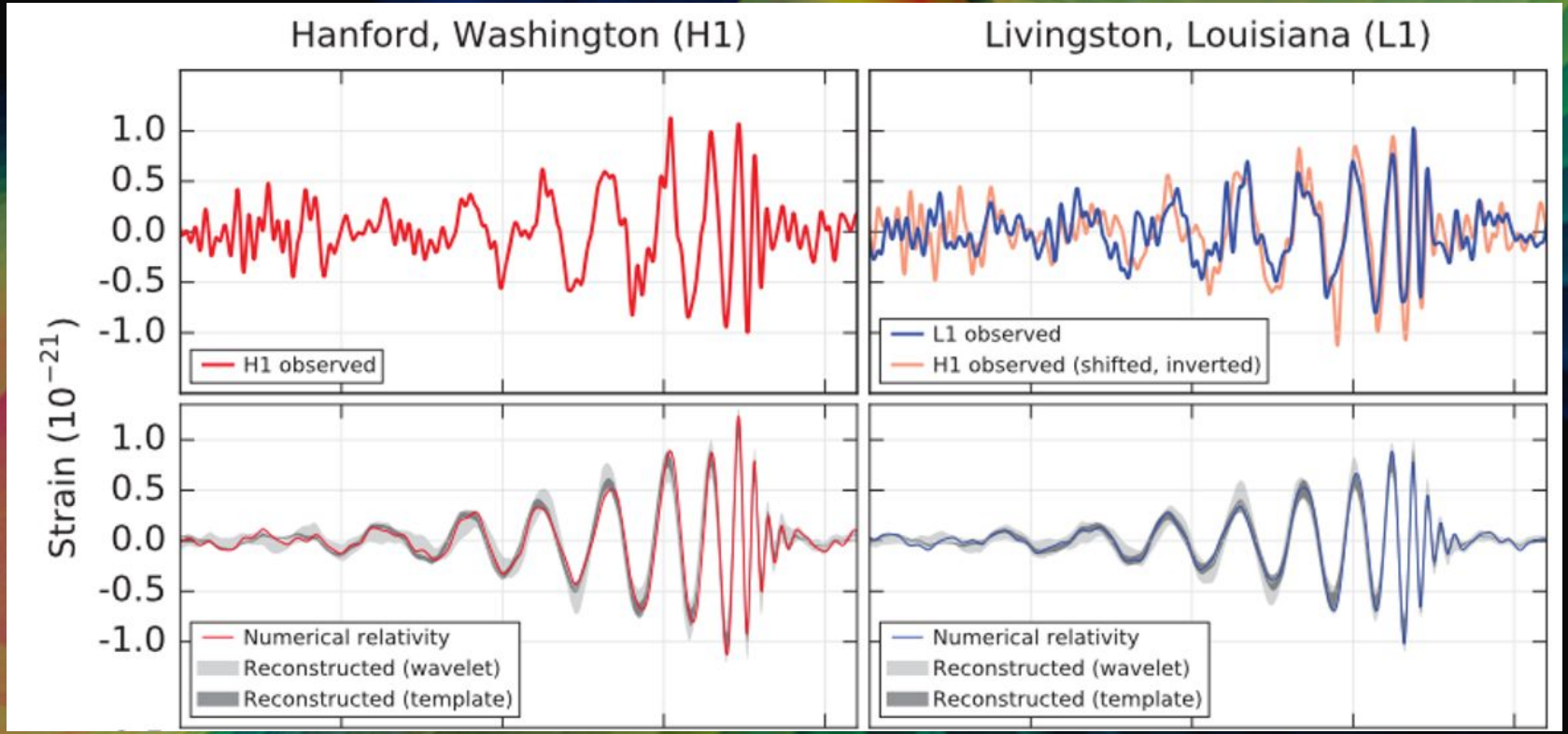


LIGO: RESONANCE & PATTERN-MATCHING



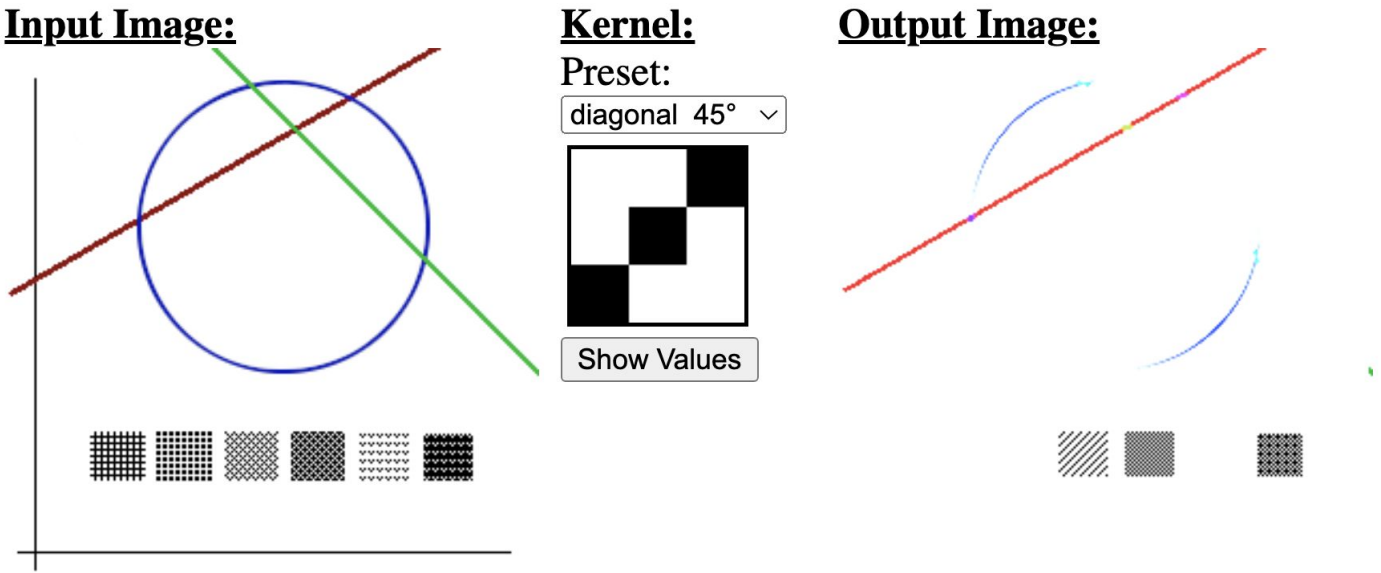


LIGO template-matching



FILTERS: PASS WHAT'S SIMILAR

Convolutions:



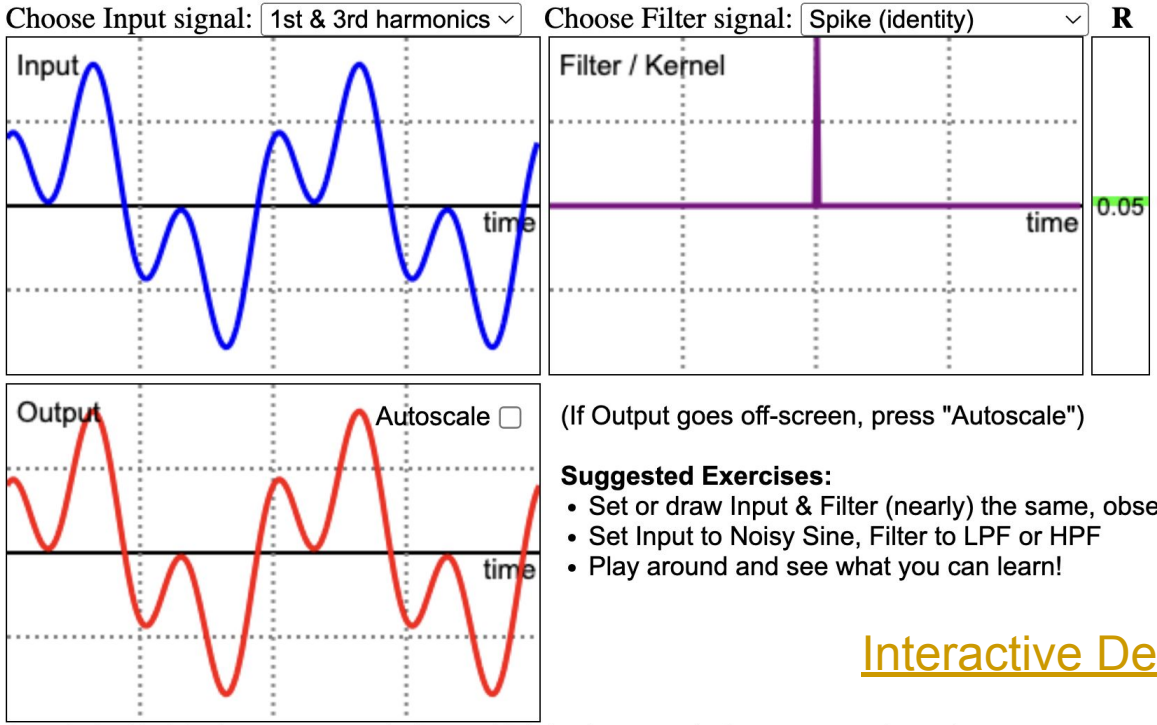
Interactive Demo

FILTERS ARE LEARNED (OR NOT)

"Black Mirror" scenario, for cats:

- Kitten raised in darkness but occasionally placed in an environment with only vertical lines
- Never develops 'feature detectors' for horizontal edges. :-(
- (Source: Blakemore and Cooper, 1970.)

SIMILARITY: CORRELATIONS



(If Output goes off-screen, press "Autoscale")

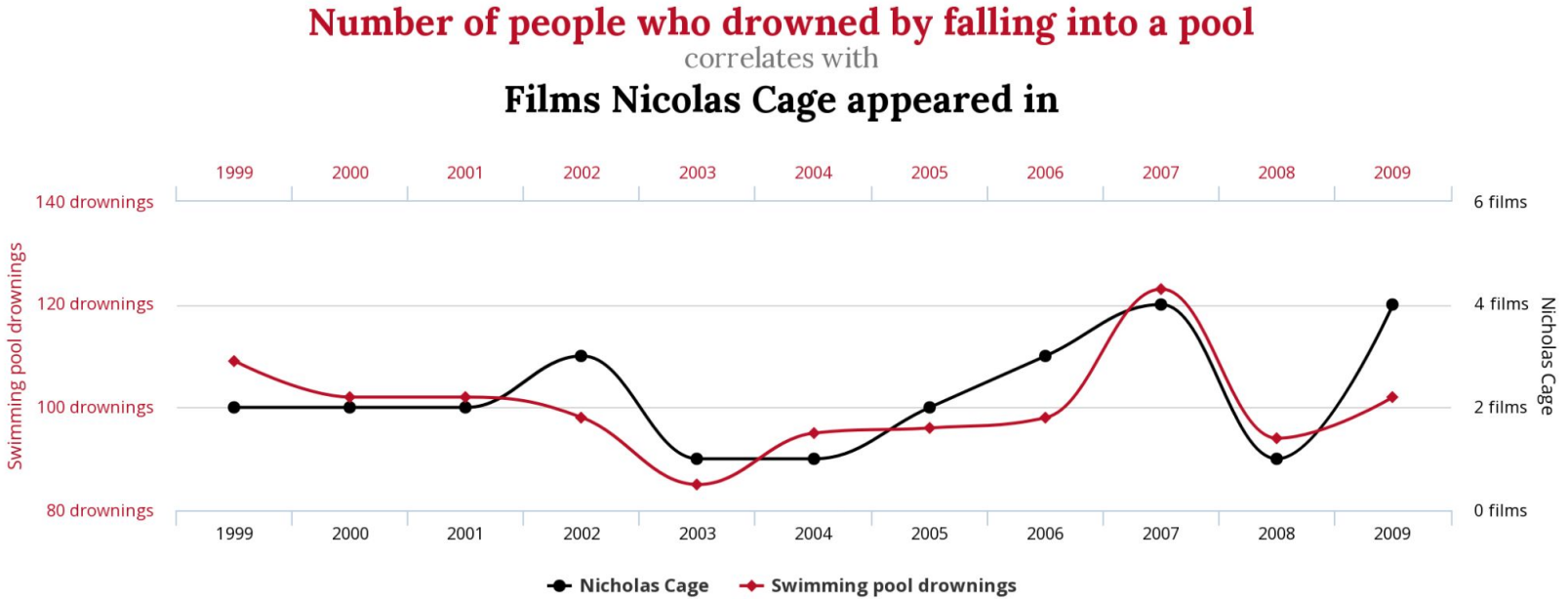
Suggested Exercises:

- Set or draw Input & Filter (nearly) the same, observe R.
- Set Input to Noisy Sine, Filter to LPF or HPF
- Play around and see what you can learn!

Interactive Demo

*Technically it's the cross-correlation, which is the convolution up to a minus sign.

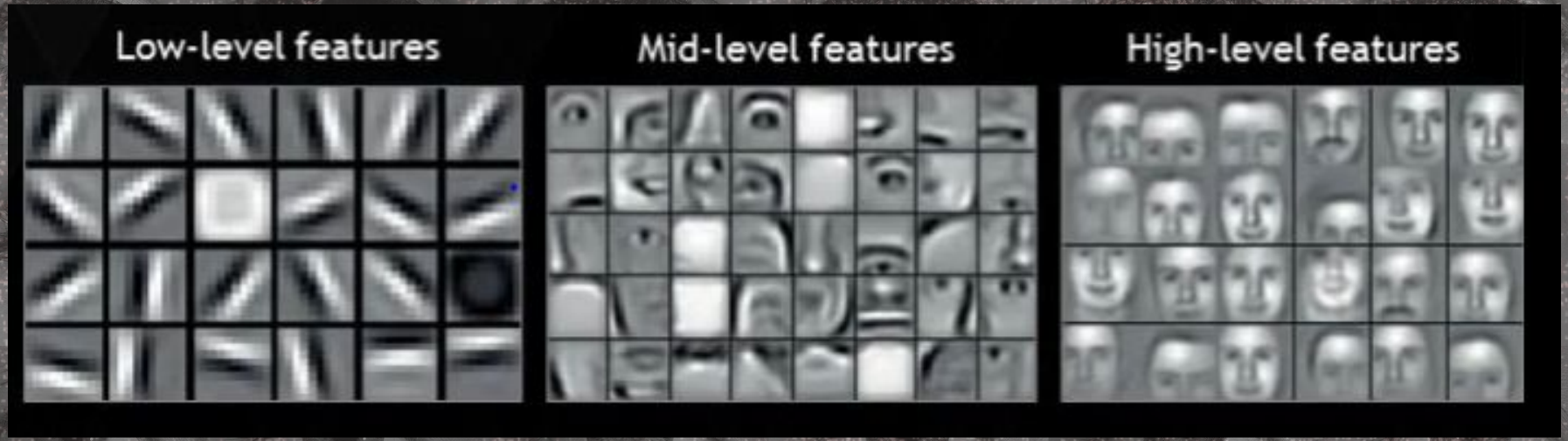
CORRELATIONS...?



THE EYE IS THE LAMP OF THE BODY

FACE DETECTORS

Can work hierarchically, patterned after visual cortex



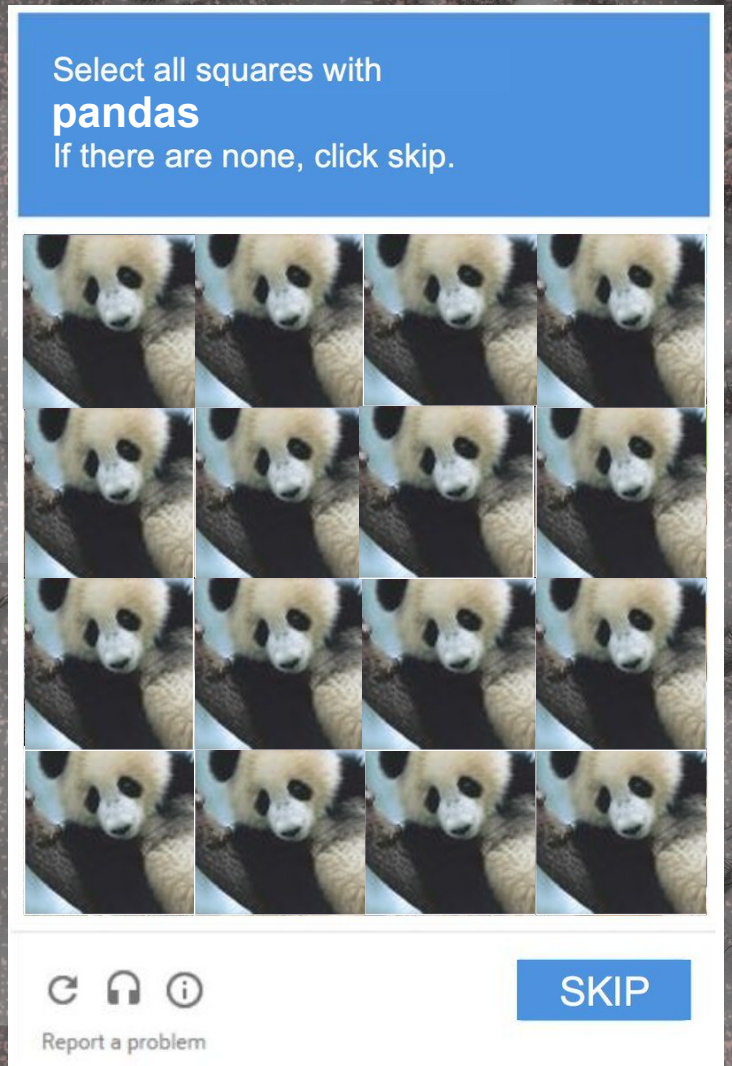
An example hierarchy of learned feature detectors – i.e., filters – for a facial recognition system. (Source: Lee et al, 2009.)

SALIENCY

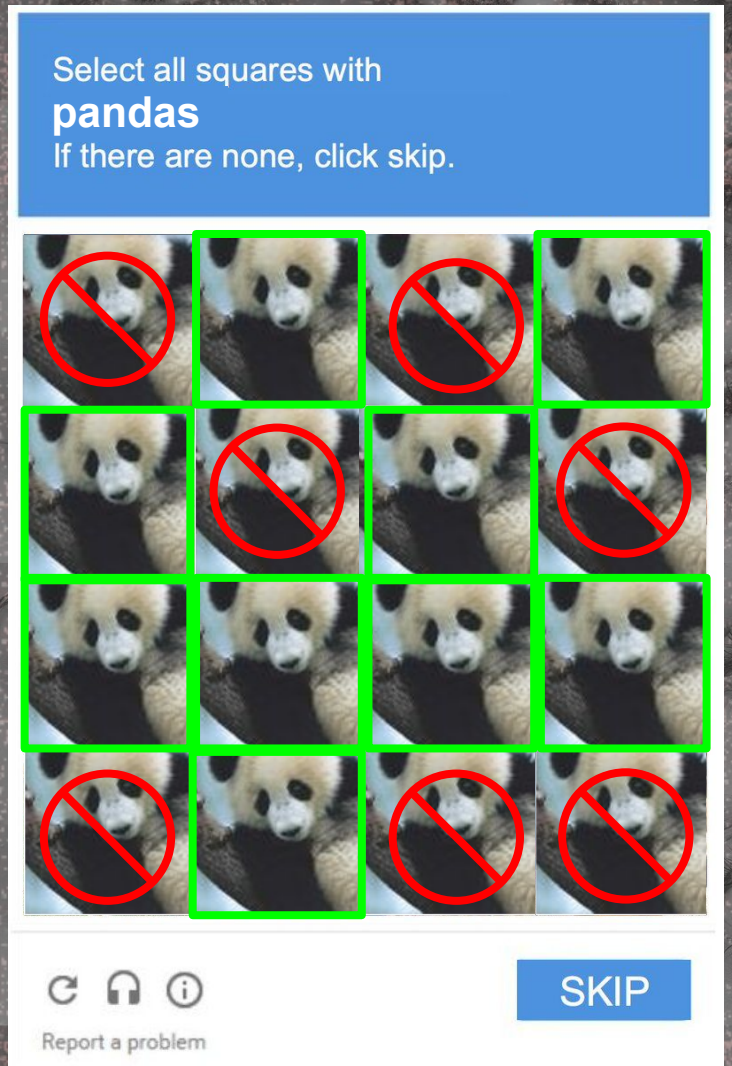
- What parts of input determine classification outcomes?
- CV systems may behave differently from humans:

Detecting "Tench":

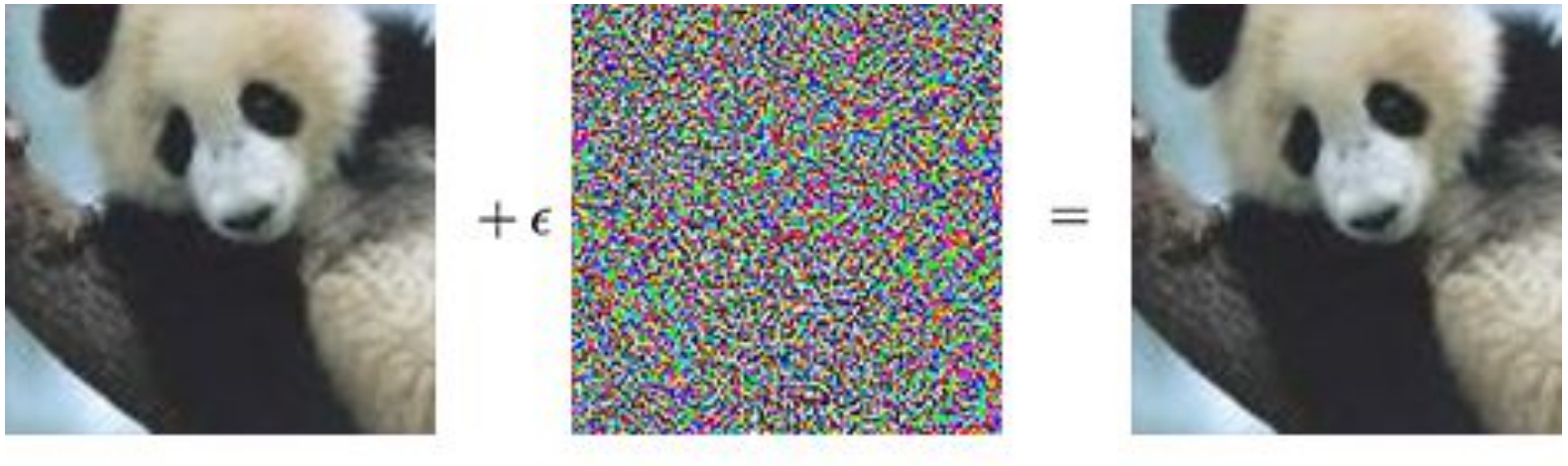
More differences between human & computer vision detectors/ classifiers:



More differences between human & computer vision detectors/ classifiers:

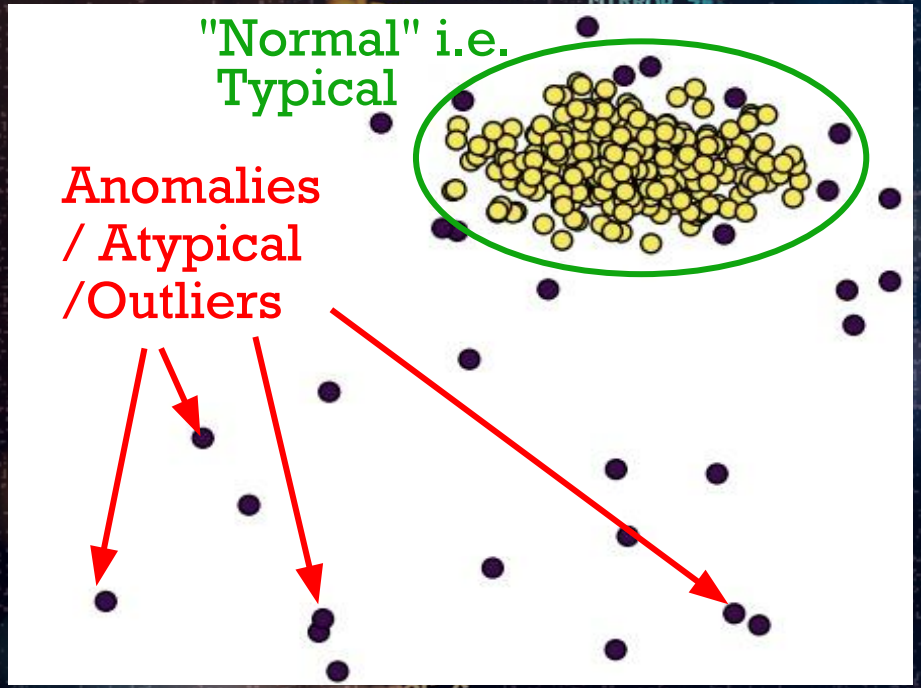


(Some had special noise patterns)



Source: Explaining and Harnessing Adversarial Examples by Goodfellow et al. (2015)

ANOMALY DETECTION



Statistical, trained on dataset of "normal" events, + similarity metric (e.g., distance)

Applications:

- Cybersecurity
- Fintech Fraud
- Monitoring Machinery
- Catching Ticket Scalpers!
- Video Surveillance (bias!)
- Sci-Fi Movie Plots

UPDATING PRIORS

Bayes' Rule:

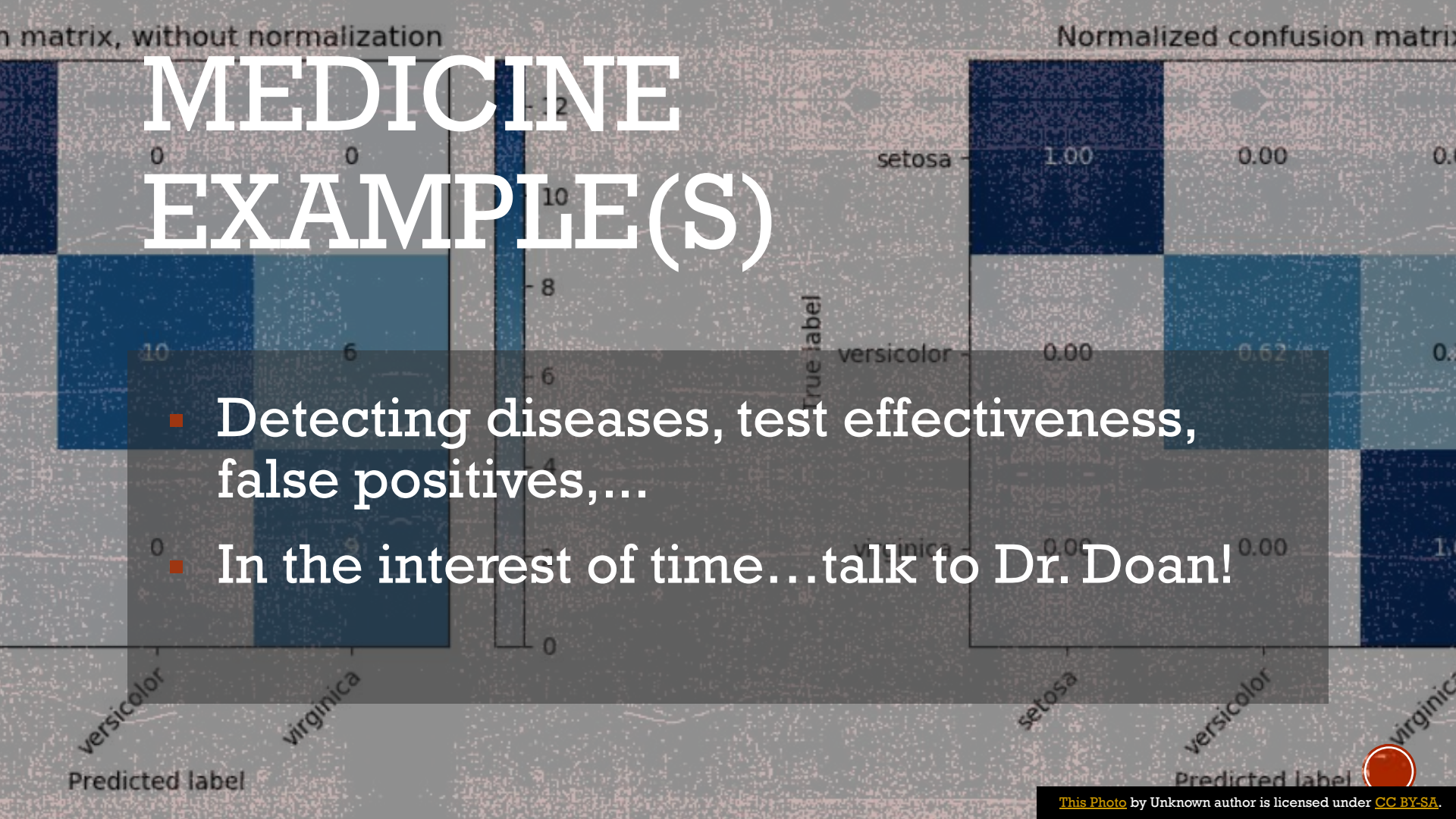
$$p(x|y) = \frac{p(y|x)}{p(y)} p(x)$$

Computing odds of: shark attacks, plane crashes,...

And also: detection probabilities, e.g. SPAM

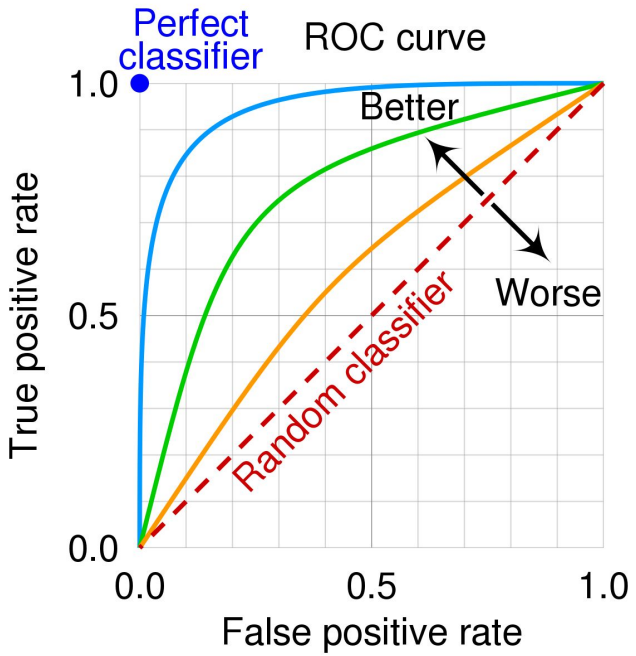
MEDICINE EXAMPLE(S)

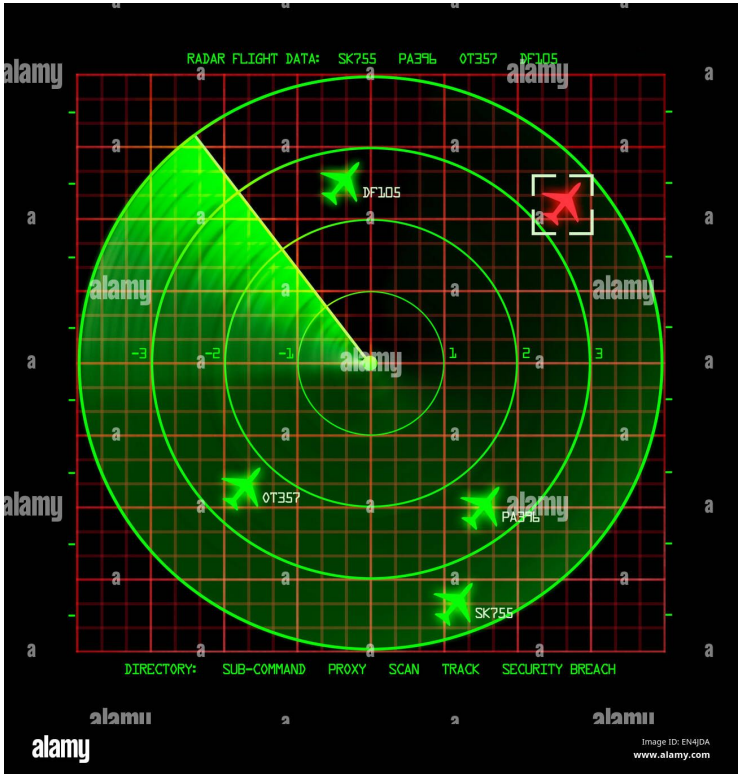
- Detecting diseases, test effectiveness, false positives,…
- In the interest of time…talk to Dr. Doan!



HOW CONFIDENT ARE YOU?

AUC-ROC & airplanes





INTERLUDE: QUESTIONS FOR DISCUSSION

QUESTIONS FOR DISCUSSION…

What's something that you didn't notice for a while?

Did you ever perform "pattern-matching," identifying something in the present based on your past experience, & that identification turned out to be wrong?

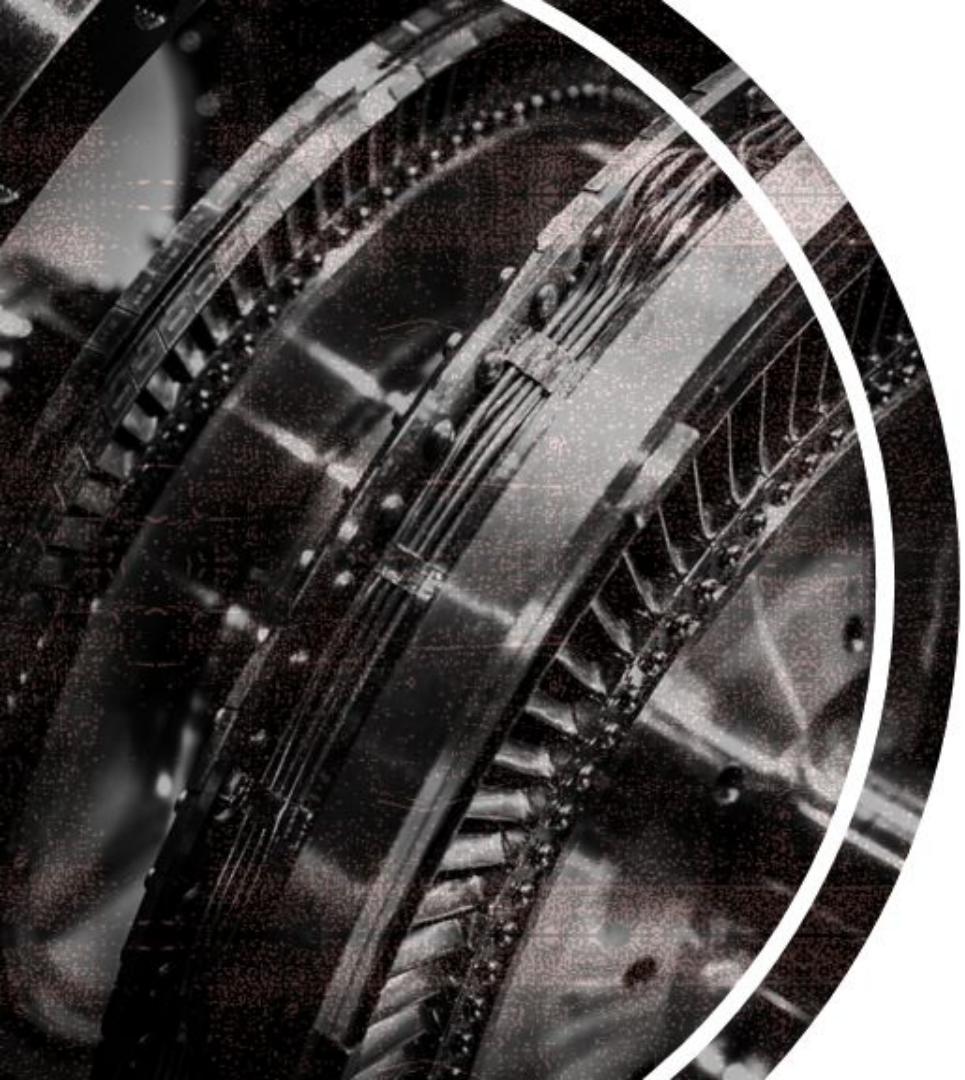
In what ways can we tune ourselves to resonate with the things of the Spirit?

What can you do to reduce your "noise floor," to become a more "sensitive detector" of the still, small voice of the Holy Spirit?

Where does your 'training data' come from? Experience? The Bible?...

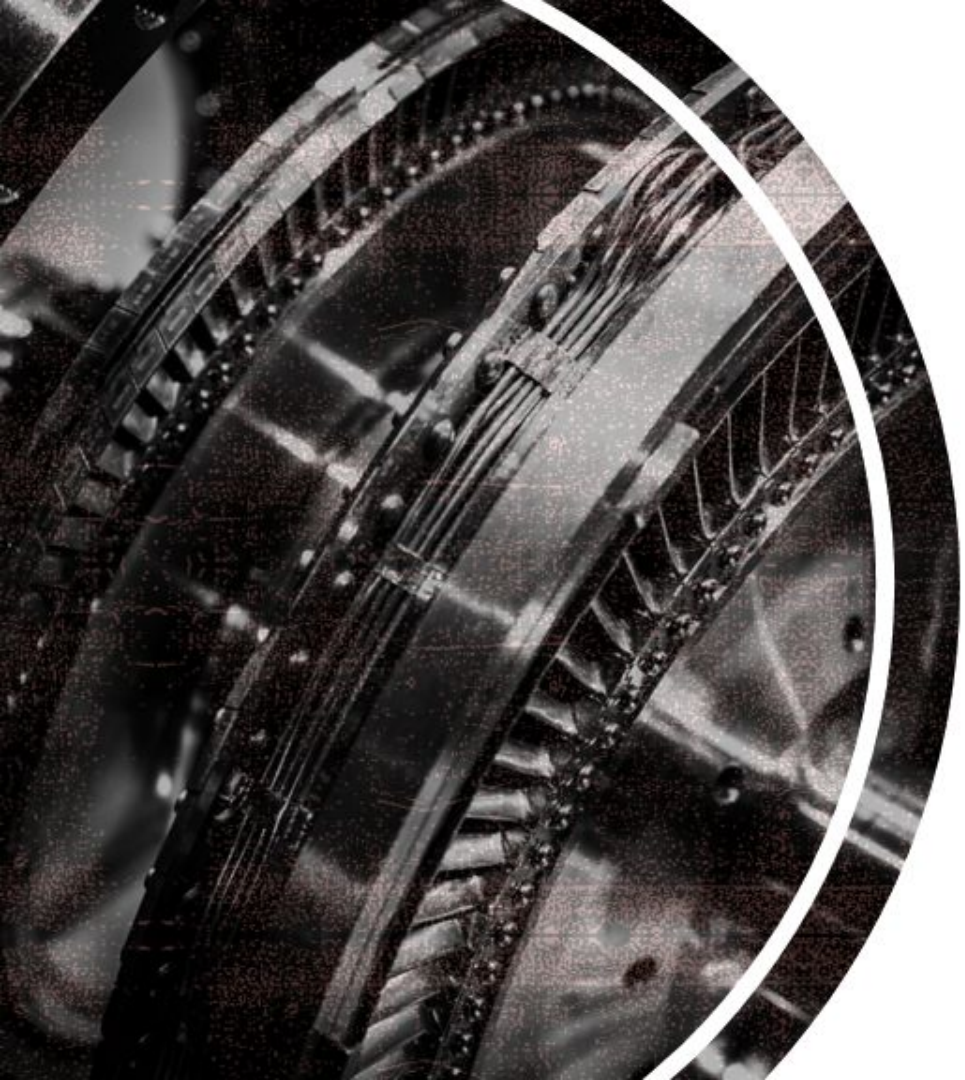
MORE QUESTIONS FOR DISCUSSION…

- Have you ever 'cleaned your dataset' of 'training data'?
- When have you "updated your priors" based on new experience?
- Have you ever seen a diagnostic metric become a goal – an end in itself?
- Is spontaneity the same thing as randomness?
- In what ways can you participate in creation, e.g. "taming chaos"?



PART II: GENERATORS

Scott H. Hawley
Belmont University
Nashville TN



OUT OF THE THE HEART, THE MOUTH SPEAKS:

Modeling Generative Physical & Creative Processes

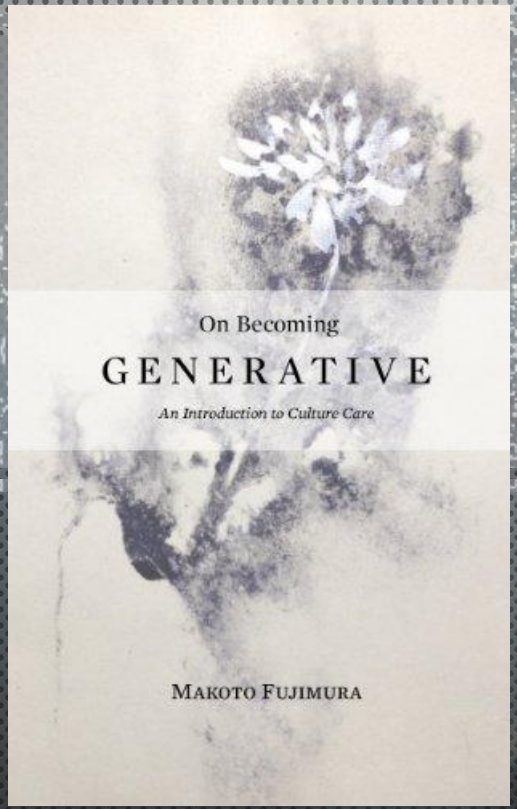
@drscotthawley

TOPIC OF THIS TALK

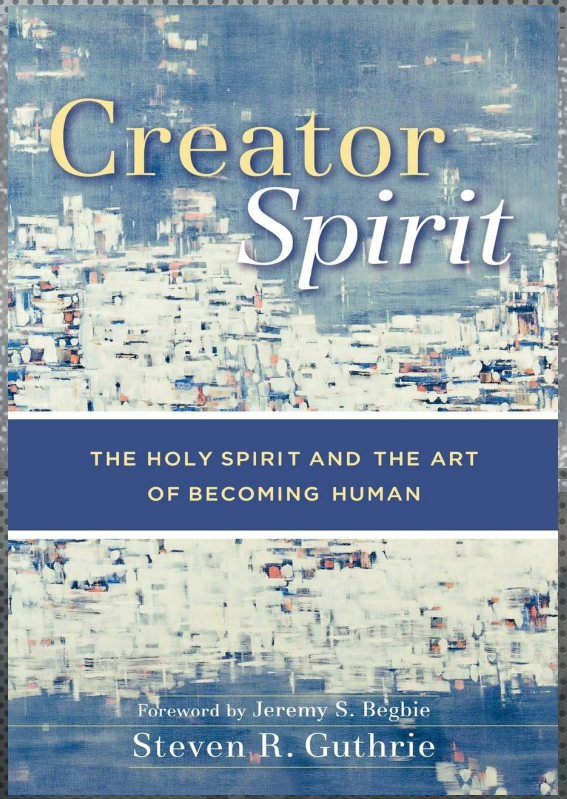
Not electrical generators!

- "Generative Models" / "Generative AI":
  - text: ChatGPT, Claude, Gemini, Llama, Mistral, etc, etc.
  - images: Stable Diffusion, Midjourney, DALL-E, Wombo
  - music: Suno, **Stable Audio** ;-) **← S.A. 2.0 released April 3!**
- Involve Data Science, Mathematics, & Computer Science
  - Much of it is centuries-old math done at massive scales
- Lots of overlap with concepts from Christian theology & devotion, creativity & the arts!
- Note that these often employ Detectors/Discriminators (from Part I)

Books On-Topic:



FUJIMURA



GUTHRIE

"GENERATORS"

Bible verses:

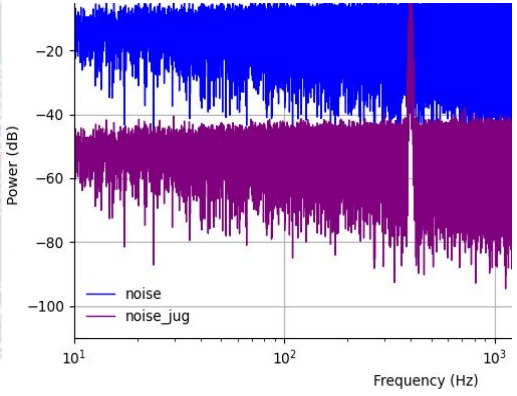
- Out of the heart the mouth speaks
- James: the tongue
- Jesus What comes out of a man defiles him
- A tree is known by its fruit…Do people get fruit from thistles?
- Created to do good works
- Bearing Fruit, being fruitful
- Stay connected to the vine
- Without faith it's impossible to please god
- God created, and we are created in his image

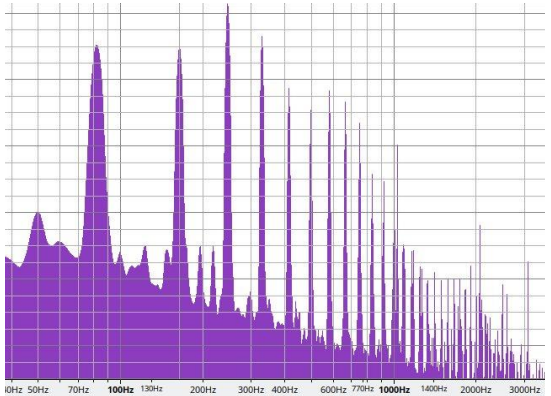
METAPHORS

- Priors (Statistical priors & beliefs)
  - the Bible, Jesus as our priors
- Training: what's your dataset?
- Whats the objective function? Love
  - Andrew Ng: optimize your ML model for one objective
- Double-minded, extra objectives, divided loyalties, no one can serve two masters, quality and diversity
- Note that metrics can become objectives: legalism
  - example from Weapons of Math Destruction: university rankings

MUSICAL SOUND PRODUCTION

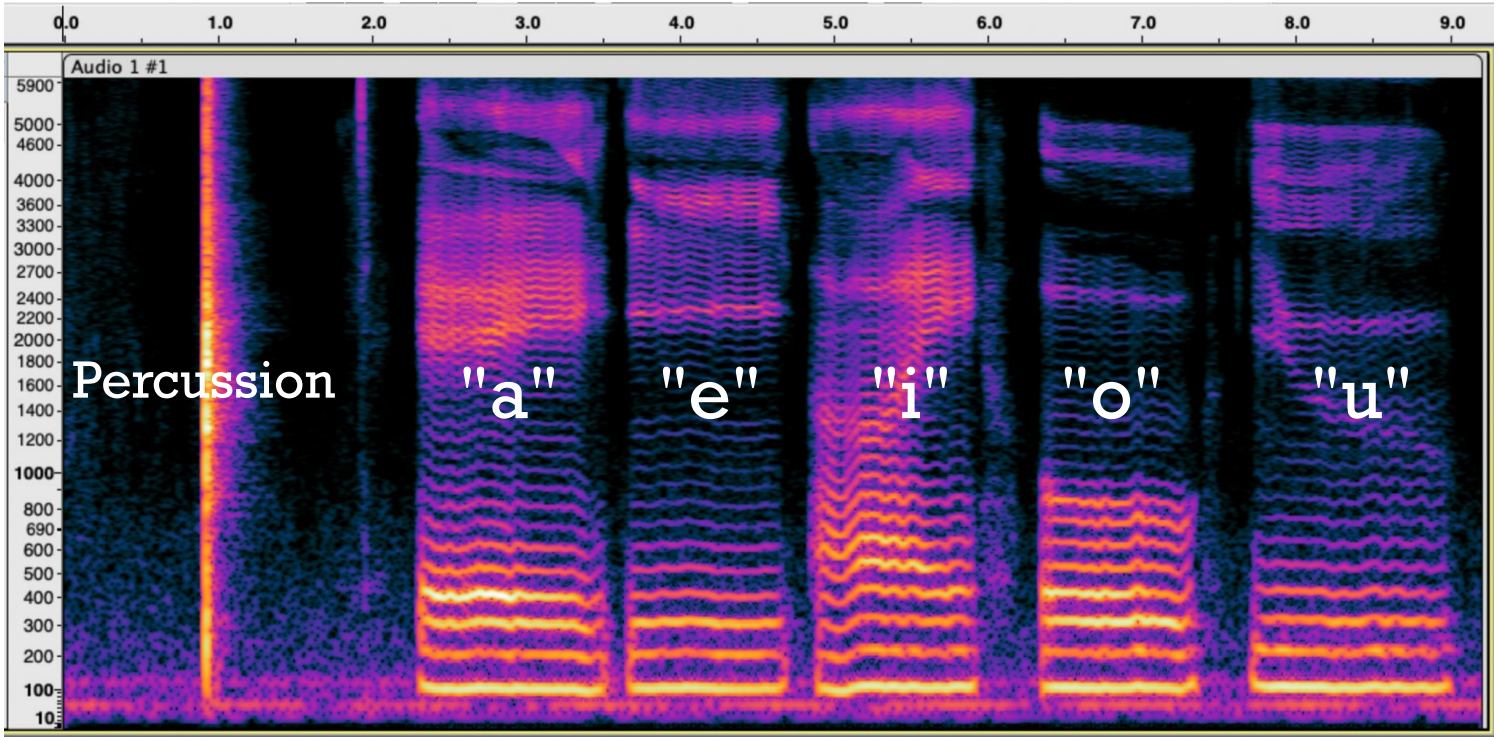
= Noise × Resonance



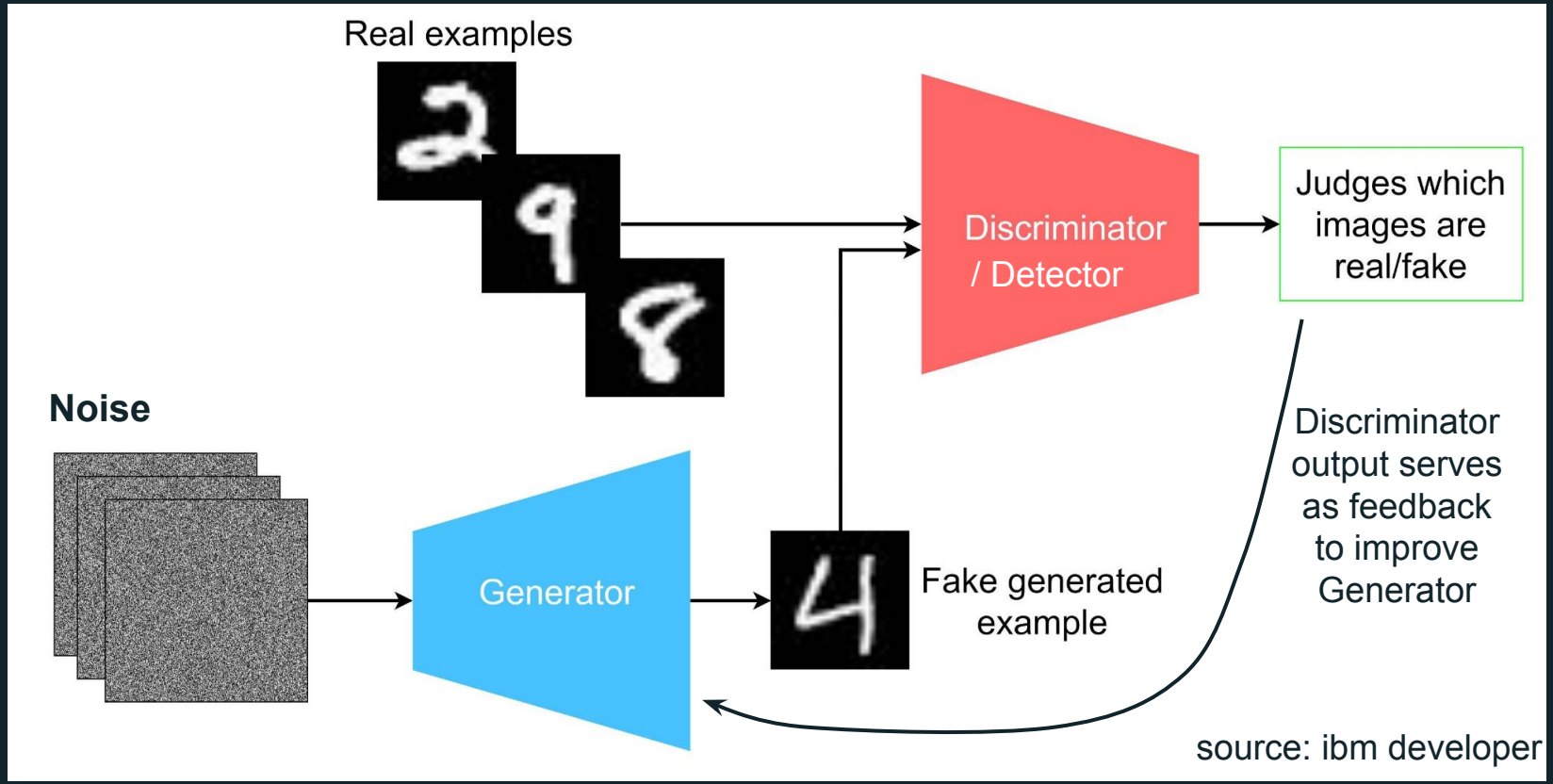


Musical Sound Prod.

Noise × Shaping (Resonance)



Generative Adversarial Networks (GANs)



Generative Adversarial Networks (GANs), conceptually

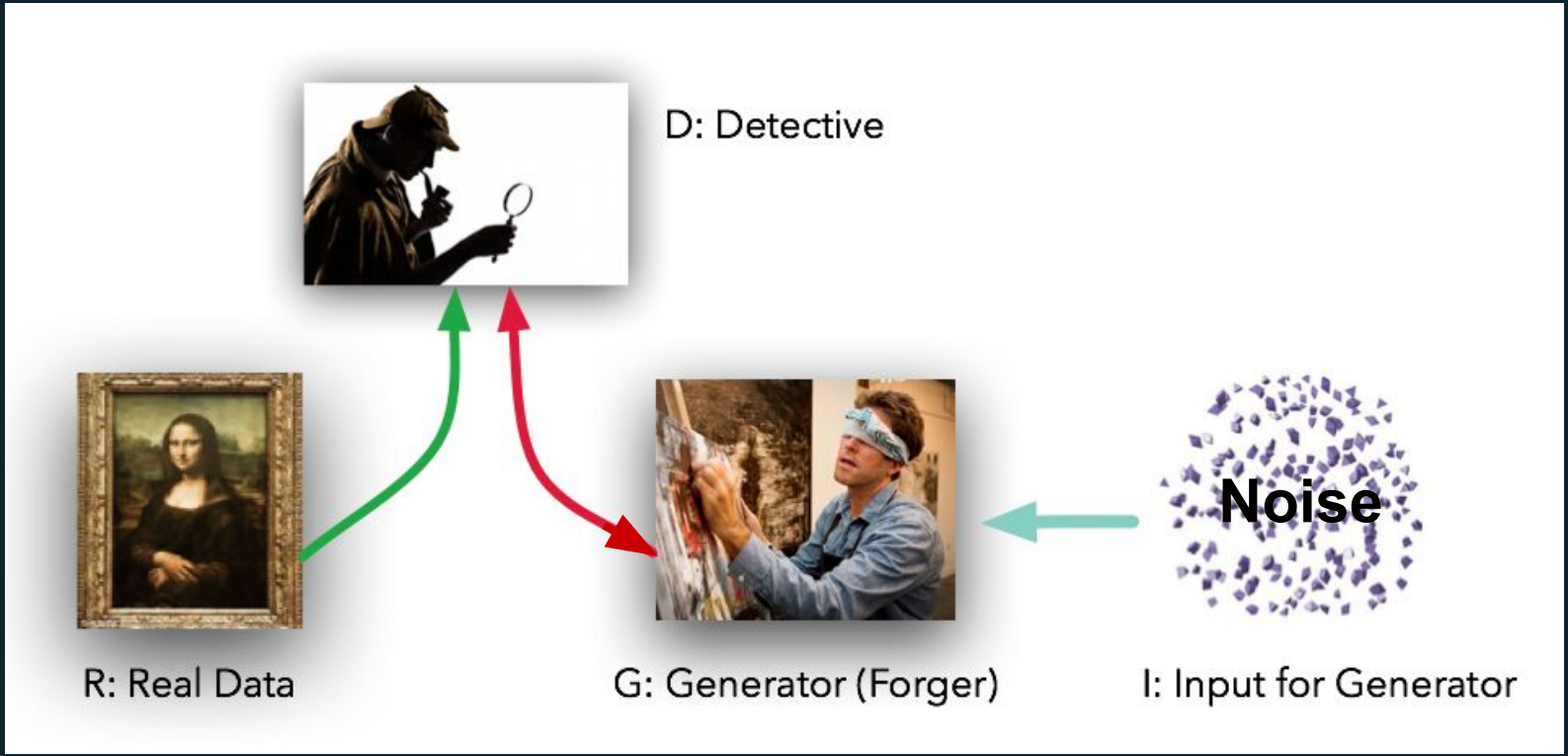
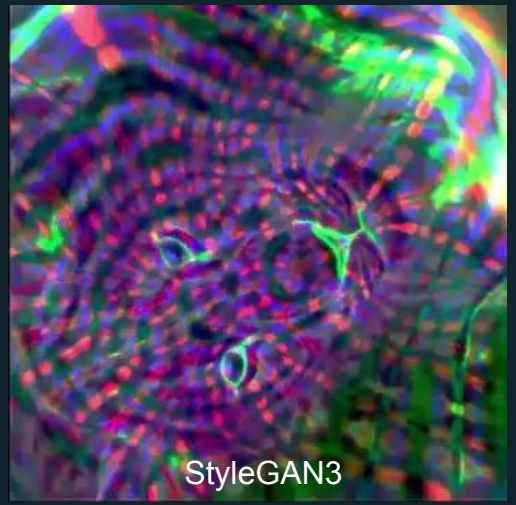
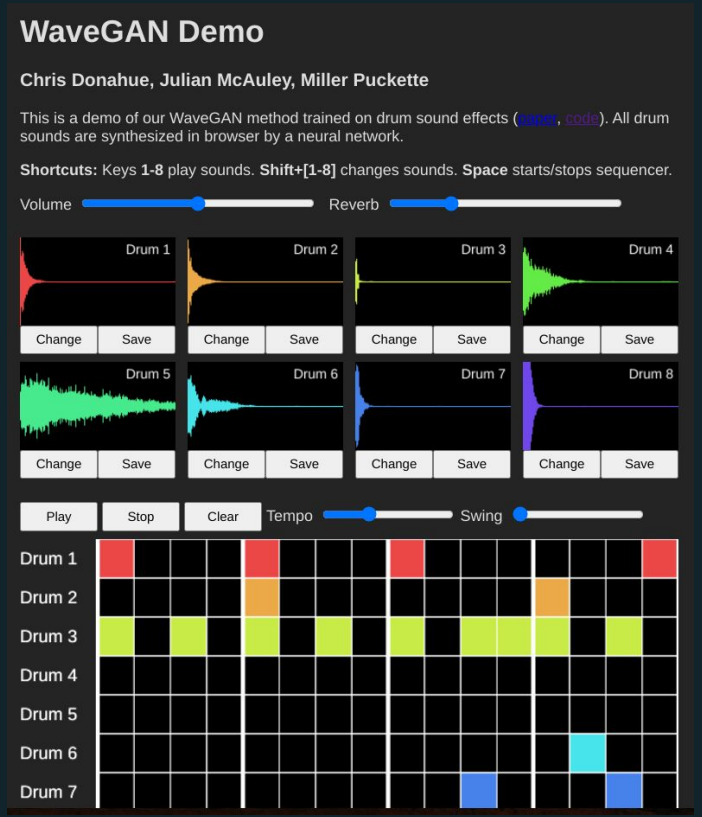


Image credit: Dev Nag

A few GAN applications



homework in my DL class



History: Generative Art Games

Is spontaneity the same as randomness?

Mozart: *Musikalisches Würfelspiel*

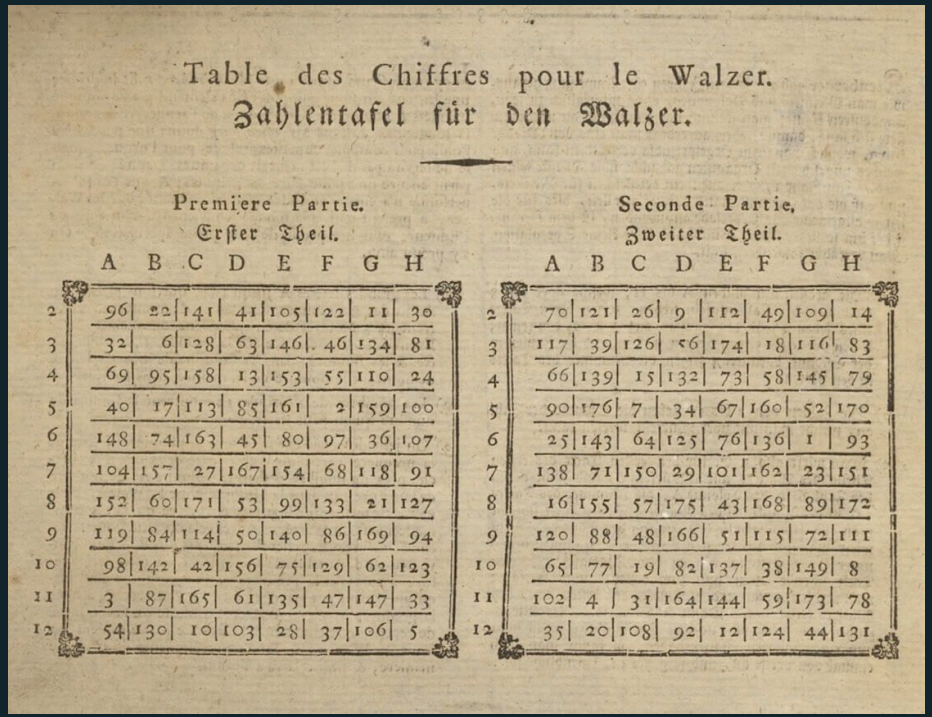


Table des Chiffres pour le Walzer.
Zahlentafel für den Walzer.

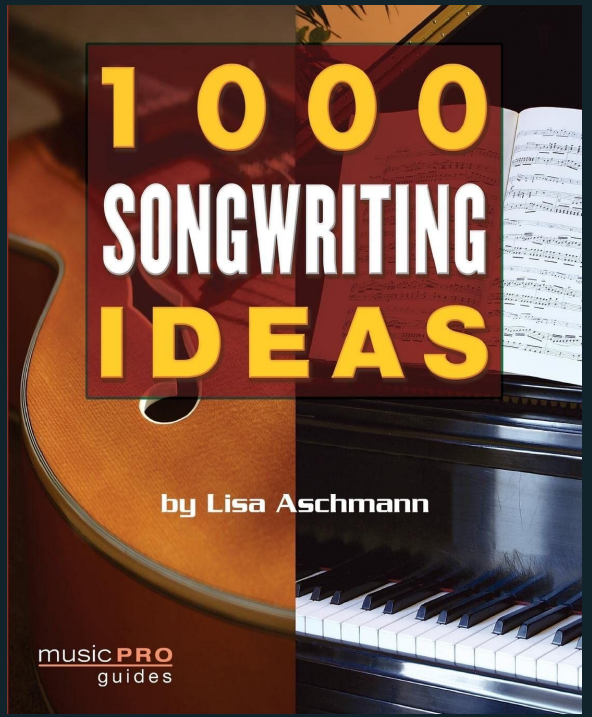
Premiere Partie.
Erster Theil.

	A	B	C	D	E	F	G	H
2	96	22	141	41	105	122	11	30
3	32	6	128	63	146	46	134	81
4	69	95	158	13	153	55	110	24
5	40	17	113	85	161	2	159	100
6	148	74	163	45	80	97	36	107
7	104	157	27	167	154	68	118	91
8	152	60	171	53	99	133	21	127
9	119	84	114	50	140	86	169	94
10	98	142	42	156	75	129	62	123
11	3	87	165	61	135	47	147	33
12	54	130	10	103	28	37	106	5

Seconde Partie.
Zweiter Theil.

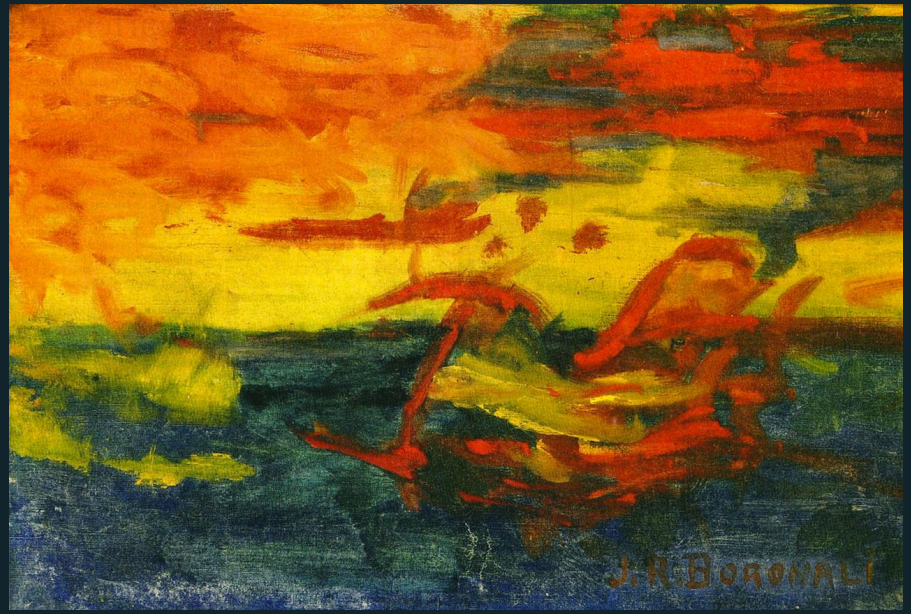
	A	B	C	D	E	F	G	H
2	70	121	26	9	112	49	109	14
3	117	39	126	56	174	18	116	83
4	66	139	15	132	73	58	145	79
5	90	176	7	34	67	160	52	170
6	25	143	64	125	76	136	1	93
7	138	71	150	29	101	162	23	151
8	16	155	57	175	43	168	89	172
9	120	88	48	166	51	115	72	111
10	65	77	19	82	137	38	149	8
11	102	4	31	164	144	59	173	78
12	35	20	108	92	12	124	44	131

Lisa Aschmann (former astrophysicist!)



History: Intentionality, Process

Near-worthless (once discovered):



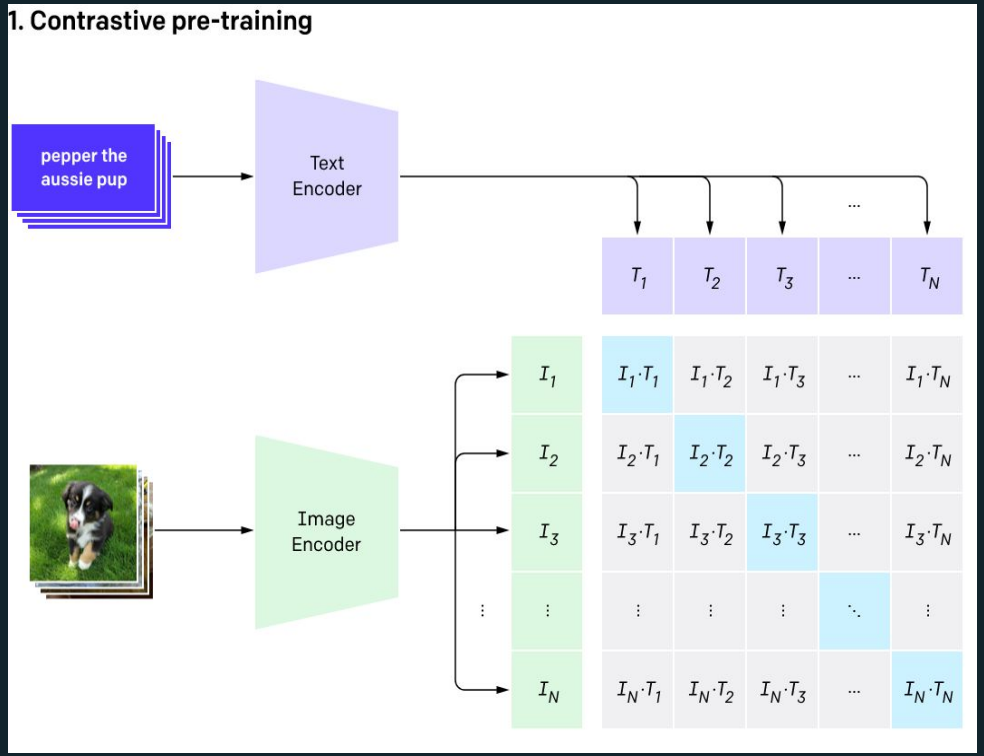
Sunset Over the Adriatic (1910)
by a donkey named Lola

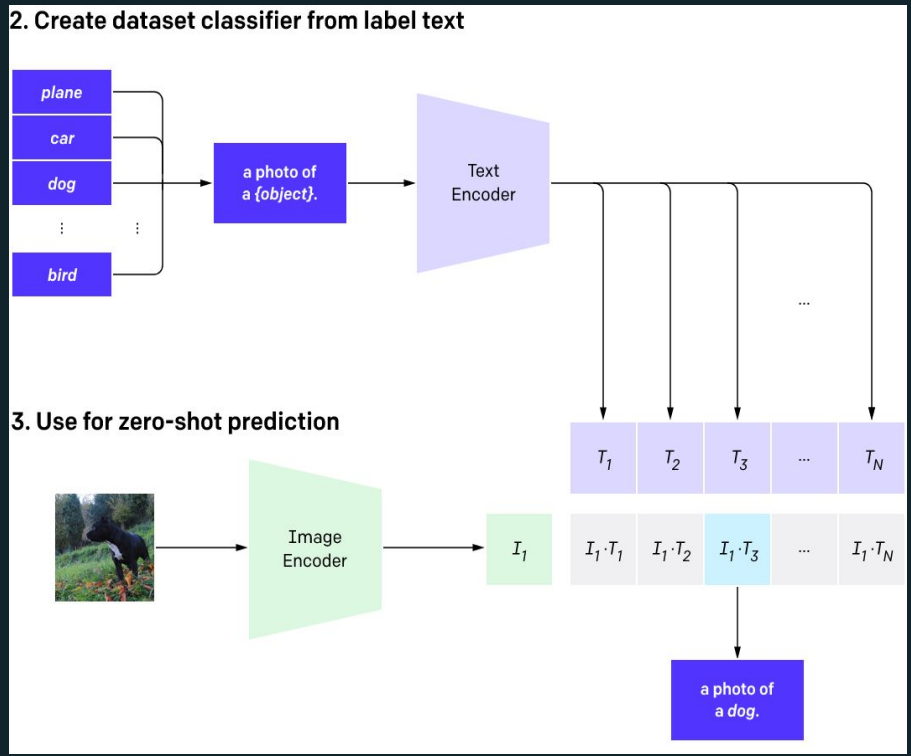
"One of the masters of 20th Century Art":

Blue Poles (1952)
by Jackson Pollock

Contrastive Language-Image Pretraining (CLIP)

(OpenAI)





CLIP+...

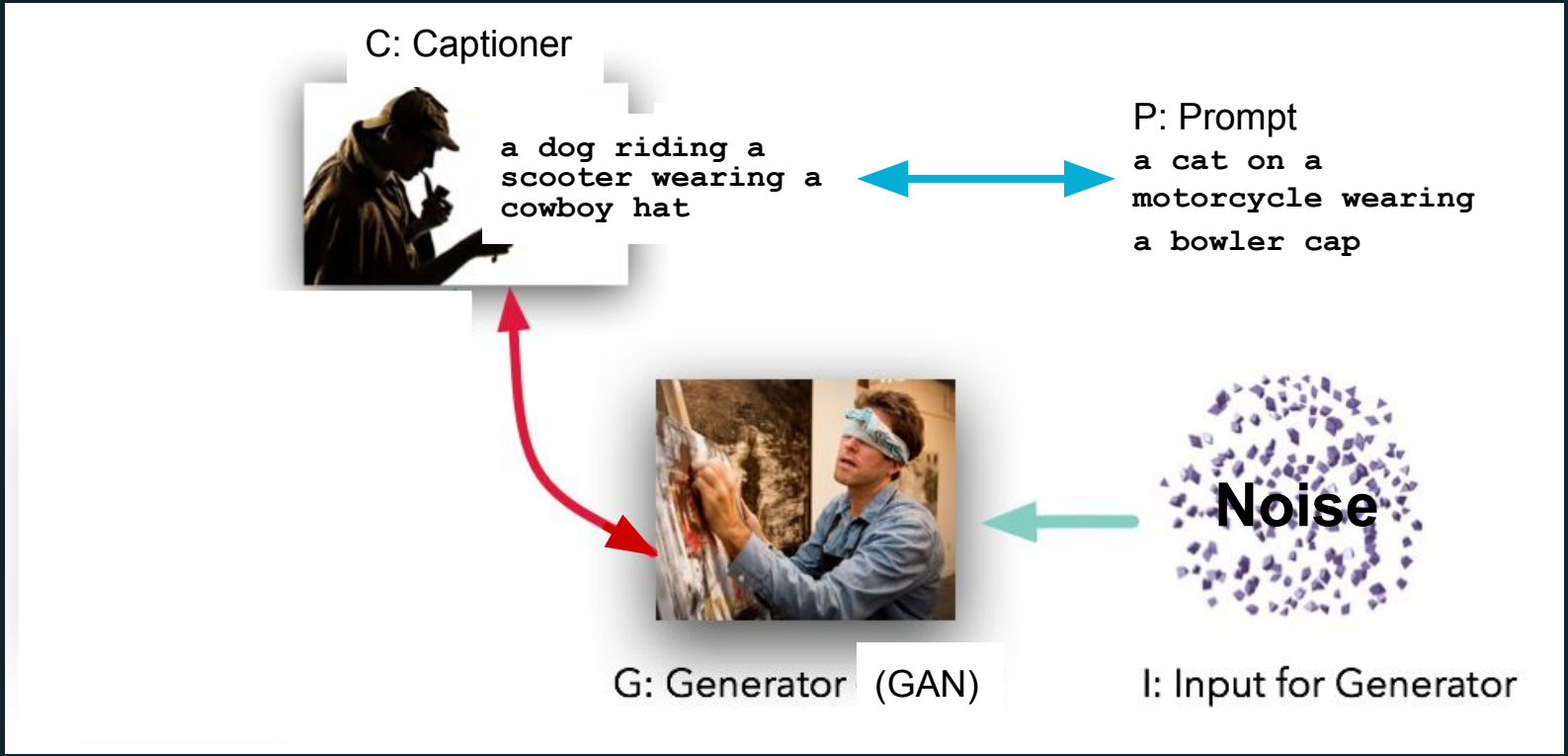


Image credit: SH+Dev Nag

"Taming Chaos"

For A.I.,

"Chaos" was my term for the random noise initialization of models, which the neural network then learns to remap.

"Taming": NN learns to *transform the probability distribution of the noise spectrum.*

Guthrie: The Defeat of Chaos

"...we could say that in its remembered past, in its expected future, and in the presence of Jesus Christ, Christianity tells the story of the defeat of chaos."

chaos: formless void "tohu wabohu"

"The modern sublime suggests that form cannot contain what is ultimate. The postmodern sublime says that form is a lie in a world of chaos. The New Testament, however, asserts that in Jesus Christ the infinite has indeed taken form… (1 John 1:1-2)."

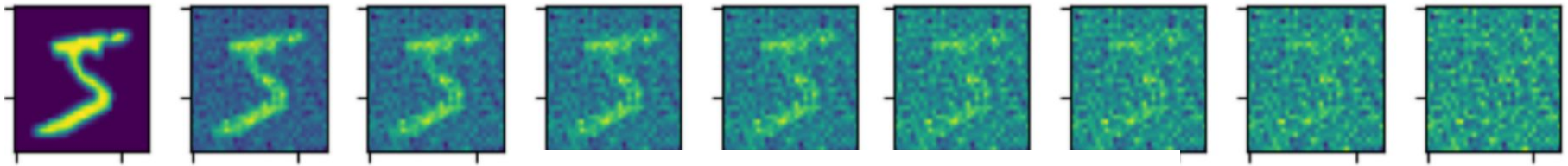
(reverse)

DIFFUSION MODELS

based on physics!

Work by shaping noise, over a series of steps

"Forward Process" / Dissipation



"Reverse Process" / Inference / Creation!

SPEAKING OF…

DreamStudio
by stability.ai

Generate | Edit

Style
Choose style

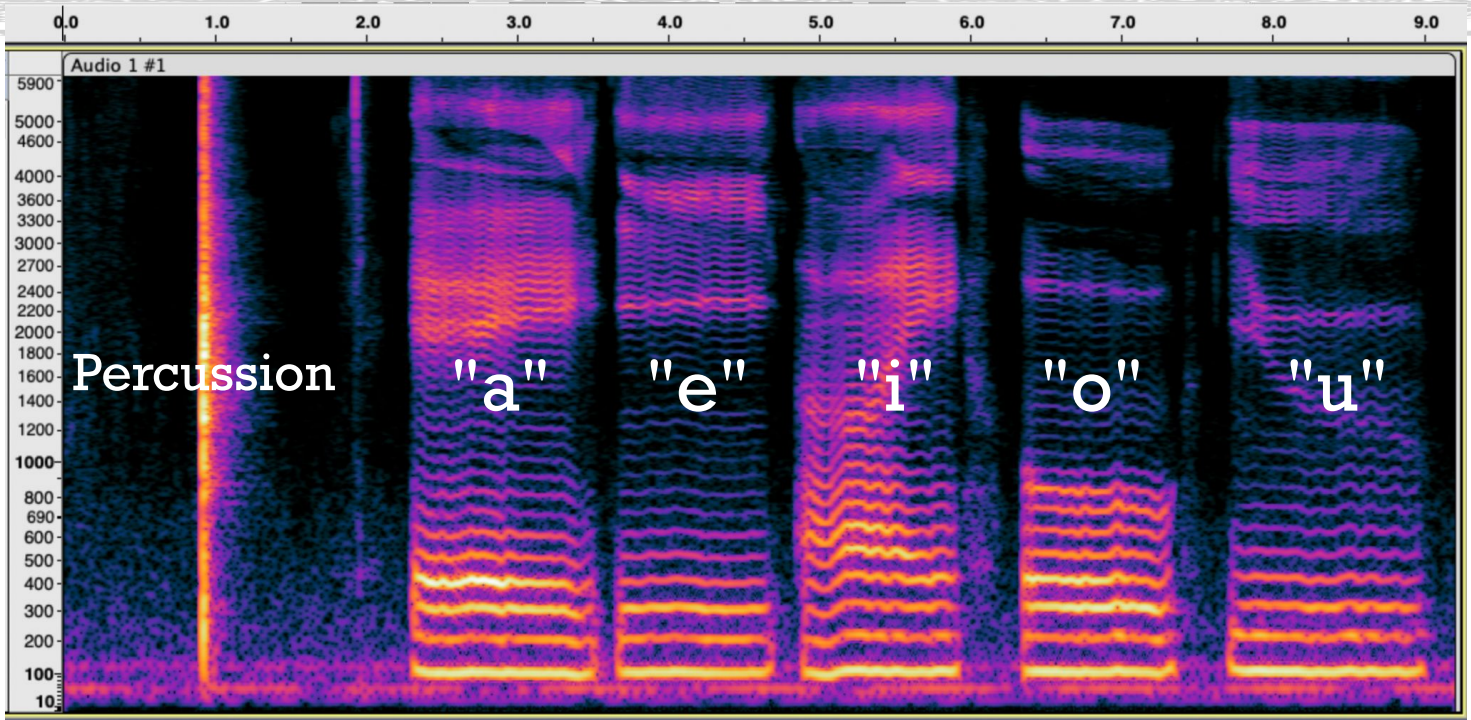
Prompt
metaphors in faith & science, detectors, generators, modern, photographic, cool, cinematic, religious

Negative prompt
monochrome, old timey

Musical Sound Production

Noise × Shaping (Resonance or…)

Diffusion models (& GANs) are "Subtractive", like sculpting marble



Large Language Models (ChatGPT, etc)

- Are trained to guess the most likely text that might come *next*.
- They are "BS artists," always willing to venture an opinion.
- "For a time is coming when people will no longer listen to sound and wholesome teaching. They will follow their own desires and will look for teachers who will tell them whatever their itching ears want to hear."
  – 2 Tim 4:3, NLT

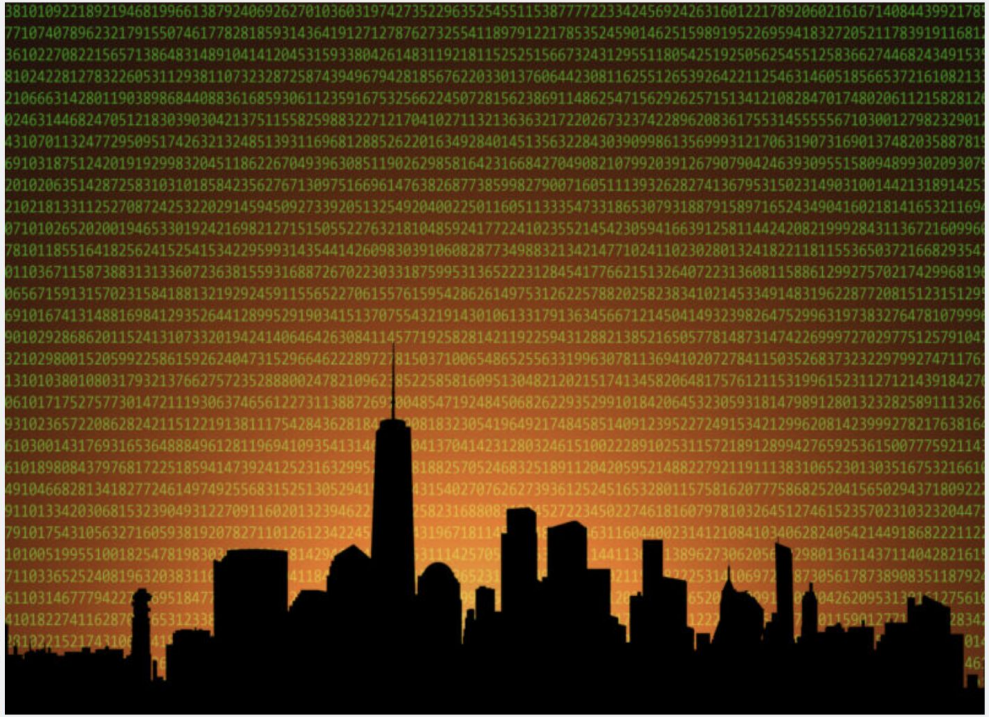
CLOSE ENOUGH FOR GOVERNMENT WORK? —

NYC's government chatbot is lying about city laws and regulations

You can be evicted for not paying rent, despite what the "MyCity" chatbot says.

KYLE ORLAND - 3/29/2024, 3:22 PM

source: ArsTechnica, 3/29/2024



Getty Images

Enlarge / Has a government employee checked all those zeroes and ones floating above the skyline?

So Don't Trust Large Language Models!

They are *not trustworthy*!

They're *great* for *fun*, but don't put them in charge of anything *important*!

So Don't Trust Large Language Models!

They are *not trustworthy*!

They're *great* for *fun*, but don't put them in charge of anything *important*!

Summary Thoughts

Hearing: sensitivity, avoiding dullness, lowering noise, filtering, comparing with what's expected,...

Fruitfulness: I'll contend that Christian fruitfulness & creativity is *not* simply shaping of noise, yet does involve giving order to things that could arranged otherwise – thus a motion from high entropy to low entropy.

Training is key to development in both areas – and training on *good* data. Training involves iteration, freedom to make mistakes, => progress!

THE END

Thanks Dr. Doan, et al!

Socials & GitHub: @drscotthawley

Also: @Hyperstate_AI is courting investors!