

Artificial Intelligence in Medicine

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Disclosure: Within the past 12 months, I have had no financial relationships with proprietary entities that produce health care goods and services.

Artificial Intelligence (AI): definition

John McCarthy, Dartmouth, 1956:

“...every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.”

Artificial Intelligence (AI): definition

1. Build systems that think exactly like humans do (“strong AI”)
2. Just get systems to work without figuring out how human reasoning works (“weak AI”)
3. Use human reasoning as a model but not necessarily the end goal

Artificial Intelligence (AI): definition

Encyclopedia Britannica:

“the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings”

Artificial Intelligence (AI): definition

Amazon: the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition

Machine learning is required

IDx-DR AI diagnostics

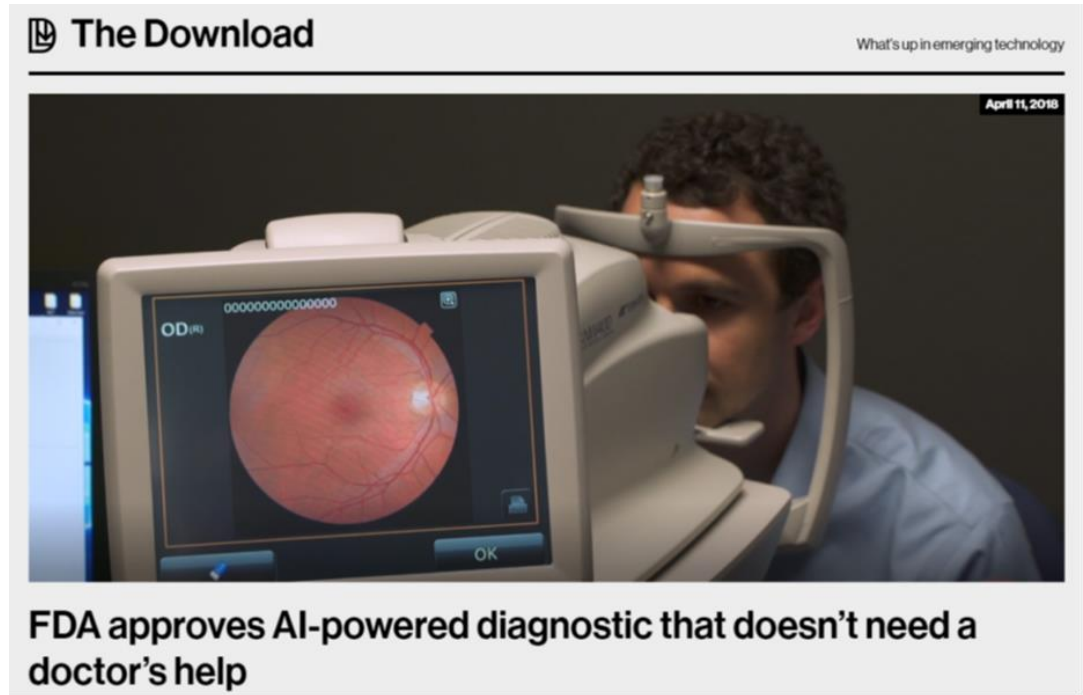
Designed to detect severe diabetic retinopathy

AI algorithm analyzes retinal images

Images uploaded to a cloud server

Delivers a positive or negative result

First device that doesn't need physician interpretation



Viz LVO diagnostic AI

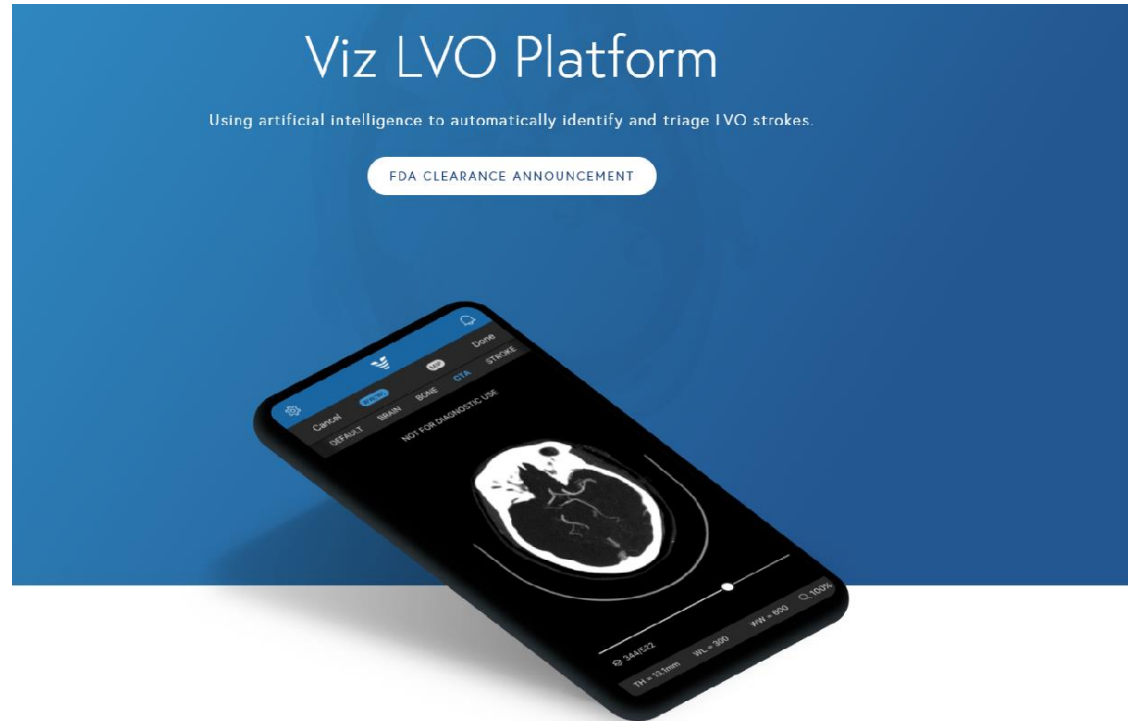
Designed to detect stroke

AI algorithm analyzes CT scan brain images

Automatically notifies a neurologic specialist

Involve specialists sooner than normally possible

Notification by cellphone



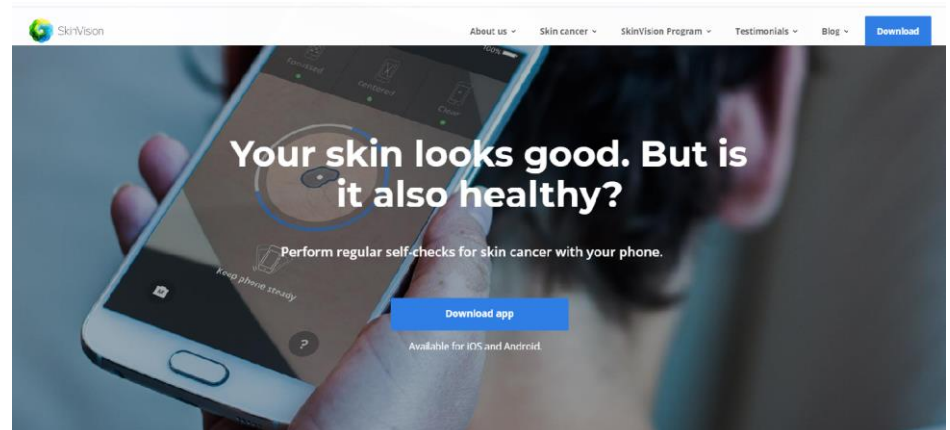
AI in dermatology

Several products directed at the consumer level

Diagnosis of skin lesions by smartphone photo/app

AI driven chatbot makes recommendations about skin products

May be driven in part by human advisors




PHONETIC KEMP INC.
Small URBAN RESEARCH LABORATORY

UKIYO CAMERA SYSTEMS
multiple phone "Saragaku"



Stanford CheXNet

Deep AI machine learning

Detect 14 lung conditions
based on chest x-ray

***Outperformed human
radiologic interpretation***

Learning based on dataset
of >100,000 chest x-rays



Input

Chest X-Ray Image

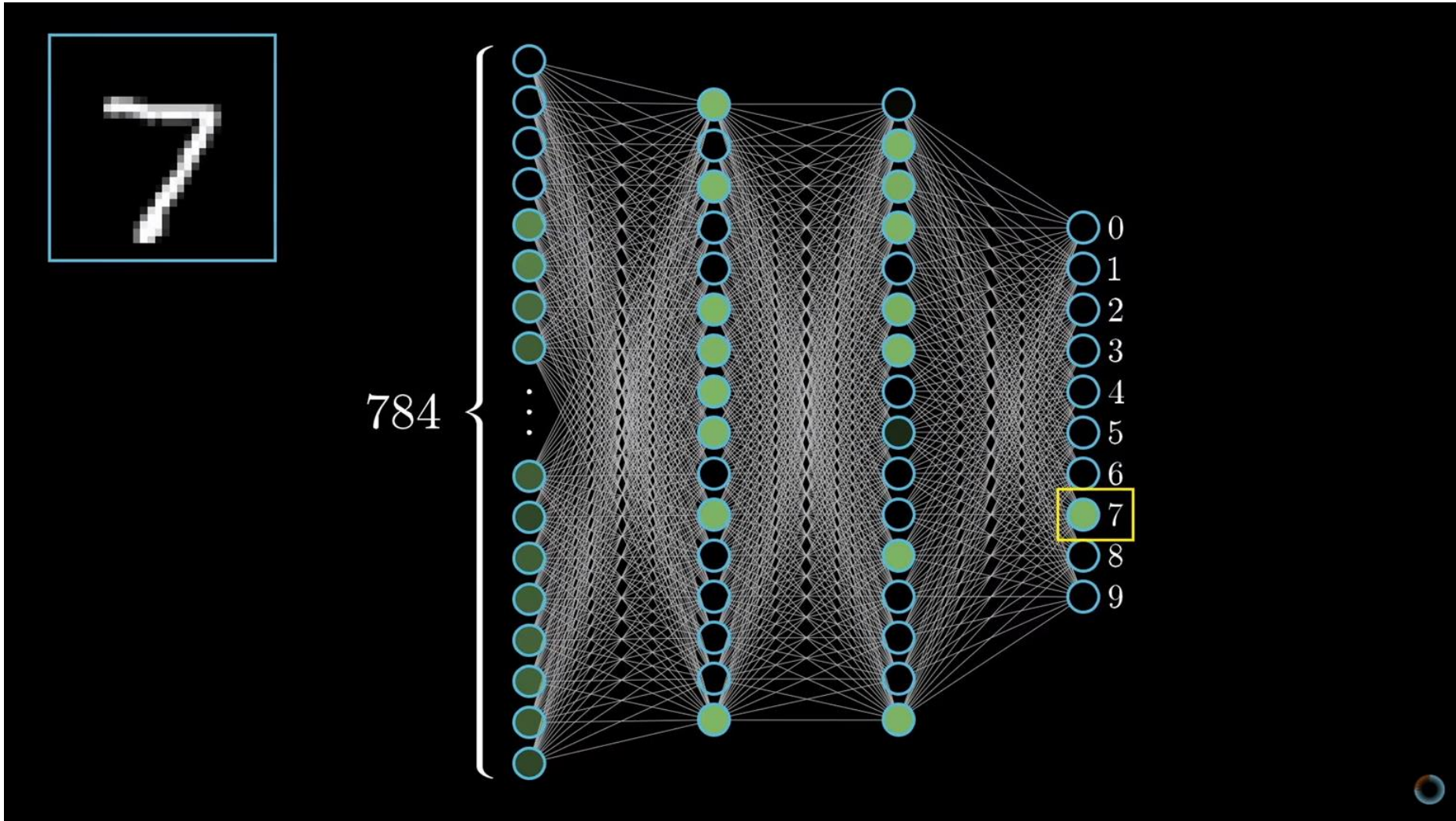
CheXNet

121-layer CNN

Output

Pneumonia Positive (85%)



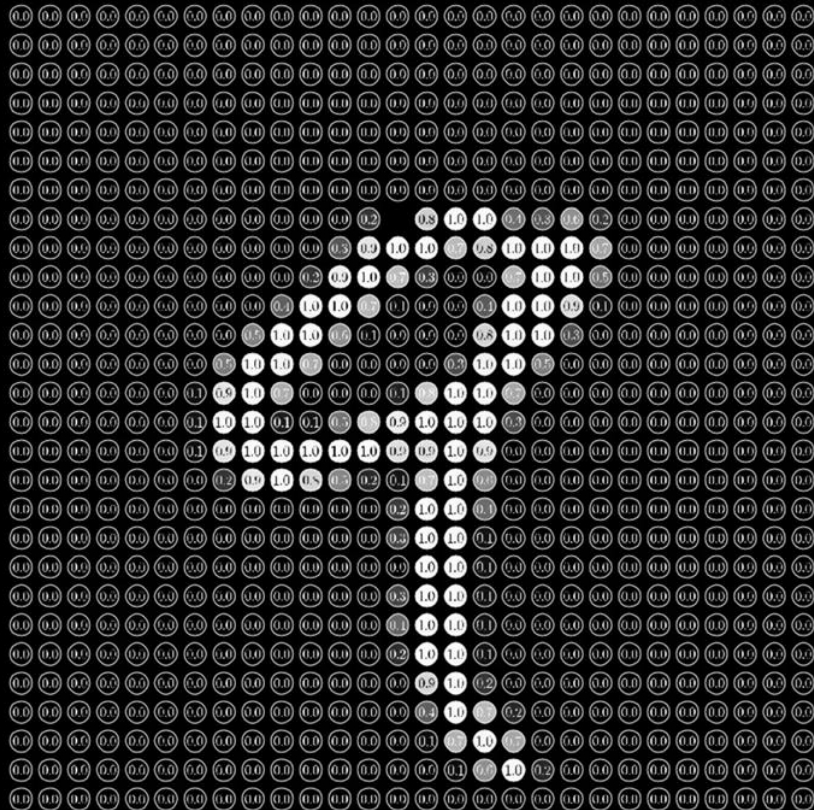


From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>

28

$$28 \times 28 = 784$$

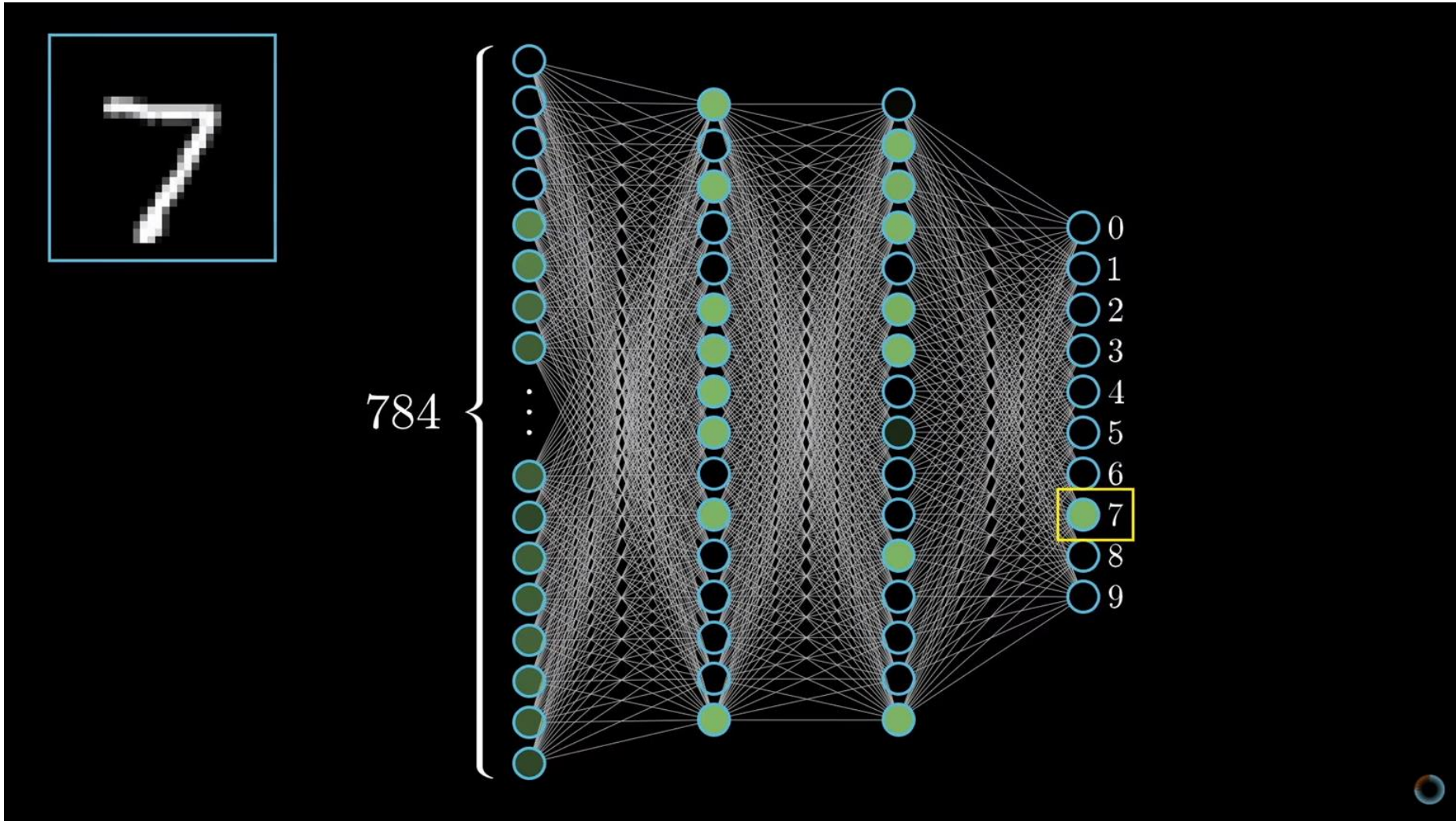
28



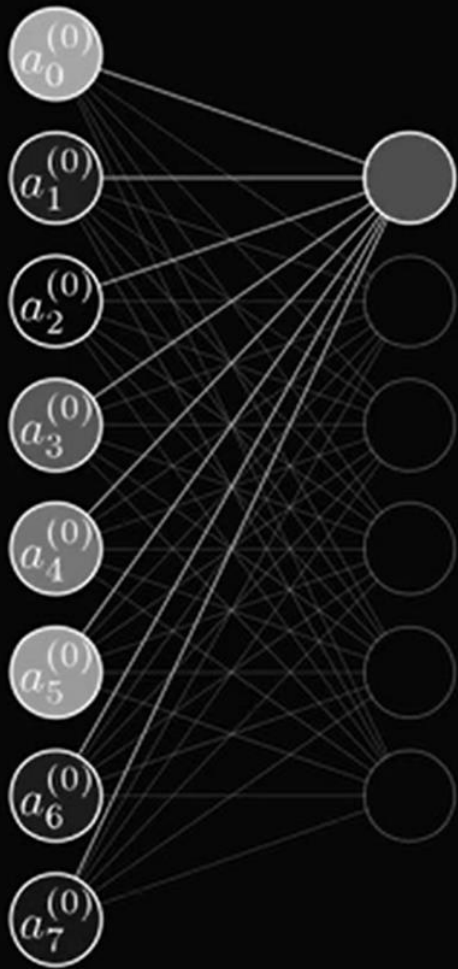
“Activation”



From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>



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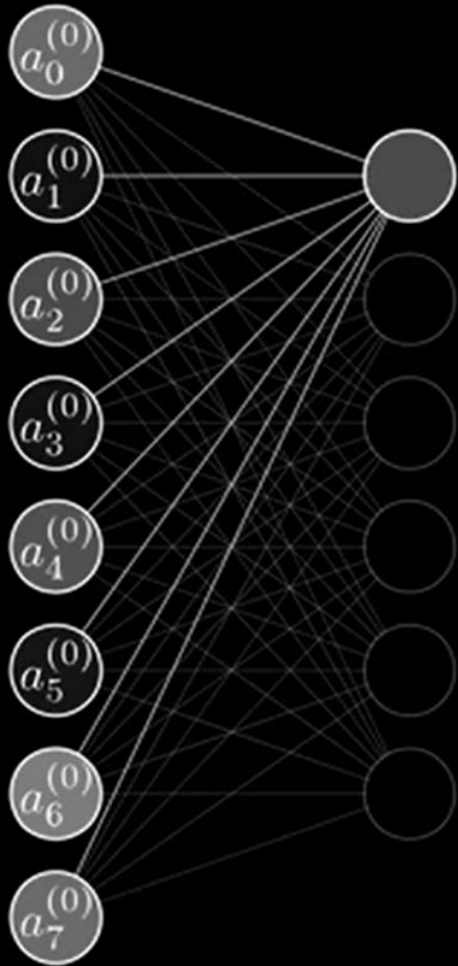
Sigmoid

$$a_0^{(1)} = \sigma \left(w_{0,0} a_0^{(0)} + w_{0,1} a_1^{(0)} + \dots + w_{0,n} a_n^{(0)} + b_0 \right)$$

↑
Bias



From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>



Sigmoid

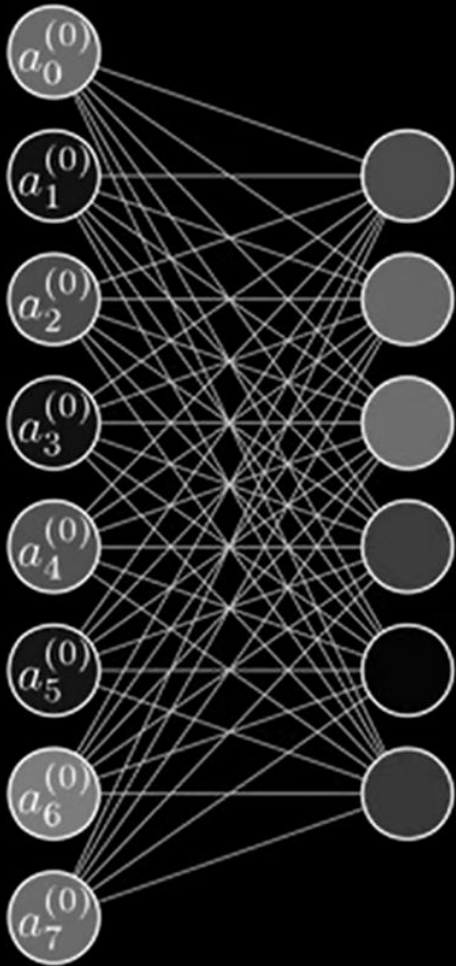
$$a_0^{(1)} = \sigma \left(w_{0,0} a_0^{(0)} + w_{0,1} a_1^{(0)} + \dots + w_{0,n} a_n^{(0)} + b_0 \right)$$

↑
Bias

$$\sigma \left(\begin{bmatrix} w_{0,0} & w_{0,1} & \dots & w_{0,n} \\ w_{1,0} & w_{1,1} & \dots & w_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{k,0} & w_{k,1} & \dots & w_{k,n} \end{bmatrix} \begin{bmatrix} a_0^{(0)} \\ a_1^{(0)} \\ \vdots \\ a_n^{(0)} \end{bmatrix} + \begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_n \end{bmatrix} \right)$$



From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>



$$\mathbf{a}^{(1)} = \sigma(\mathbf{W}\mathbf{a}^{(0)} + \mathbf{b})$$

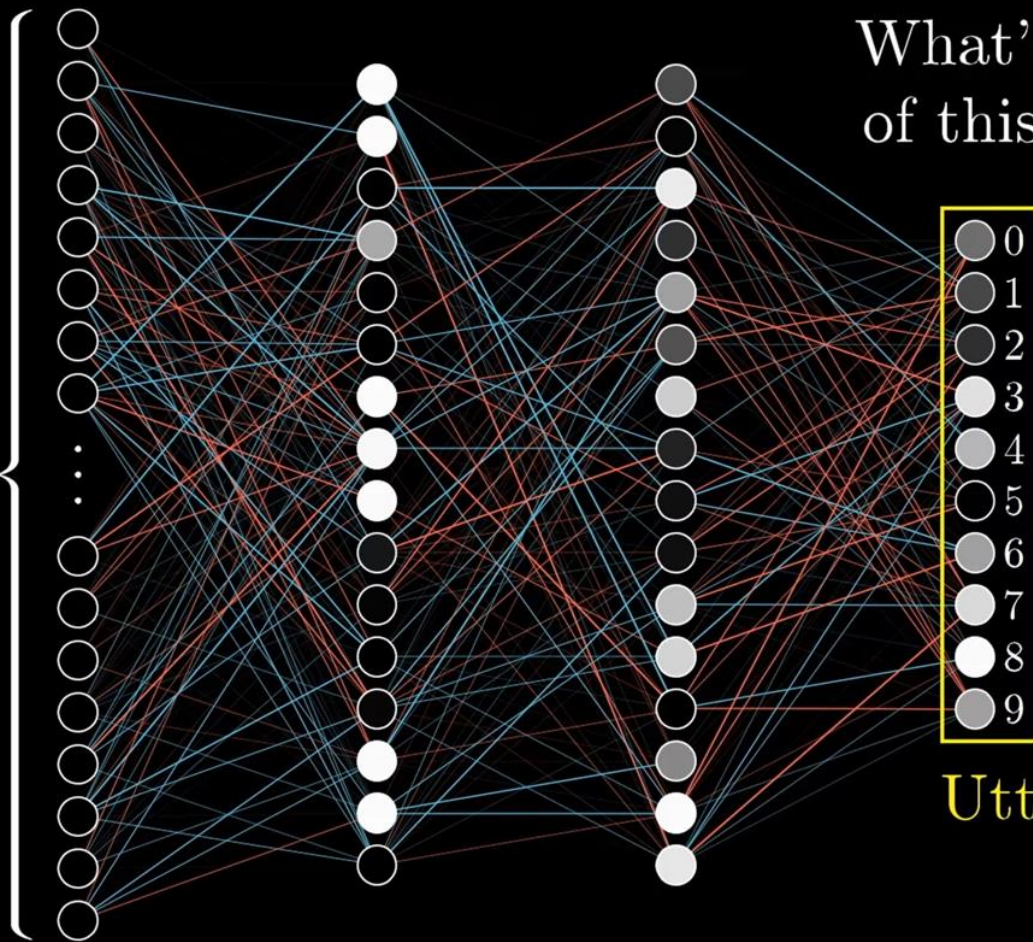
$$\sigma \left(\begin{bmatrix} w_{0,0} & w_{0,1} & \dots & w_{0,n} \\ w_{1,0} & w_{1,1} & \dots & w_{1,n} \\ \vdots & \vdots & \ddots & \vdots \\ w_{k,0} & w_{k,1} & \dots & w_{k,n} \end{bmatrix} \begin{bmatrix} a_0^{(0)} \\ a_1^{(0)} \\ \vdots \\ a_n^{(0)} \end{bmatrix} + \begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_n \end{bmatrix} \right)$$



From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>



784



What's the "cost" of this difference?

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9

Utter trash



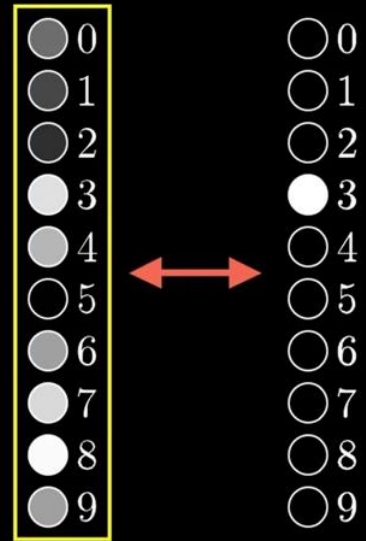
From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>

Cost of **3**

3.37

0.1863	←	$(0.43 - 0.00)^2 +$
0.0809	←	$(0.28 - 0.00)^2 +$
0.0357	←	$(0.19 - 0.00)^2 +$
0.0138	←	$(0.88 - 1.00)^2 +$
0.5242	←	$(0.72 - 0.00)^2 +$
0.0001	←	$(0.01 - 0.00)^2 +$
0.4079	←	$(0.64 - 0.00)^2 +$
0.7388	←	$(0.86 - 0.00)^2 +$
0.9817	←	$(0.99 - 0.00)^2 +$
0.3998	←	$(0.63 - 0.00)^2$

What's the "cost" of this difference?



Utter trash





Propagate backwards

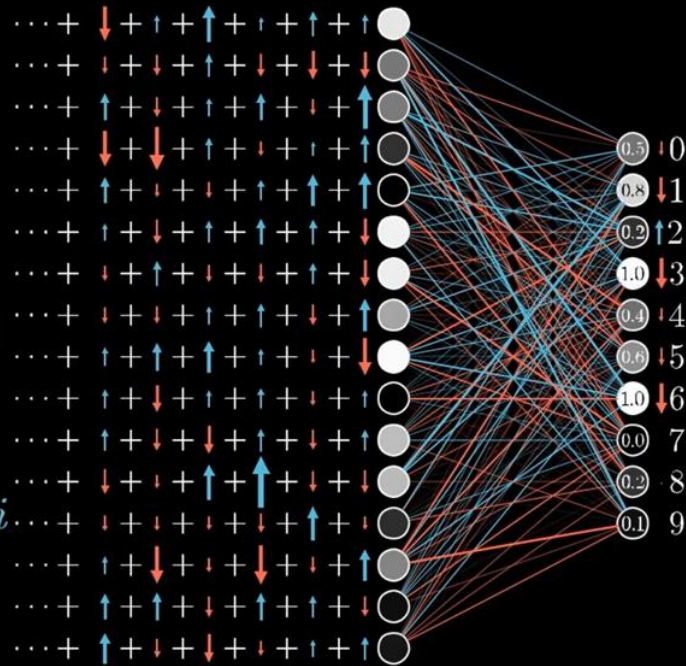
Increase b

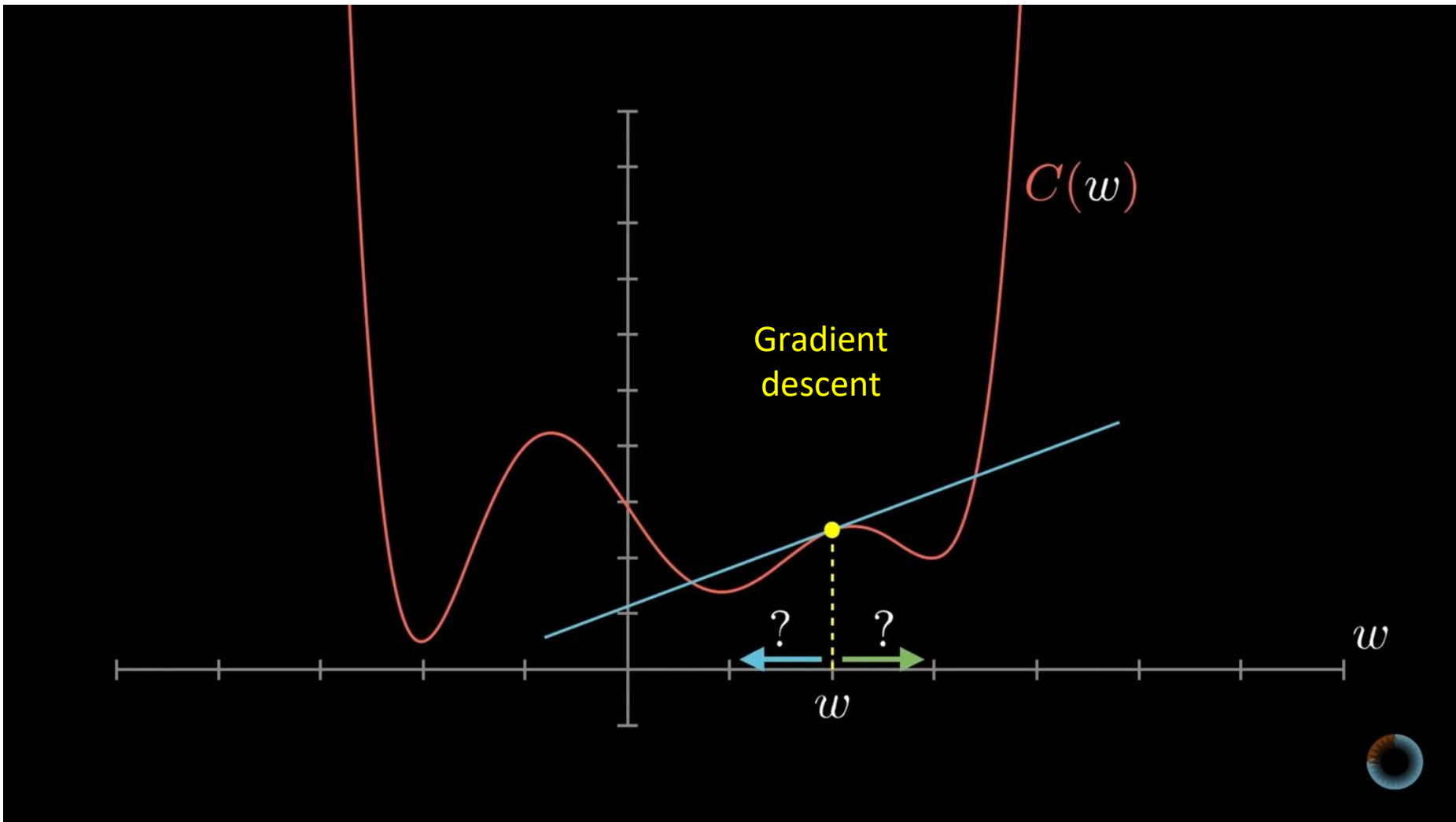
Increase w_i

in proportion to a_i

Change a_i

in proportion to w_i



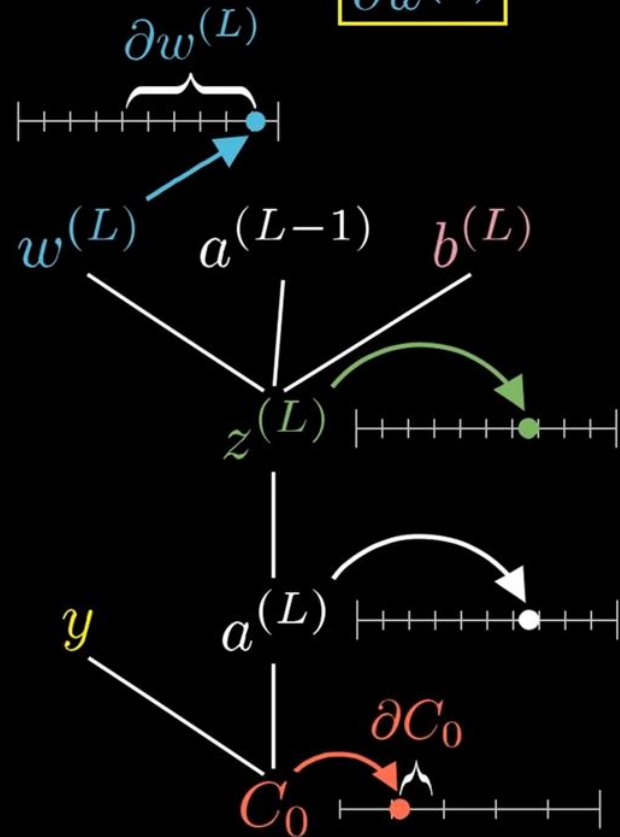


From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>

$$\frac{\partial C_0}{\partial w^{(L)}}$$

What we want

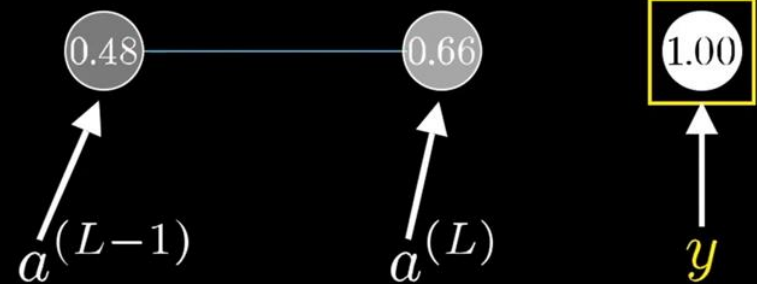
$$C_0(\dots) = (a^{(L)} - y)^2$$



$$z^{(L)} = w^{(L)} a^{(L-1)} + b^{(L)}$$

$$a^{(L)} = \sigma(z^{(L)})$$







Desired output



$$C = \frac{1}{2n} \sum_x \|y(x) - a^L(x)\|^2,$$



From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com> and Neural Networks and Deep Learning (online book) by Michael Nielsen

							...	Average over all training data ↓
w_0	-0.08	+0.02	-0.02	+0.11	-0.05	-0.14	...	→ -0.08
w_1	-0.11	+0.11	+0.07	+0.02	+0.09	+0.05	...	→ +0.12
w_2	-0.07	-0.04	-0.01	+0.02	+0.13	-0.15	...	→ -0.06
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
$w_{13,001}$	+0.13	+0.08	-0.06	-0.09	-0.02	+0.04	...	→ +0.04

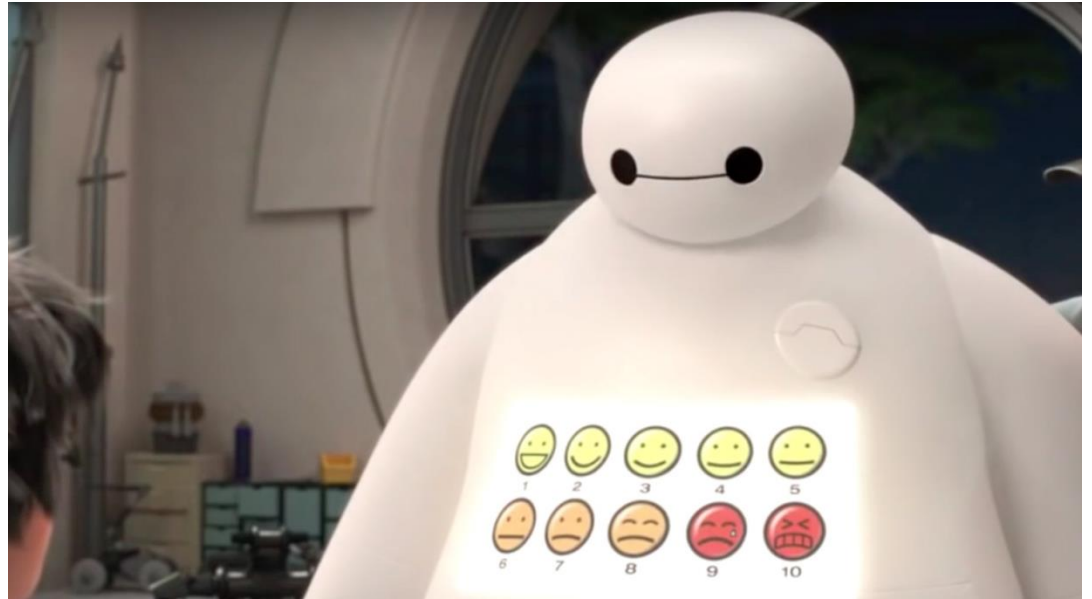


From: Grant Sanderson, 3blue1brown website: <https://www.3blue1brown.com>

The limit of the universe is the output

Nothing in the universe is not the output

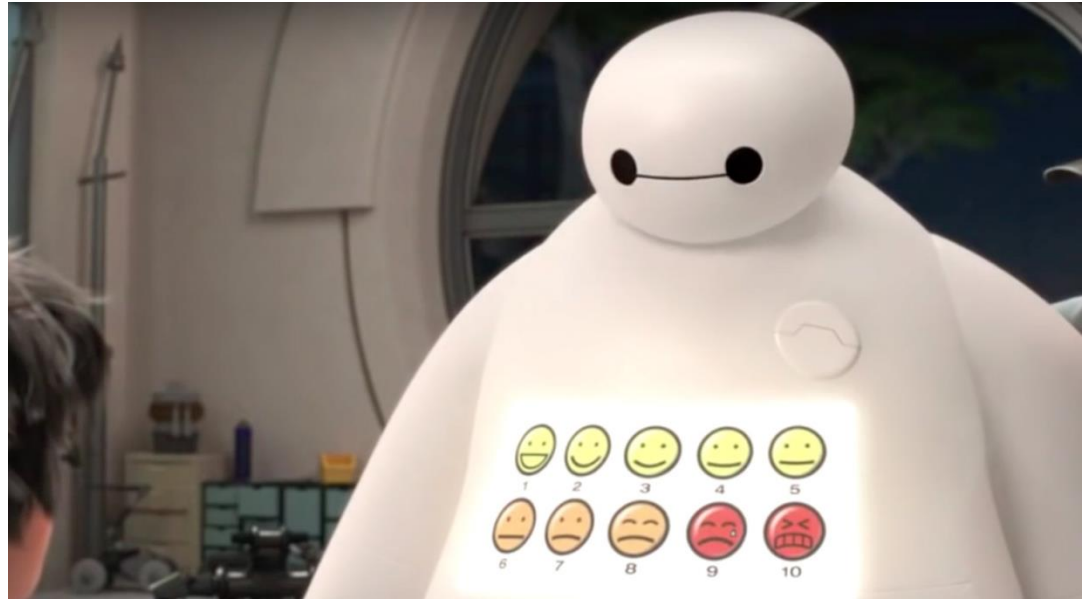
Any input can produce any programmed output



The limit of the universe is the output

Nothing in the universe is not the output

Any input can produce any programmed output



More artificial than intelligent?

“Deep learning” - over a hundred neural net levels

What are all those levels doing? Even the engineers don't know

Will the network always make the right call?

Is there any way to have oversight?

**MIT
Technology
Review**

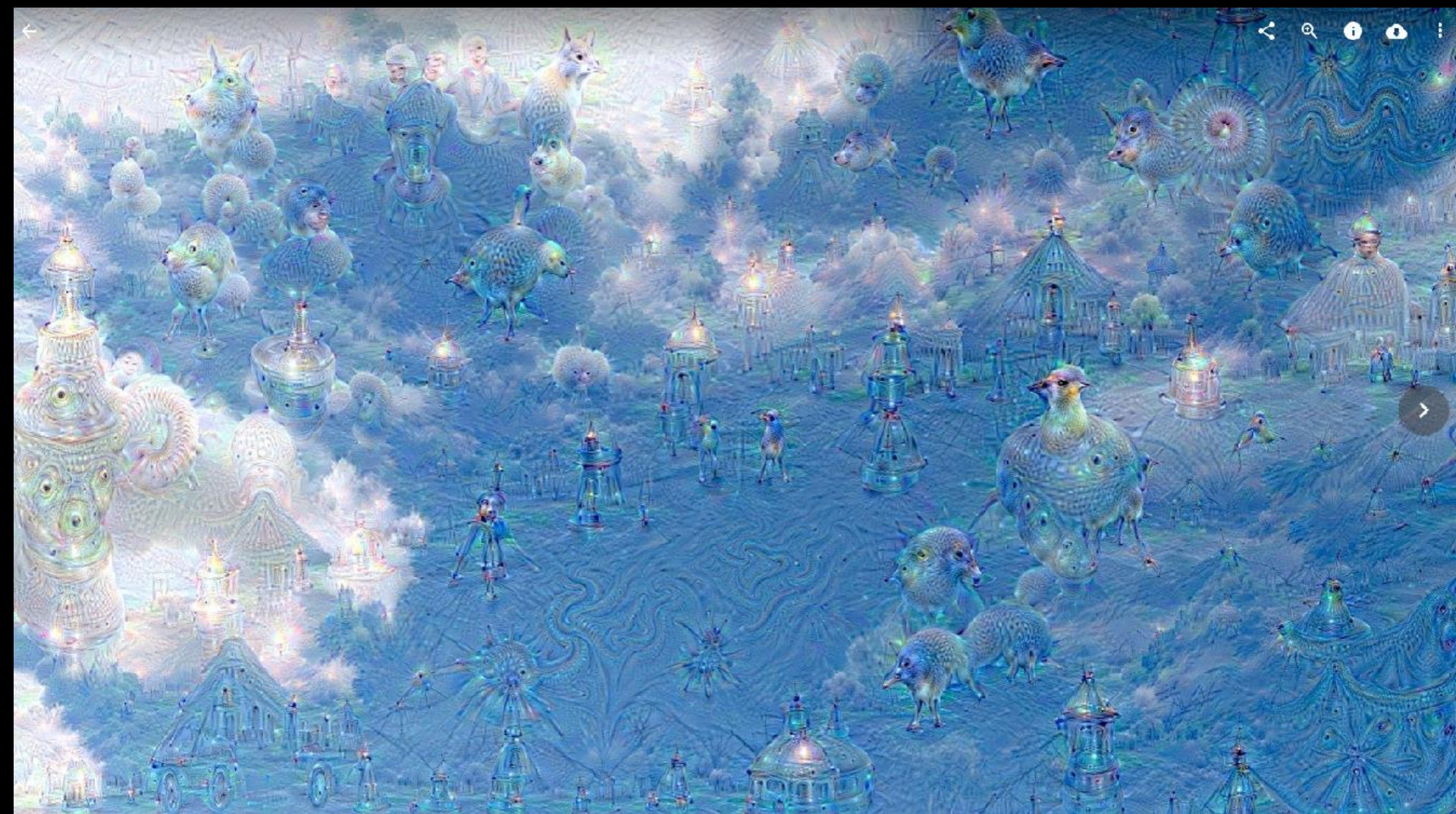
Intelligent Machines

The Dark Secret at the Heart of AI

No one really knows how the most advanced algorithms do what they do. That could be a problem.

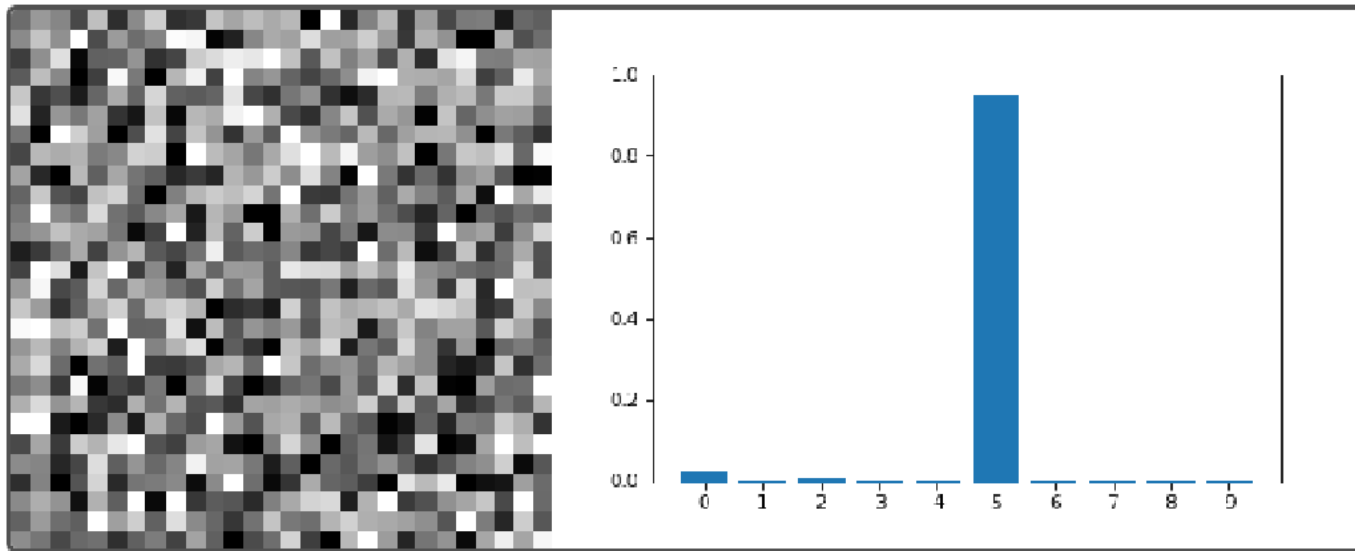
by Will Knight April 11, 2017





adversarial example

Non-Targeted "5"

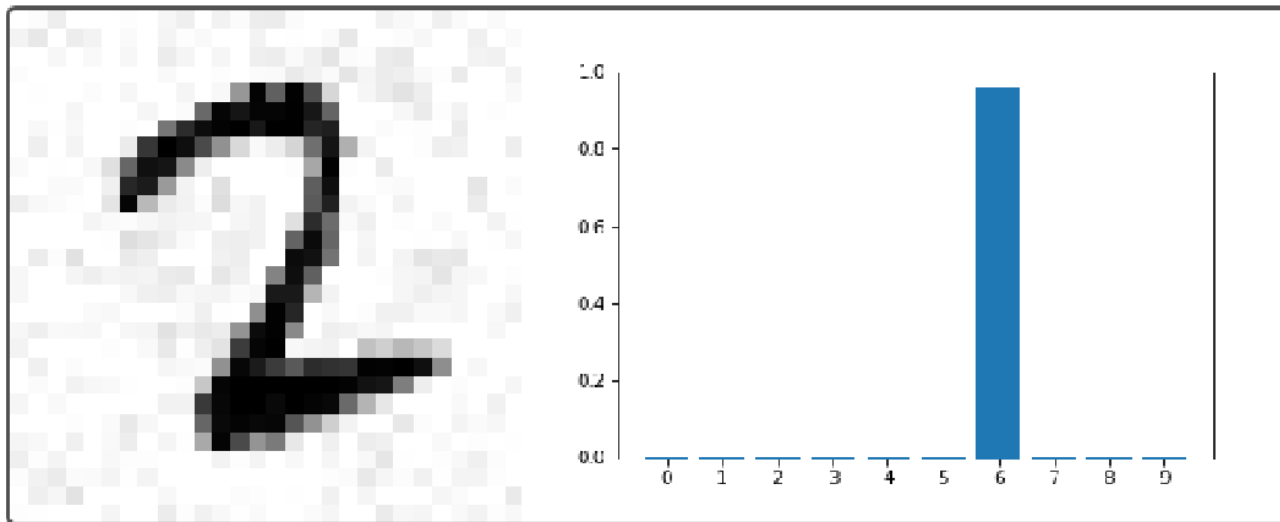


The left side is the non-targeted adversarial example (a 28 X 28 pixel image). The right side plots the activations of the network when given the image.

Source: Machine Learning at Berkeley blog

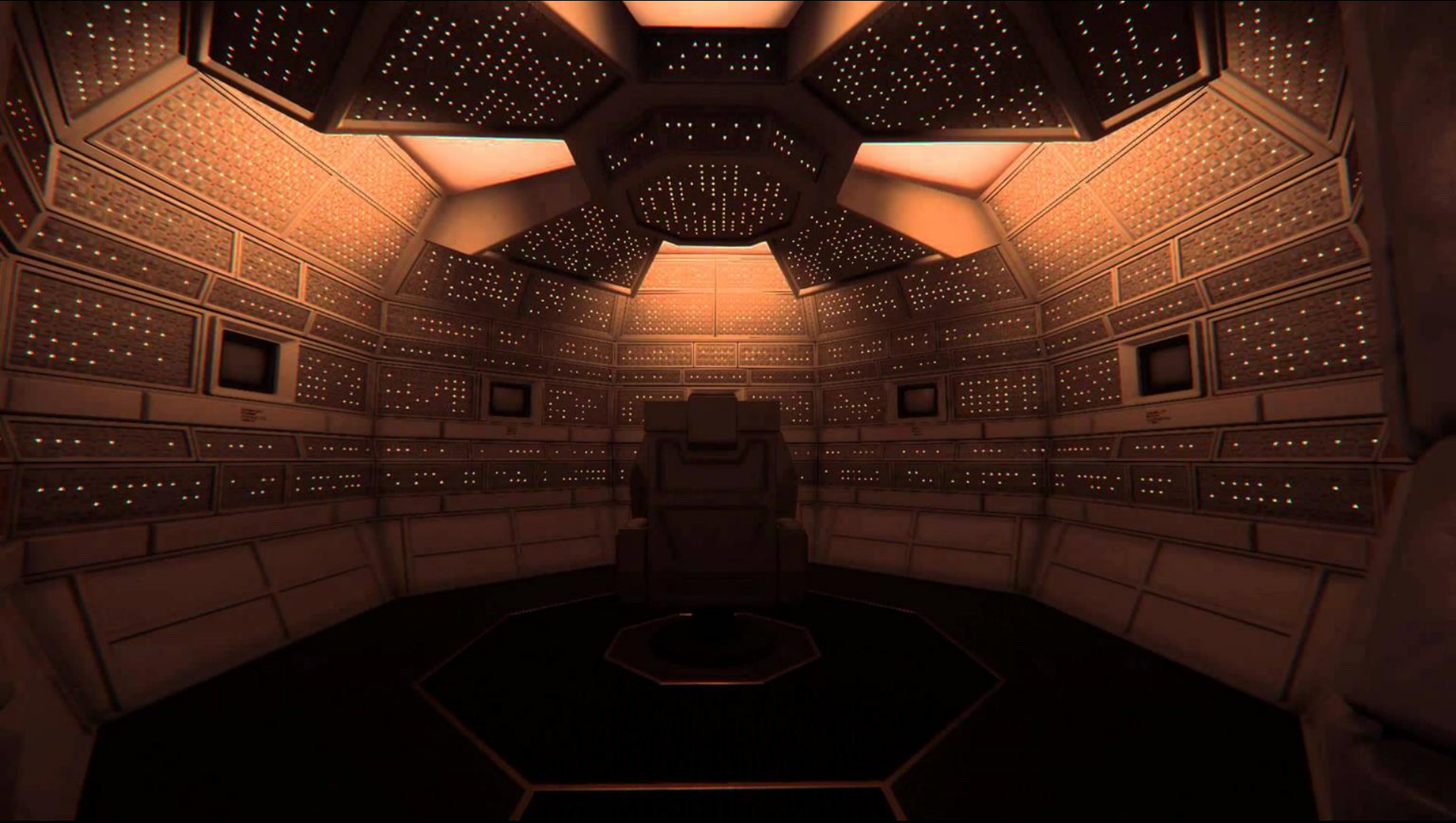
adversarial example

Targeted "6" [x_target=2]



The left side is the targeted adversarial example (a 28 X 28 pixel image). The right side plots the activations of the network when given the image.

Source: Machine Learning at Berkeley blog



“I keep sounding the alarm bell but until people see robots going down the street killing people, they don’t know how to react because it seems so ethereal.” - Elon Musk



1. **Core public agencies, such as those responsible for criminal justice, healthcare, welfare, and education (e.g “high stakes” domains) should no longer use “black box” AI and algorithmic systems.** This includes the unreviewed or unvalidated use of pre-trained models, AI systems licensed from third party vendors, and algorithmic processes created in-house. The use of such systems by public agencies raises serious due process concerns, and at a minimum they should be available for public auditing, testing, and review, and subject to accountability standards.

Genomics, drug
discovery, oncology

Oncology – lots of
data and treatments

Watson – “reads”
literature, protocols,
patient charts

Treatment plans
concordant with
tumor board 93% of
breast cancer cases



A screenshot of the IBM Watson Health website's Oncology page. The top navigation bar includes the IBM logo, a "Marketplace" button, a search bar, and user icons. The main navigation menu lists "IBM Watson Health", "Life sciences", "Oncology" (which is underlined), "Value-based care", "Government", "Imaging", and "Blog". The main content area features a header "Oncology and Genomics" and a primary headline "Bringing confident decision-making to oncology". Below this is a sub-headline: "Provide evidence-backed cancer care to each patient, by understanding millions of data points". A photograph of a female doctor in a white coat with a stethoscope is on the right. A yellow "Let's talk" button is overlaid on the bottom right of the image.

Some published studies are erroneous

Some published studies cannot be reproduced

Some published studies are fraudulent

Algorithms can be taught to make biased decisions

Frequent auditing will probably be needed

AI Treatment Design



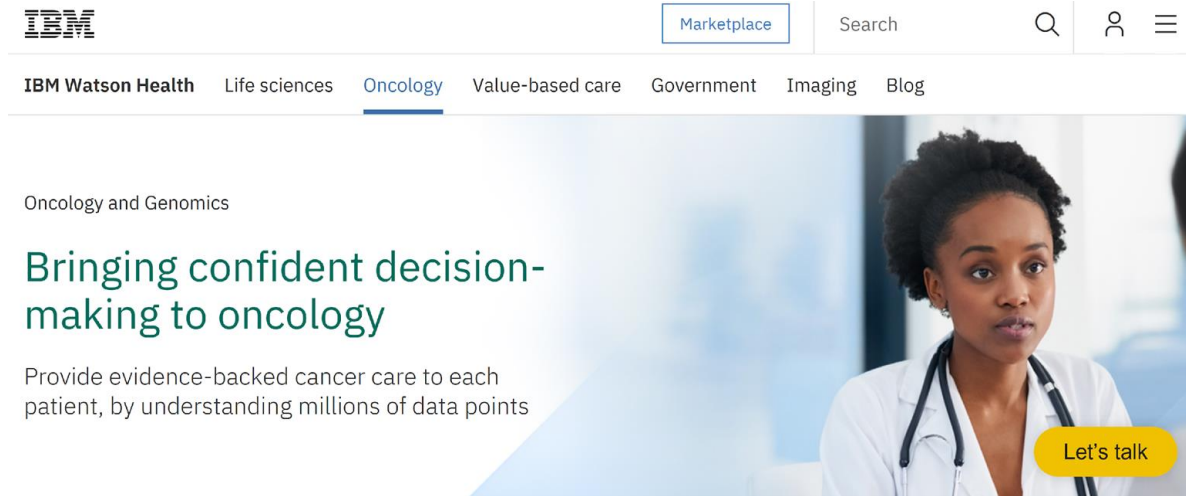
MD Anderson fallout:
\$39M loss

Requires costly, well-organized data input

Data input requires lots of time and labor

Can only draw conclusions on the data it is trained on

No recent system updates



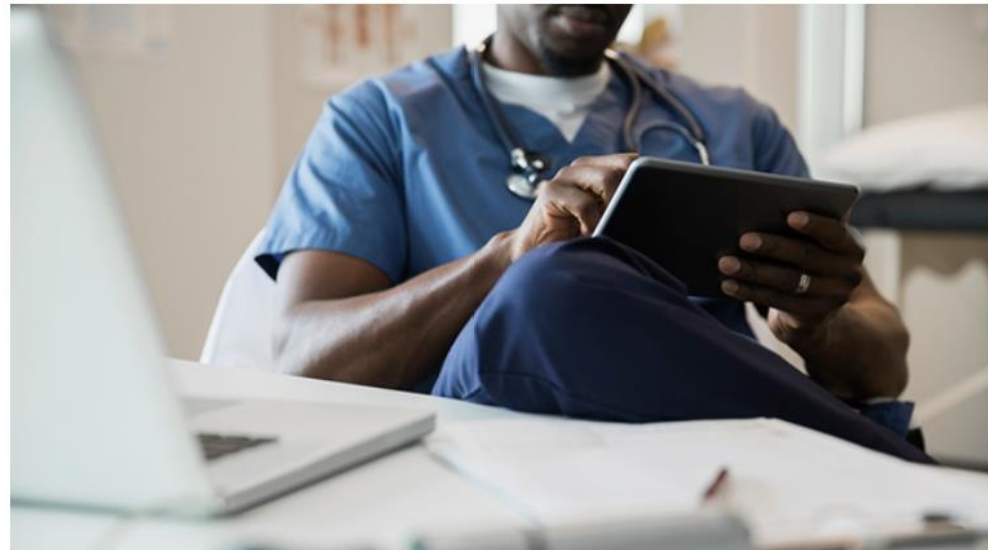
“Human intelligence outperforms machine-learning applications in complex decision making routinely required during the course of care, because machines do not yet possess mature capabilities for perceiving, reasoning, or explaining.”

Four Lessons In The Adoption Of Machine Learning In Health Care

Ernest Sohn, Joachim Roski, Steven Escaravage, Kevin Maloy

MAY 9, 2017

10.1377/hblog20170509.059985



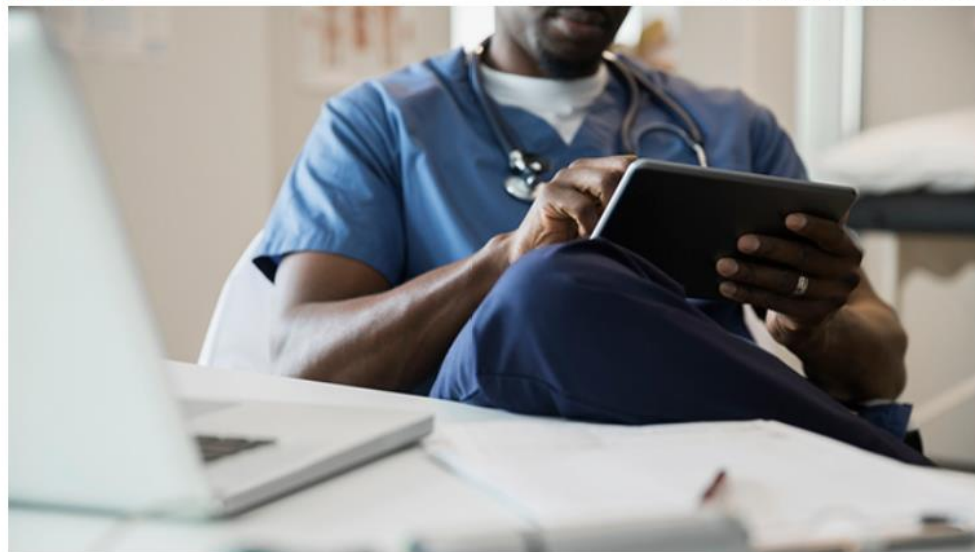
“... machine learning can be effectively deployed today to reduce more routine, time-consuming, and resource-intensive tasks, allowing freed-up personnel to be redeployed to support higher-end work.”

Four Lessons In The Adoption Of Machine Learning In Health Care

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AI embedded in workplace messaging system

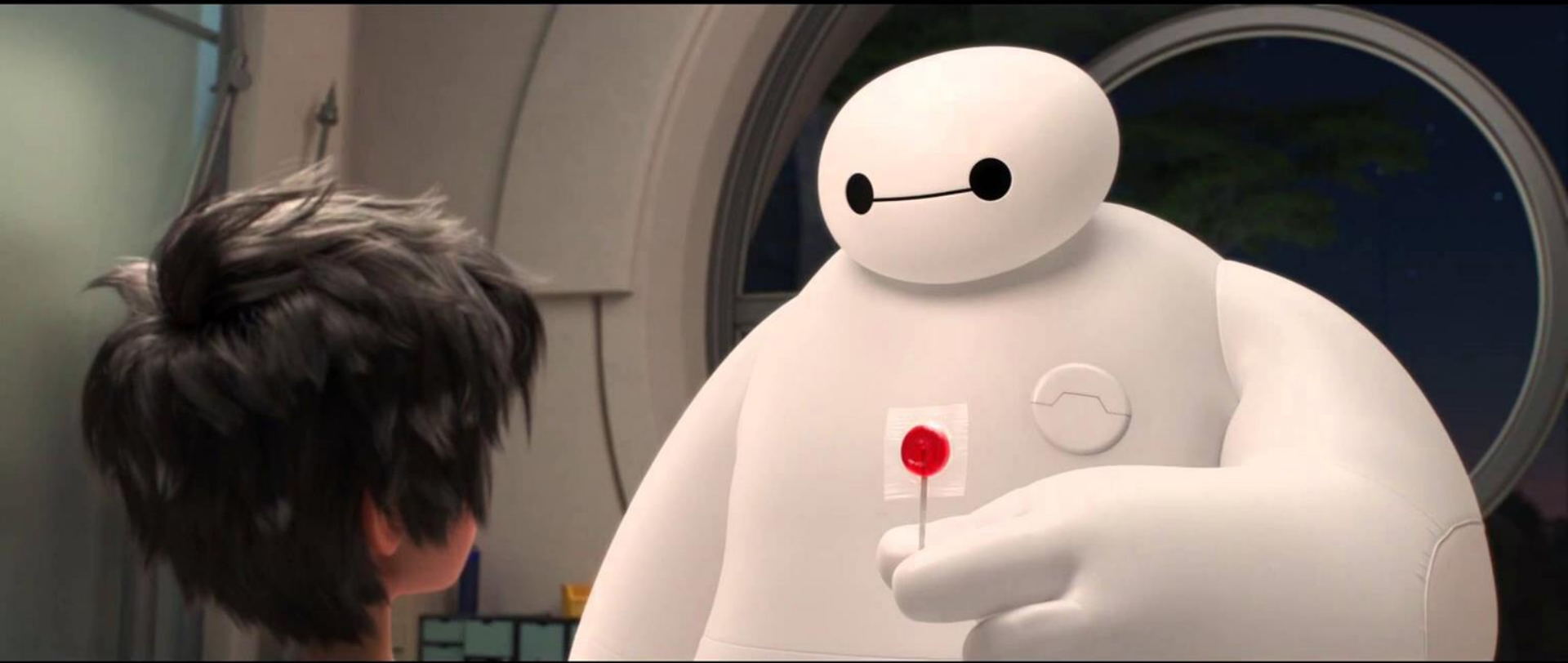
Prompts managers to solicit feedback from workers stress level

Suggests reading material

IBM Watson Tone Analyzer

Analyzes emails for negative language

The screenshot shows the Social.Lab website. At the top, there is a red navigation bar with the logo "Social.Lab" and links for "Home", "Services", "Who we are", "Jobs", and "Contact". Below the navigation bar, a dark grey banner contains the text: "Join us on our rooftop. Where do we find our inspiration? Sometimes on our rooftop. It offers an amazing 270° degree view of Brussels." The main visual is a large image of people silhouetted against a bright sunset, jumping and dancing on a rooftop. Below this image, a red banner features the text: "Heels and Wheels. All work, no play? Why walk when you can glide? Our kick scooters are the perfect way to get around the office." The bottom section of the page is white and contains the IBM logo, a "Marketplace" button, a search bar, and a "Get Started Free" button. Below this, there is a breadcrumb trail "Products and Services" and a "Tone Analyzer" section. The "Tone Analyzer" section includes a speech bubble icon, the text "Tone Analyzer", "Understand emotions and communication style in text.", and two buttons: "Get started free" and "View demo". There is also a link "Already using Tone Analyzer? Login". On the right side of the page, there is a vertical bar with a bar chart and the text "Talk to an expert".



Physician burnout is skyrocketing

EMRs don't help

Solution?

Digital scribes!

Fill out the EMR through voice recognition

Suggest diagnoses

Educational tool

HEALTH

How Tech Has Undermined—and May Now Save—the Doctor-Patient Relationship



AI software with voice recognition

Simplifies patient note preparation

Shares note to the cloud

Allows MD more face time with patients

Interacts with EMR for orders, lab trends



The image shows a screenshot of the MDops website. At the top left is the MDops logo, which consists of a green clock icon followed by the text "MDops". To the right of the logo is a navigation menu with links for "Solutions", "Products", "Pricing", "Company", "News", and "Blog". A green button labeled "Get in Touch" is positioned to the right of the "Blog" link. Below the navigation is a large hero image featuring a male doctor in a white lab coat holding a smartphone, with a female doctor in a white lab coat in the background. Overlaid on the hero image is the text "Simplified Clinical Documentation" in a large, white, sans-serif font. Below this headline is the subtext "Dictate instant notes using your iPhone, increasing your time with patients" in a smaller, white, sans-serif font. At the bottom right of the hero image are two buttons: a green button labeled "Learn More" and a blue button labeled "Watch Video".

AI software

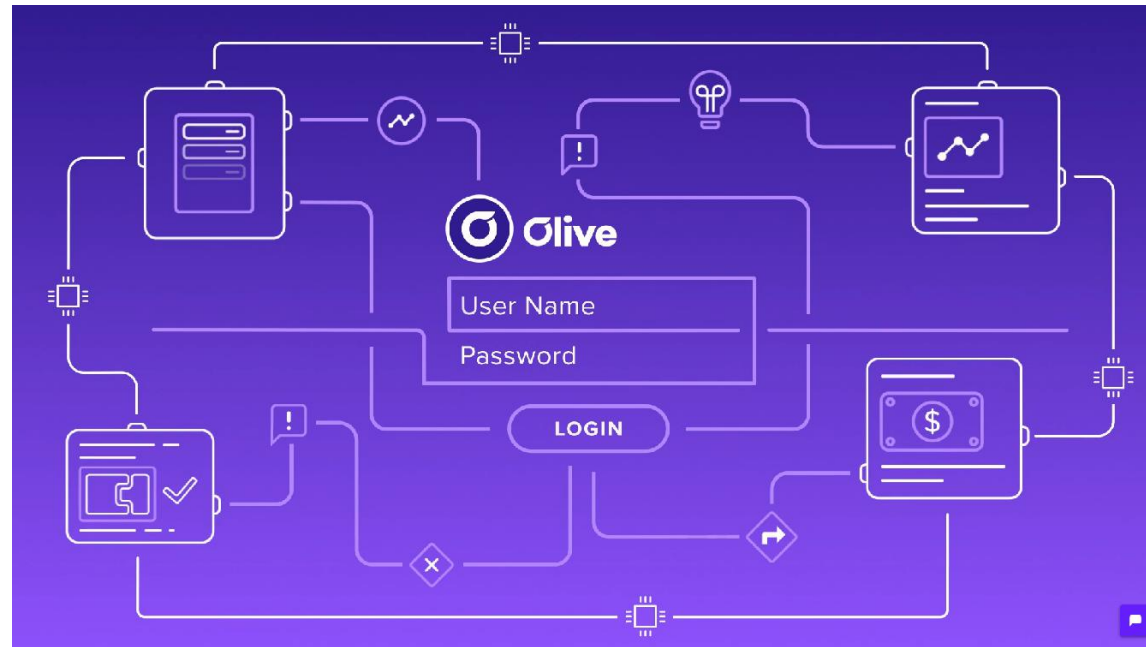
Gets an email account
and EMR sign-in

Checks patient
insurance eligibility
against online portals

Reduced insurance
denials

Reduced days in AR

Scheduling, orders,
patient engagement



Geared toward
Medicare Advantage

AI identification of
diagnosis codes from
patient chart

PDF, EMR, scanned
files

Improve risk
adjustment and
reimbursement

Research?





106 STARTUPS TRANSFORMING HEALTHCARE WITH AI



istock.com/hilch

Conclusions

Powerful
technology

Existent or likely:

diagnostics

digital scribes

chart mining

call centers

treatment design

Too early:

complex clinical

decision making

BUSINESS 02.01.18 09:22 AM

THE WIRED GUIDE TO ARTIFICIAL INTELLIGENCE

Supersmart algorithms won't take all the jobs, but they are learning faster than ever, doing everything from medical diagnostics to serving up ads.

BY [TOM SIMONITE](#)

ARTIFICIAL INTELLIGENCE IS overhyped—there, we said it. It's also incredibly important.