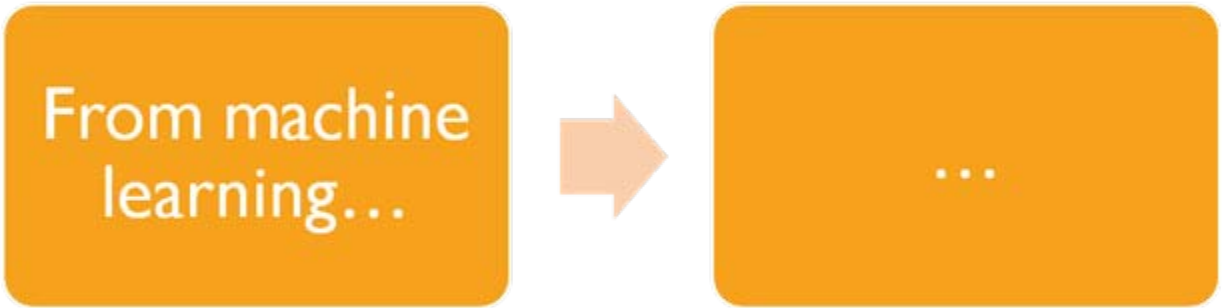
FROM MACHINE LEARNING, TO DEEP LEARNING

Jeremy Howard
fast.ai & USF

j@fast.ai
@jeremyphoward


From machine learning…
…


What's New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YAHOO!


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Help

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Literature, Photography...

Business & Economy
Companies, Finance, Jobs...

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Universities, K-12, College Entrance...

Entertainment
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Government
Military, Politics, Law, Taxes...

Health
Medicine, Diseases, Drugs, Fitness...

News & Media
Full Coverage, Newspapers, TV...

Recreation & Sports
Sports, Travel, Autos, Outdoors...

Reference
Libraries, Dictionaries, Quotations...

Regional
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- Online: Lewinsky video testimony
- NASA comet mission
- NBA season opens
- Weekend's top movies

more...

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- Shop for your Valentine
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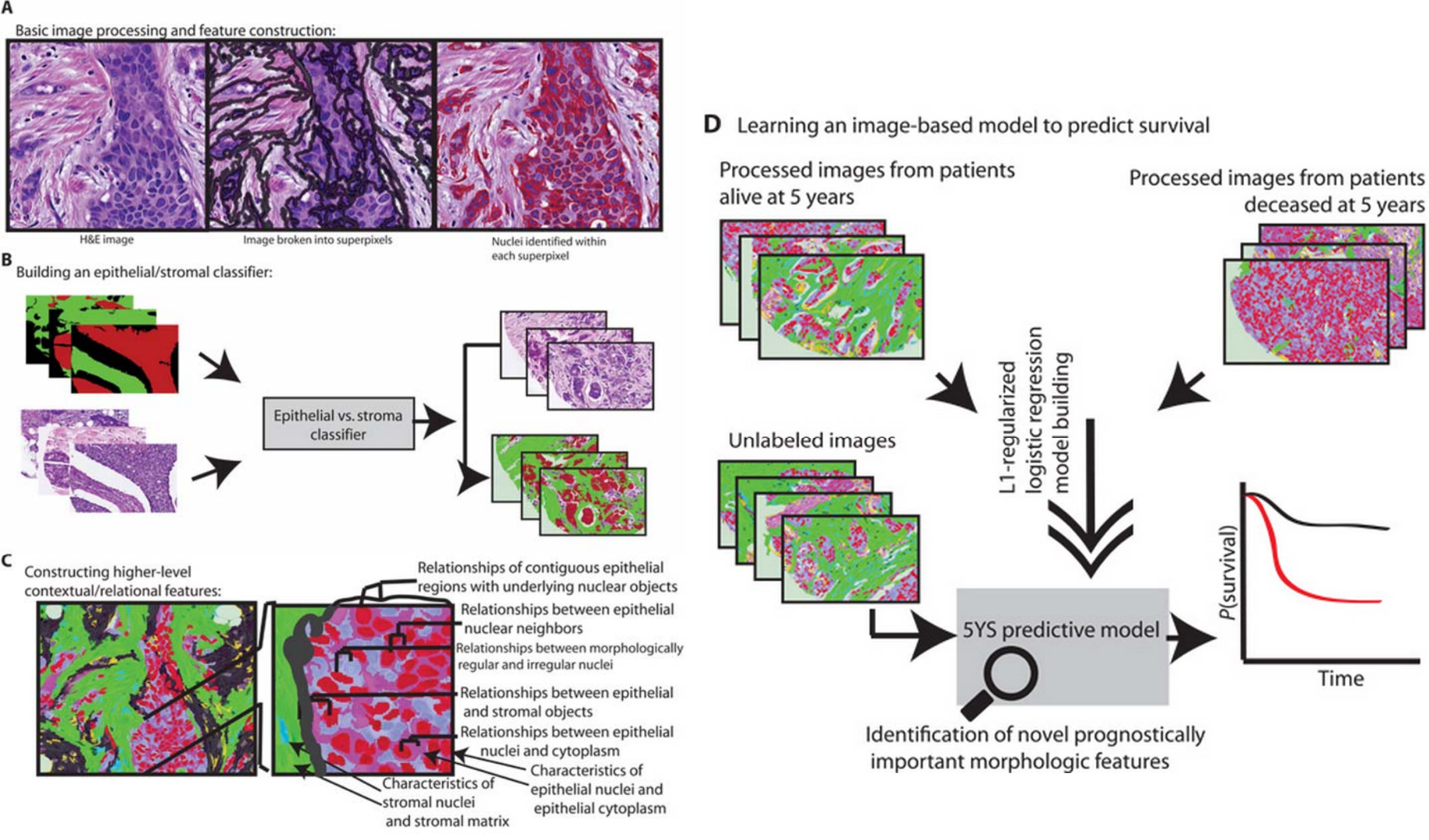

A
Basic image processing and feature construction:
H&E image
Image broken into superpixels
Nuclei identified within each superpixel
B
Building an epithelial/stromal classifier:
Epithelial vs. stroma classifier
C
Constructing higher-level contextual/relational features:
Relationships of contiguous epithelial regions with underlying nuclear objects
Relationships between epithelial nuclear neighbors
Relationships between morphologically regular and irregular nuclei
Relationships between epithelial and stromal objects
Relationships between epithelial nuclei and cytoplasm
Characteristics of epithelial nuclei and epithelial cytoplasm
Characteristics of stromal nuclei and stromal matrix
D
Learning an image-based model to predict survival
Processed images from patients alive at 5 years
Processed images from patients deceased at 5 years
Unlabeled images
L1-regularized logistic regression model building
5YS predictive model
P(survival)
Time
Identification of novel prognostically important morphologic features

HORIZONTAL APPLICATIONS

Machine Learning

MARKETING APPLICATIONS

RISK APPLICATIONS

Credit risk

Treasury or currency risk

Fraud detection

Accounts Payable Recovery

Anti-money laundering

HUMAN RESOURCES APPLICATIONS

MORE HORIZONTAL APPLICATIONS…

Sales

- Lead prioritization

Customer support

- Call routing
- Call center message optimization
- Call center volume forecasting

Logistics

- Demand forecasting

VERTICAL APPLICATIONS

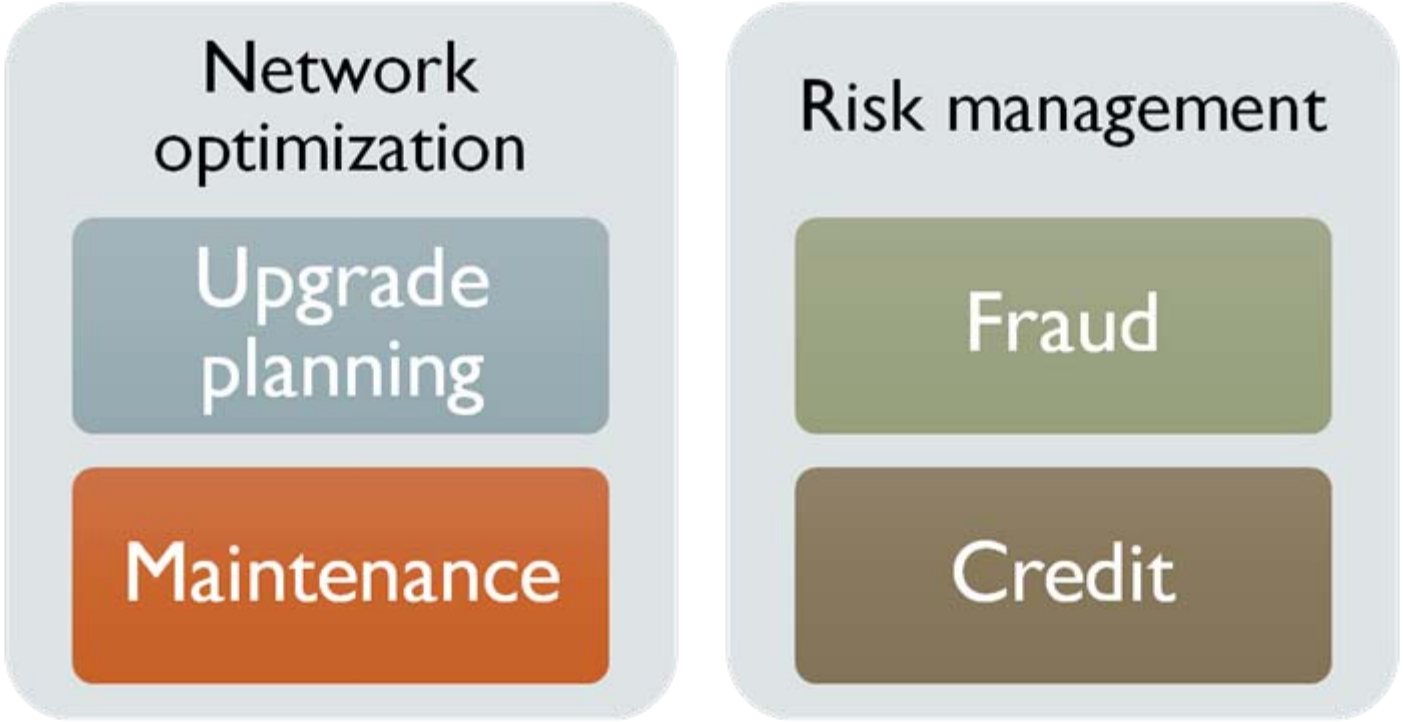
Machine Learning

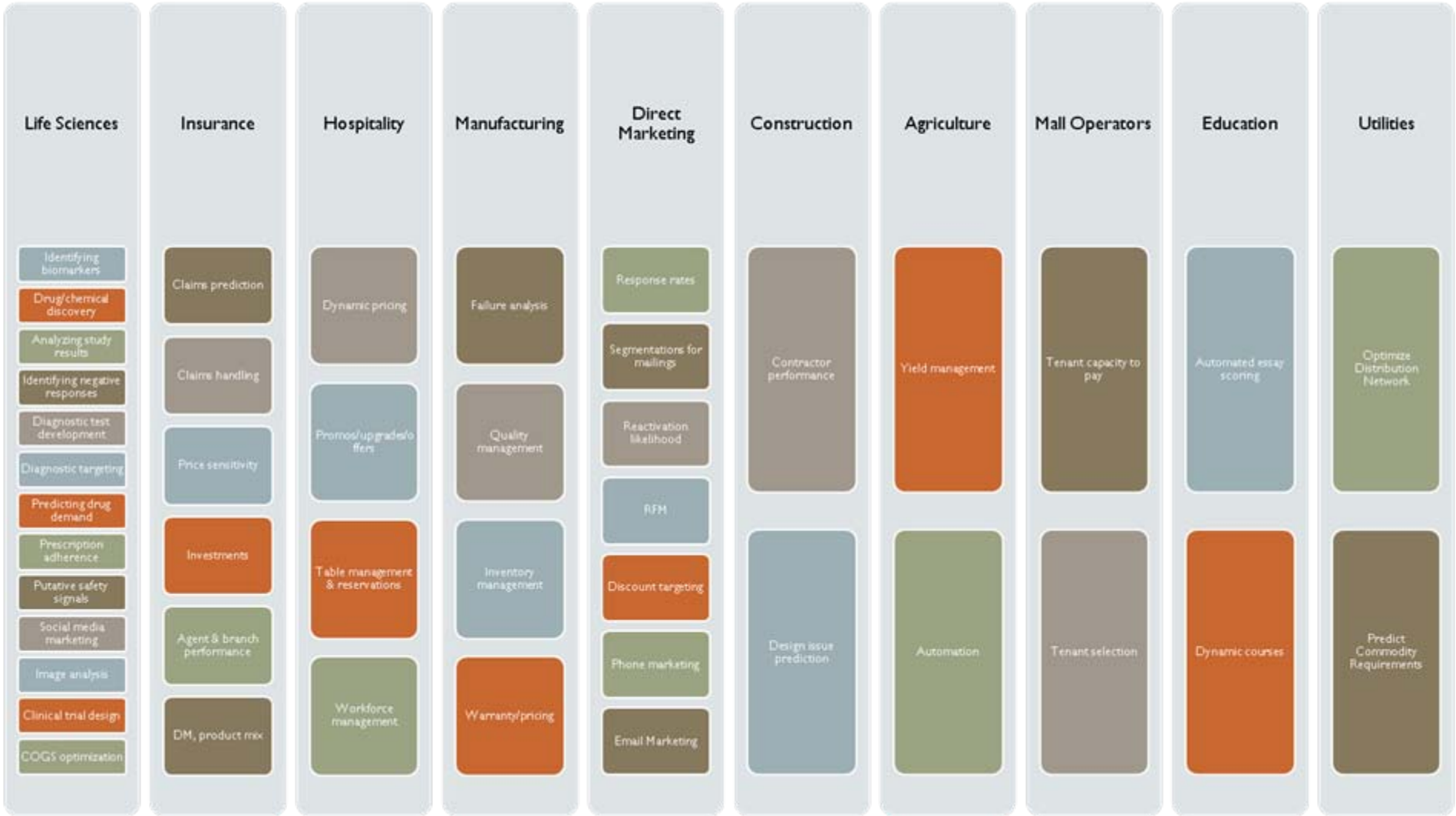
HEALTHCARE APPLICATIONS

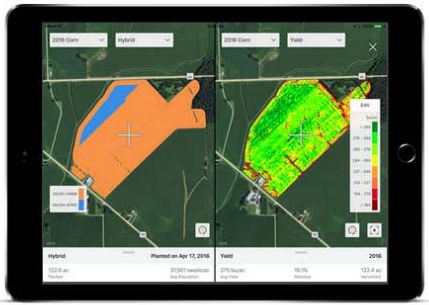
RETAIL APPLICATIONS

TRAVEL APPLICATIONS

TELCO OPPORTUNITIES




Life Sciences
Identifying biomarkers
Drug/chemical discovery
Analyzing study results
Identifying negative responses
Diagnostic test development
Diagnostic targeting
Predicting drug demand
Prescription adherence
Putative safety signals
Social media marketing
Image analysis
Clinical trial design
COGS optimization
Insurance
Claims prediction
Claims handling
Price sensitivity
Investments
Agent & branch performance
DM, product mix
Hospitality
Dynamic pricing
Promos/upgrades/offers
Table management & reservations
Workforce management
Manufacturing
Failure analysis
Quality management
Inventory management
Warranty/pricing
Direct Marketing
Response rates
Segmentations for mailings
Reactivation likelihood
RFM
Discount targeting
Phone marketing
Email Marketing
Construction
Contractor performance
Design issue prediction
Agriculture
Yield management
Automation
Mall Operators
Tenant capacity to pay
Tenant selection
Education
Automated essay scoring
Dynamic courses
Utilities
Optimize Distribution Network
Predict Commodity Requirements



COMPARE MAPS SIDE-BY-SIDE

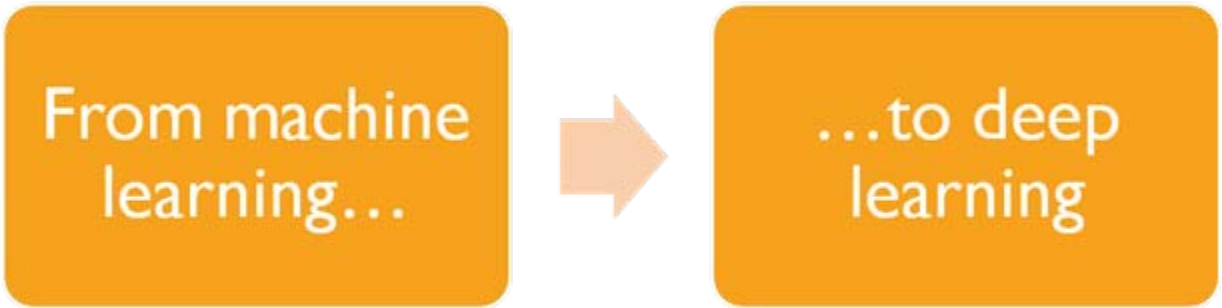
Use side-by-side maps to compare critical data layers in your field, including yield, soil maps, application rate, seed population rate and more.

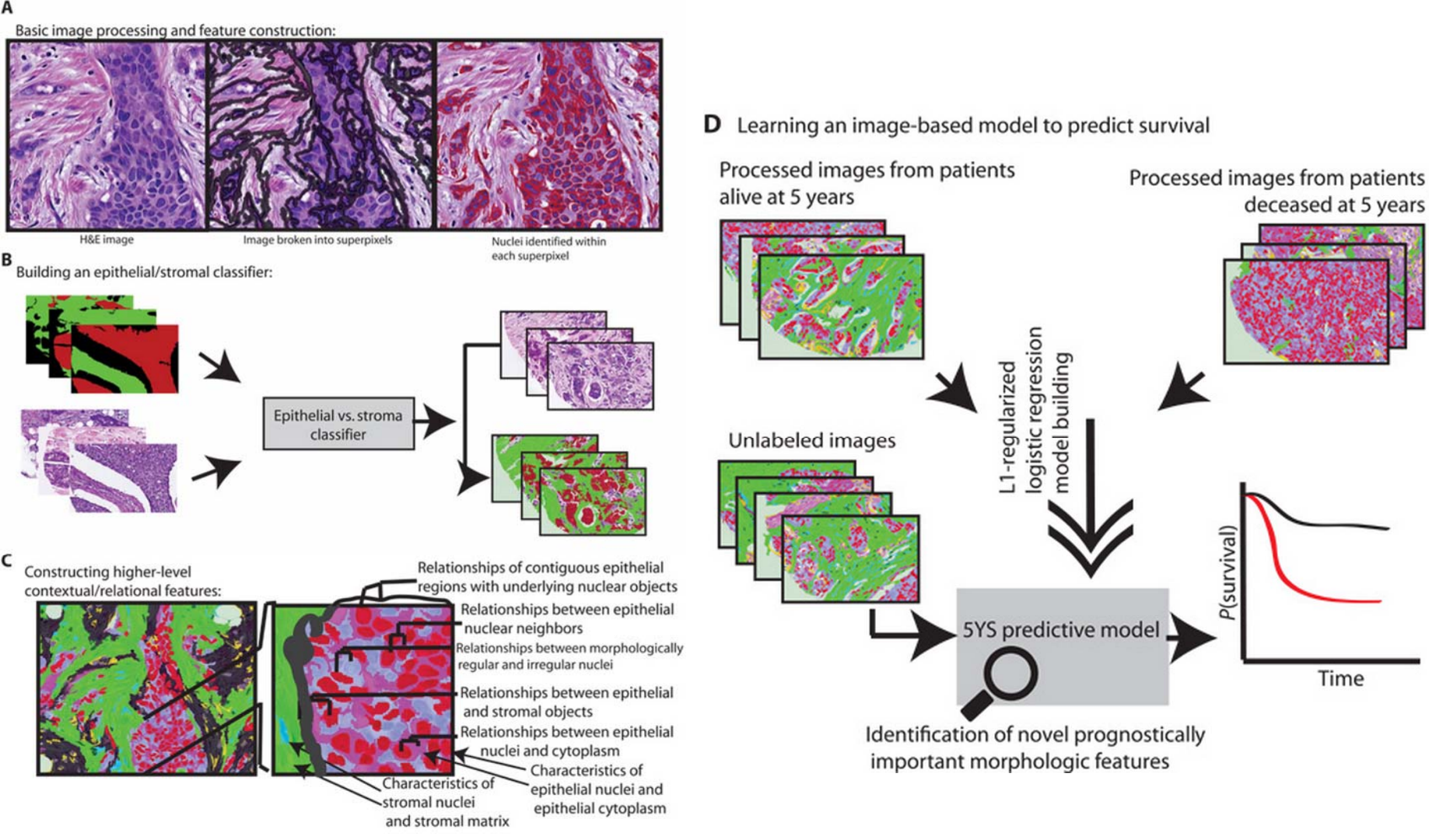
YIELD ANALYSIS

Easily analyze performance by hybrid, soil type, or by your customized regions, so you can make the best agronomic decisions year-round.

FIELD REGION ANALYSIS

Use your data layers to identify and save field regions for deeper analysis. Then, measure the impact of your agronomic decisions on yield in each region after harvest.


From machine learning…
…to deep learning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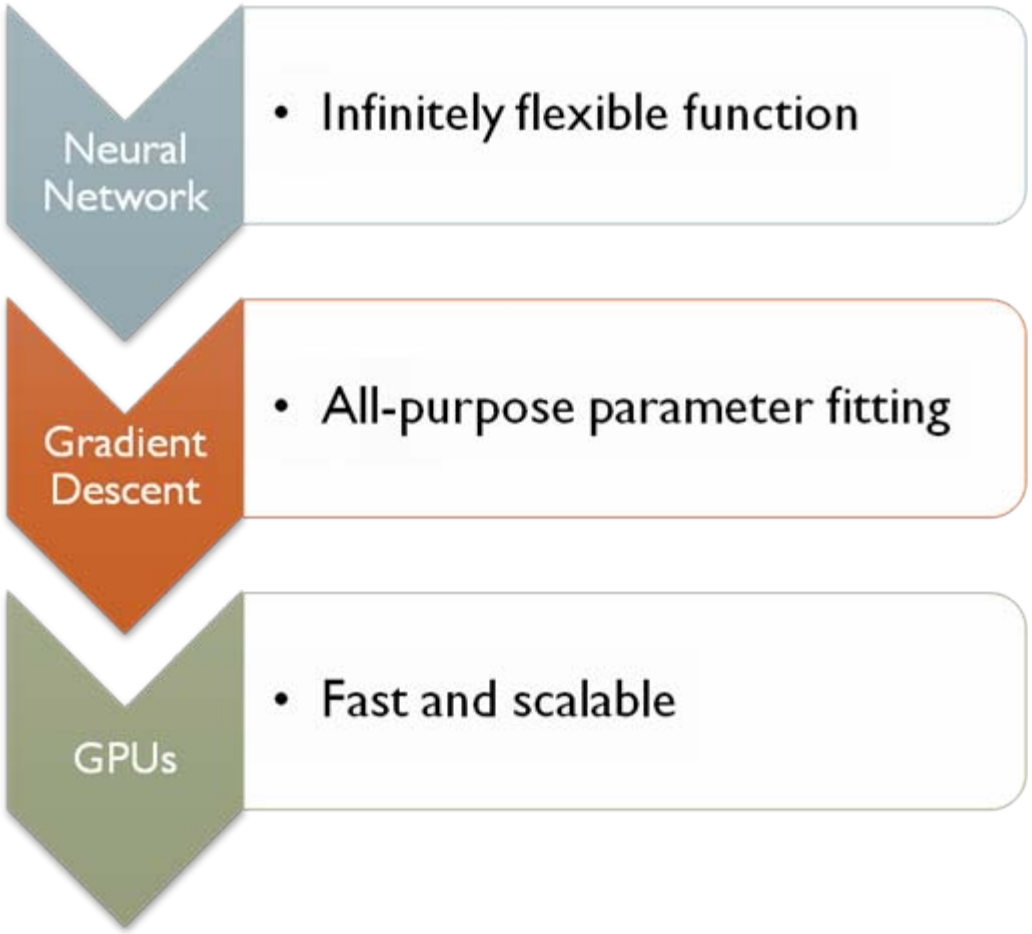
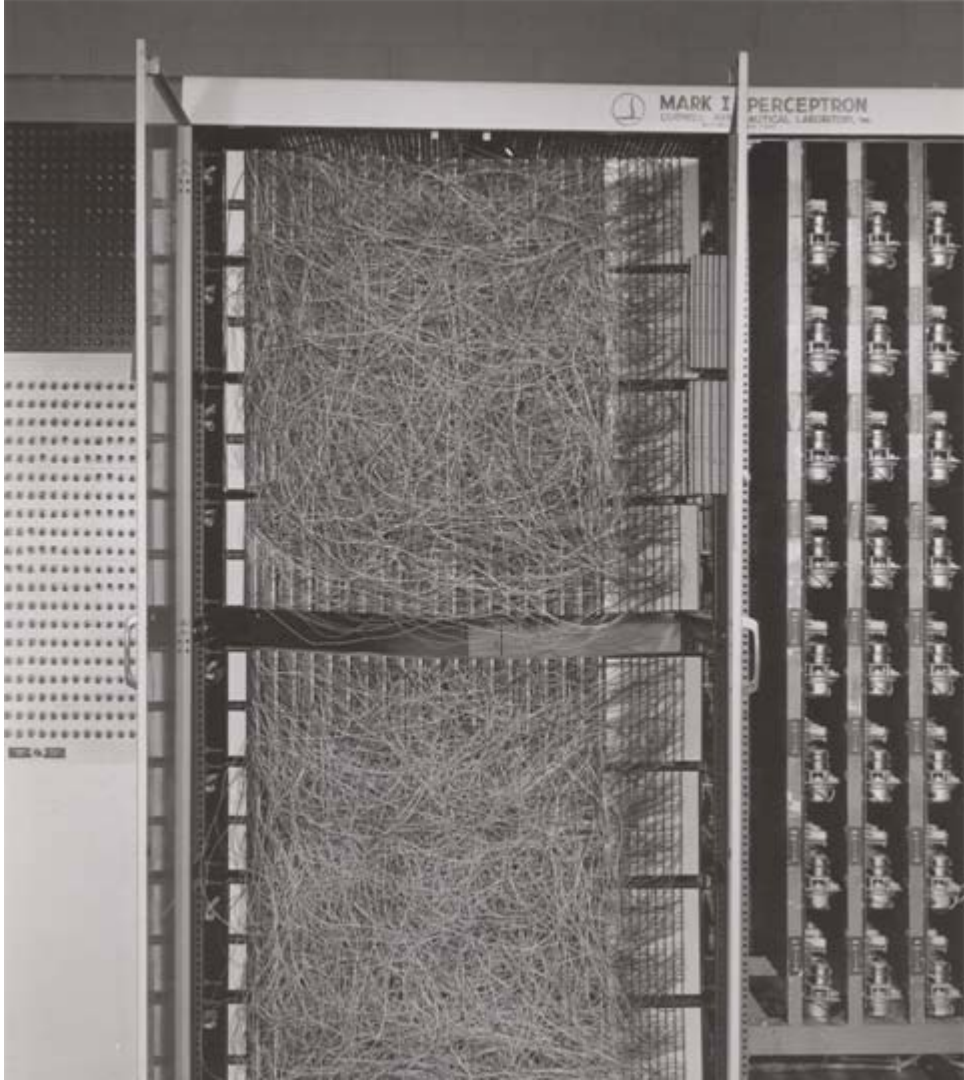
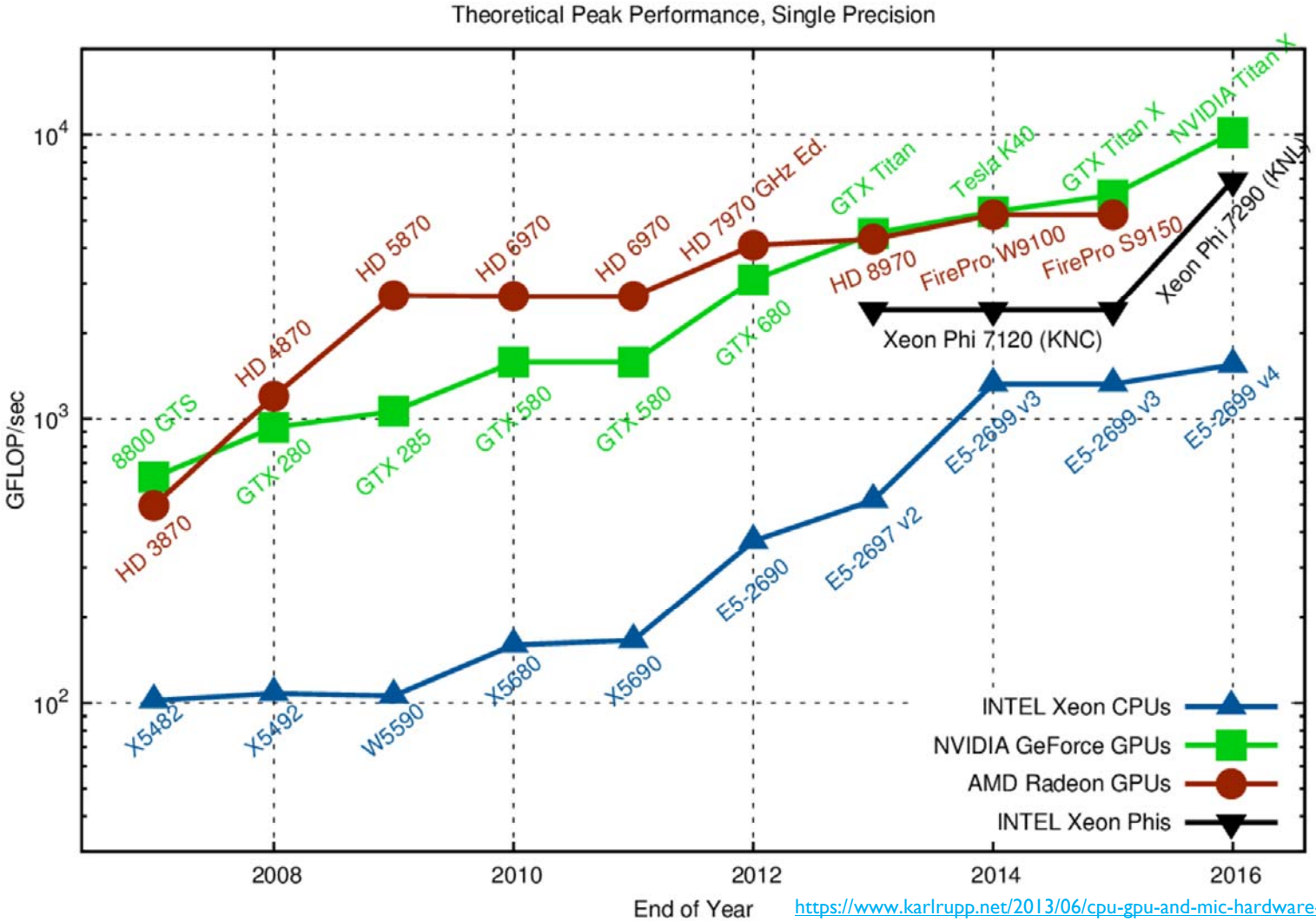

Neural Network
• Infinitely flexible function
Gradient Descent
• All-purpose parameter fitting
GPUs
• Fast and scalable

MARK I PERCEPTRON AT THE CORNELL AERONAUTICAL LABORATORY (1957)





GTX 1080ti: $730

E5-2699: $4115

https://www.karlrupp.net/2013/06/cpu-gpu-and-mic-hardware-characteristics-over-time/

“the team decided to enter the contest at the last minute and designed its software with *no specific knowledge* about how the molecules bind to their targets... working with a relatively *small set of data*”

Keith Penner

student team led by the computer cientist Geoffrey E. Hinton used deep- arning technology to design software.

The technology, called de
to use in services like App
which is based on Nuance
recognition service, and i
machine vision to identify

But what is new in recent
accuracy of deep-learning
neural networks or just “r
to the neural connections

“There has been a number of stunning new results with deep-learning methods,” said Yann LeCun, a computer scientist at New York University who did pioneering research in handwriting recognition at Bell Laboratories. “The kind of jump we are seeing in the accuracy of these

www.nytimes.com/2012/11/24/science/scientists-see-advances-in-deep-learning-

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The New York Times

Science

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ENVIRONMENT | SPACE & COSMOS

Scientists See Promise in Deep-Learning Programs

Deep Learning Framework for Recognition of Cattle using Muzzle Point Image Pattern

Article (PDF Available) *in* Measurement 116 · October 2017 *with* 68 Reads

Cite this publication

DOI: 10.1016/j.measurement.2017.10.064

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14.65 · IIIT Naya Raipur, Chhattisgarh

Amit Pandey
2.28 · Indian Institute of Technology (...

Satwik Kondamudi
2.28 · Banaras Hindu University

+ 3

Anand Mohan
20.91 · Indian Institute of Technology (...

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Abstract

Animal biometrics is a frontier area of computer vision, pattern recognition and cognitive science to plays the vital role for the registration, unique identification, and verification of livestock (cattle). The existing handcrafted texture feature extraction and appearance based feature representation techniques are unable to perform the animal recognition in the unconstrained environment. Recently deep learning approaches have achieved more a recognition of species or individual animal using visual features. In this research, we propose the deep le based approach for identification of individual cattle based on their primary muzzle point (nose pattern) i pattern characteristics to addressing the problem of missed or swapped animals and false insurance cla major contributions of the work as follows: (1) preparation of muzzle point image database, which are nc available, (2) extraction of the salient set of texture features and representation of muzzle point image of the deep learning based convolution neural network, deep belief neural network proposed approaches. The stacked denoising auto-encoder technique is applied to encode the extracted feature of muzzle point images and (3) experimental results and analysis of proposed approach. Extensive experimental results illustrate that the proposed deep learning approach outperforms state-of-the-art methods for recognition of cattle on muzzle point image database. The efficacy of the proposed deep learning approach is computed under different identification settings. With multiple test galleries, rank-1 identification accuracy of 98.99% is achieved.

Computers and Electronics in Agriculture

Volume 93, April 2013, Pages 111-120

Automatic identification of marked pigs in a pen using image pattern recognition

Mohammadamin Kashiha [a] ✉, Claudia Bahr [a] ✉, Sanne Ott [b, c] ✉, Christel P.H. Moons [b] ✉, Theo A. Niewold [c] ✉, F.O. Ödberg [b] ✉, Daniel Berckmans [a]

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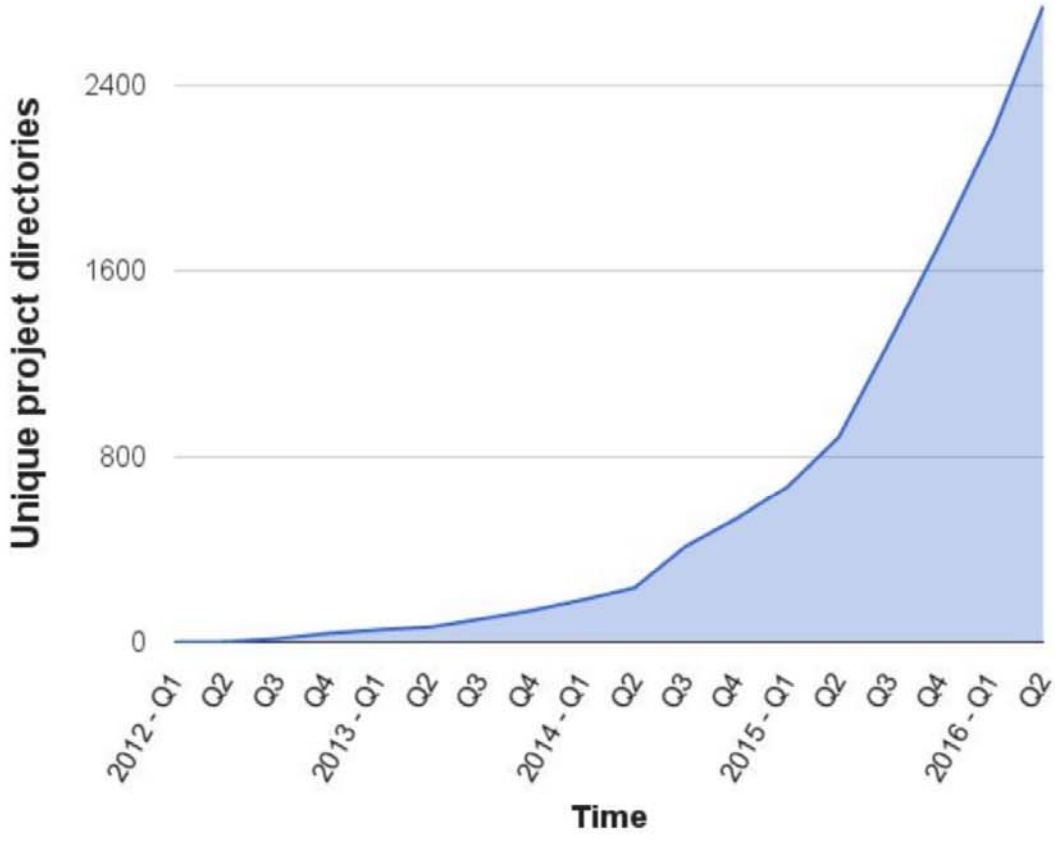
https://doi.org/10.1016/j.compag.2013.01.013 Get rights and content

Abstract

Taking visual labelling of videos by an experienced ethologist as the gold standard, pigs could be identified with an average accuracy of 88.7%. It was also shown that behaviours such

Growing Use of Deep Learning at Google

of directories containing model description files



Across many products/areas:

Android
Apps
drug discovery
Gmail
Image understanding
Maps
Natural language understanding
Photos
Robotics research
Speech
Translation
YouTube
… many others ...

MIT Technology Review

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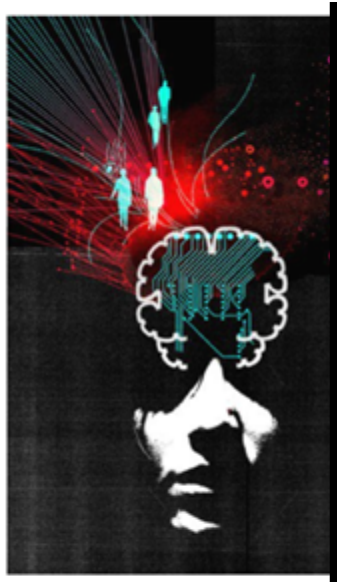
Deep Learning

With massive amounts of computational power, machines can now recognize objects and translate speech in real time. Artificial intelligence is finally getting smart.



by Robert D. Hof

When Ray Kurzweil met with Google CEO Larry Page last July, he wasn't looking for a job. A respected inventor who's become a machine-intelligence futurist, Kurzweil wanted to discuss his upcoming book *How to Create a Mind*. He told Page, who had read an

Newsweek

WHAT'S BIGGER THAN FIRE AND ELECTRICITY? ARTIFICIAL INTELLIGENCE, SAYS GOOGLE BOSS

BY ANTHONY CUTHBERTSON ON 1/22/18 AT 8:56 AM

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TECH & SCIENCE GOOGLE ARTIFICIAL INTELLIGENCE

Google CEO Sundar Pichai believes artificial intelligence could have "more profound" implications for humanity than electricity or fire, according to recent comments.

Pichai also warned that the development of artificial intelligence could pose as much risk as that of fire if its potential is not harnessed correctly.

"AI is one of the most important things humanity is working on," Pichai said in an interview with MSNBC and Recode, set to air on Friday, January 26. "It's more profound than, I don't know, electricity or fire."

The South Korean professional Go player Lee Sedol reviews the match after finishing against Google's artificial-intelligence program, AlphaGo.

Lee Jin-man / AP

How Google's AlphaGo Beat a Go World Champion

Inside a man-versus-machine showdown

DEEPMIND AI REDUCES GOOGLE DATA CENTRE COOLING BILL BY 40%

WEDNESDAY, 20TH JULY, 2016

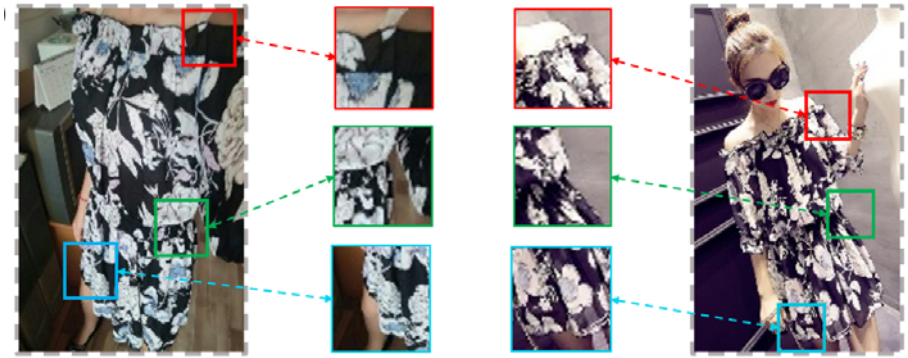
by Rich Evans, Research Engineer, DeepMind and Jim Gao, Data Centre Engineer, Google

DeepFashion: Powering Robust Clothes Recognition and Retrieval with Rich Annotations

Ziwei Liu Ping Luo Shi Qiu Xiaogang Wang Xiaoou Tang

Multimedia Laboratory, The Chinese University of Hong Kong

IEEE Conference on Computer Vision and Pattern Recognition (CVPR) 2016

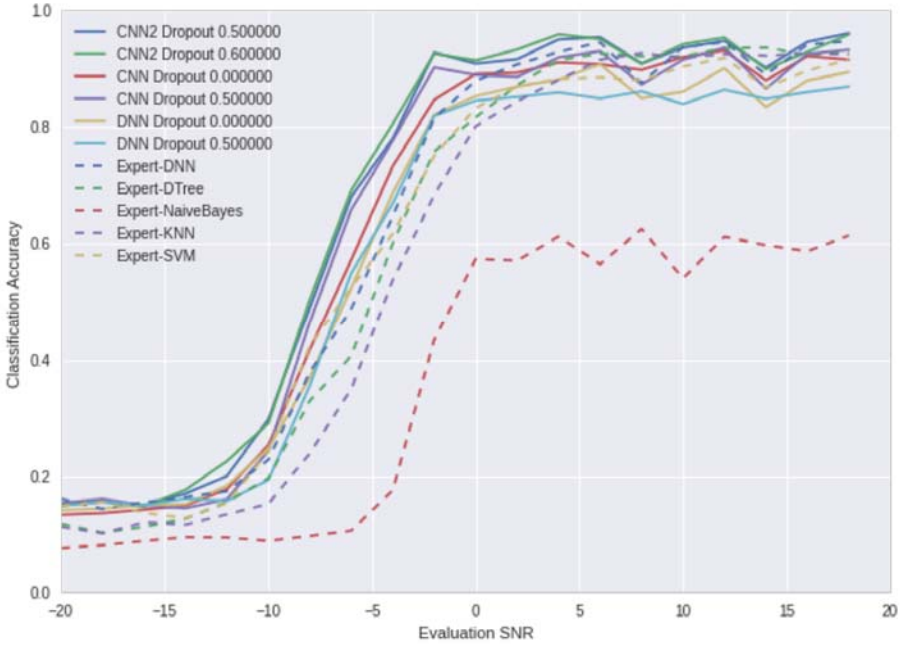


Convolutional Radio Modulation Recognition Networks

Timothy J. O'Shea[1], Johnathan Corgan[2], and T. Charles Clancy[1]

[1] Bradley Department of Electrical and Computer Engineering, Virginia Tech, 900 N Glebe Road, Arlington, VA 22203 USA oshea@vt.edu
[2] Corgan Labs, 6081 Meridian Ave., Suite 70-111, San Jose, CA 95120 johnathan@corganlabs.com

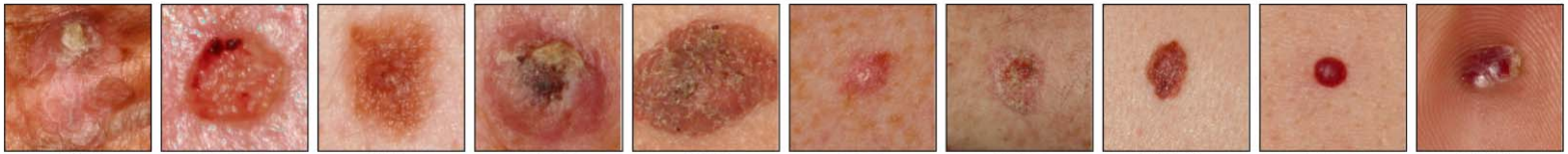
At low-SNR the best CNN model is outperforming expert feature based systems by 2.5-5dB of SNR...
This is a significant performance improvement, and one that could potentially **at least double effective coverage area of a sensing system**

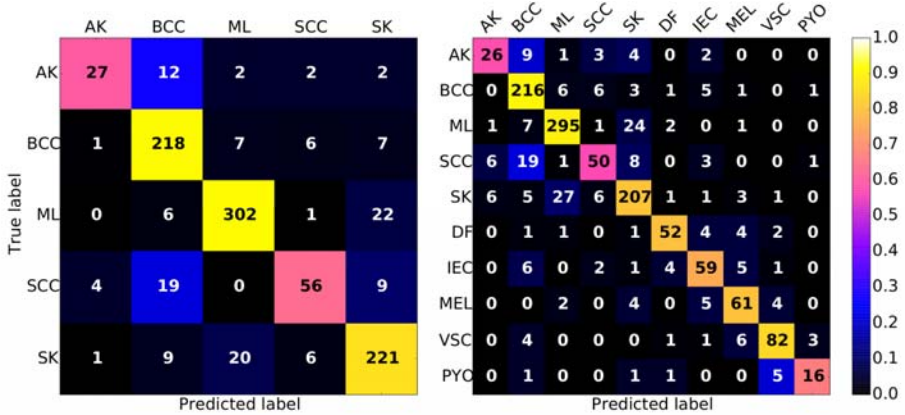


Deep Features to Classify Skin Lesions

Jeremy Kawahara, Aïcha BenTaieb, and Ghassan Hamarneh

Medical Image Analysis Lab, School of Computing Science, Simon Fraser University, Canada





lesion seg.	10-class = 67%
per-image-mean	10-class = **81.8%**

"These experiments indicate that deep features do generalize well to these skin images and outperform competing approaches [4, 5], *despite our approach not using (nor requiring) any lesion segmentations*…. previous work reported **15.6% accuracy** for [Actinic Keratosis] where here we improve it to **60%**"

Massively Multitask Networks for Drug Discovery

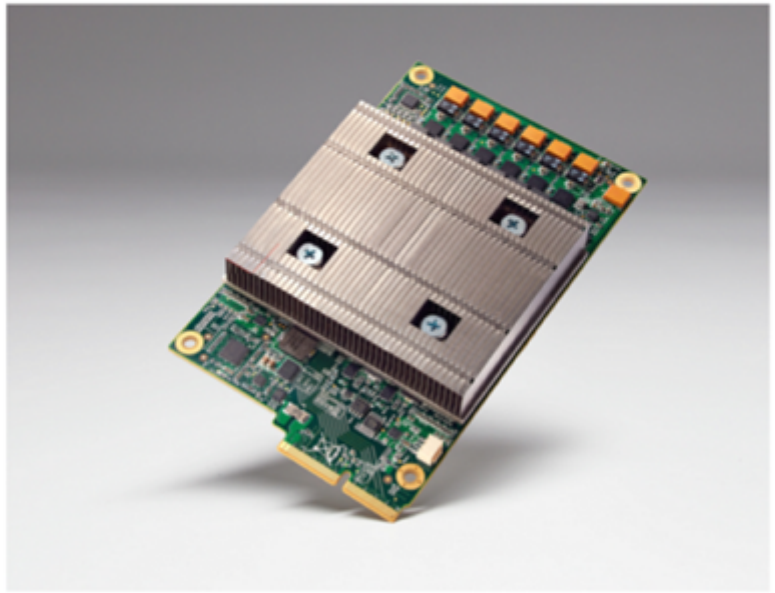
Bharath Ramsundar[*,†,◦] RBHARATH@STANFORD.EDU
Steven Kearnes[*,†] KEARNES@STANFORD.EDU
Patrick Riley[◦] PFR@GOOGLE.COM
Dale Webster[◦] DRW@GOOGLE.COM
David Konerding[◦] DEK@GOOGLE.COM
Vijay Pande[†] PANDE@STANFORD.EDU

Model	PCBA ($n = 128$)	MUV ($n = 17$)	Tox21 ($n = 12$)	Sign Test CI
Logistic Regression (LR)	.801	.752	.738	[.04, .13]
Random Forest (RF)	.800	.774	.790	[.06, .16]
Single-Task Neural Net (STNN)	.795	.732	.714	[.04, .12]
Pyramidal (2000, 100) STNN (PSTNN)	.809	.745	.740	[.06, .16]
Max{LR, RF, STNN, PSTNN}	.824	.781	.790	[.12, .24]
1-Hidden (1200) Layer Multitask Neural Net (MTNN)	.842	.797	.785	[.08, .18]
Pyramidal (2000, 100) Multitask Neural Net (PMTNN)	**.873**	**.841**	**.818**	

Home / Google IO

Google's Tensor Processing Unit could advance Moore's Law 7 years into the future

Google unveils a custom chip, which it says advances computing performance by three generations.



Credit: Google

3 COMMENTS

THE WALL STREET JOURNAL.

Google Pushes Into Machine Learning

What if Facebook Had an Opposing-Viewpoints Button?

The Polaroid-Style Instant Camera Is Back

TECH

Google Isn't Playing Games With New Chip

Built in secret, Tensor Processing Unit has strategic role in speeding up artificial intelli

Google CEO Sundar Pichai speaks Wednesday at the company's annual developers

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enlitic

HOME HEALTHCARE TECHNOLOGY BLOG ABOUT US CAREERS

HELPING PHYSICIANS HELP PATIENTS

A modern machine learning company
dedicated to revolutionizing diagnostic healthcare

Welcome To Enlitic

Enlitic uses recent advances in machine learning to make medical diagnostics faster, more accurate, and more accessible. The company's mission is to provide the tools that allow physicians to fully utilize the vast stores of medical data collected today, regardless of what form they are in - such as medical images, doctors' notes, and structured lab tests. To realize this vision, we are building on state-of-the-art deep learning algorithms and partnering with top research hospitals and medical device manufacturers.

> *"Medical diagnostics is, at its heart, a data problem - turning images, lab tests, patient histories, and so forth into a diagnosis and proposed intervention. Recent applied machine learning breakthroughs, especially using deep learning, have shown that computers can rapidly turn large amounts of data of this kind into deep insights, and find subtle patterns. This is the biggest opportunity for positive impact using data that I've seen in my 20+ years in the field."*
>
> — Founder and CEO, Jeremy Howard

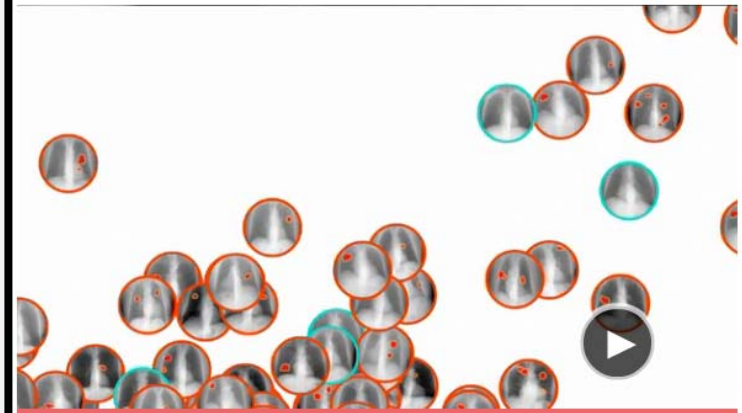
	False Positive Rate	False Negative Rate
Panel of 4 Human Radiologists	**66.3%**	**7.0%**
Enlitic Algorithm	**47.5%**	**0.0%**

CNN Money Business Markets Tech Personal Finance Small Business Luxury stock tickers

Could this computer save your life?

Recommend 399

By Jillian Eugenios @jillianeugenios



Cancer is good at hiding.

It's so good that sometimes sick patients are sent home with a clean bill of health.

And screenings don't always help: A 2013 study by Oxford University found "no evidence" that screening programs are responsible for the decline in breast cancer, and a study by the Huntsman Cancer Institute last year found that colon cancer is missed in about 6% of colonoscopies.

A company is looking to change that margin of error by bringing a super-smart computer into the examination room.

"In one panel of scans that we looked at, when you look at the number of times that radiologists sent someone home with a clean bill of health, about 7% of the time that patient was ultimately found to have cancer," said John Zedlewski, a data scientist with Enlitic, a medical technology company.

See & Spray for cotton weeding

Now introducing intelligent weeding in cotton

Sense & Decide

Computer vision sees every plant and determines appropriate treatment for each

Massive libraries of plant images enable our machine's unparalleled ability to distinguish subtle differences between cotton plants and weeds of many species and sizes

See & Spray does not rely on spacing or color to identify weeds - it intelligently and instantaneously recognizes the difference between plants even in conditions that would challenge the human eye

"deep learning" retail

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How **Deep Learning** is Causing a 'Seismic Shift' in the **Retail** Industry

insideHPC - Feb 6, 2018

Deep learning systems can more accurately predict the item a customer wants, and in turn, could greatly improve efficiency in the online **retail** environment. What if through **deep learning** techniques **retailers** could predict future preferences and stocking needs? Waste would be minimal, and **retailers** would be only stock ...

Will Amazon Go Capture the Holy Grail of **Retail**?

Knowledge@Wharton - 1 hour ago

The app tutorial explains the concept like this: "Our checkout-free shopping experience is made possible by the same types of technologies used in self-driving cars: computer vision, sensor fusion and **deep learning**. Our Just Walk Out technology automatically detects when products are taken from or returned to the shelves ...

Amazon Go Storms the **Retail** Barricades
DMN - 3 hours ago

View all

Vision Systems Technology Revolutionizes Brick and Mortar **Retail**

ARC Viewpoints (blog) - 17 hours ago

Amazon, however, has made a breakthrough in the **retail** by opening an automated **retail** food store – Amazon Go in Seattle, Washington. Vision systems, sensor fusion, and **deep learning** are the technologies behind providing customers a cashier-less and checkout-free shopping experience. The use of vision technology, ...

Is this the end of the line for the great British queue?
The Upcoming - 12 hours ago

View all

GUEST COMMENT AI and the future of **retail**

InternetRetailing.net - 12 hours ago

The AI solution will then use this information – thanks to **deep learning** algorithms – to make predictions about future shopping behaviour and intent to influence decisions. This will allow a **retailer** to anticipate the next best step in a shopper's journey, and deliver the most relevant individualised experience. The shopper is ...

Extract! 4.0 – Textkernel launches the first fully **Deep Learning** ...

Onrec - Feb 8, 2018

From self-driving cars to automated personal assistants, **Deep Learning** has revolutionised nearly every field it has been applied to. "**Deep Learning** has transformed entire industries including automotive, healthcare, **retail** and financial services. Today, Textkernel is revolutionising the HR domain with its launch of Extract!

What 2018 holds for AI and **deep learning**

Gigabit Magazine - Technology News, Magazine and Website - Feb 8, 2018

2018 is set to be an exciting year for businesses seeking to harness the power of **deep learning** on their journey towards intelligent enterprise. .... "Facial recognition is already completely transforming security with biometric capabilities being adopted, and seeing how tech and **retail** are merging, like Amazon is with Whole ...

Global Artificial Intelligence in **Retail** Market to Achieve Growth with ...

Digital Journal - Feb 7, 2018

Technologies such as machine learning and **deep learning** could also significantly contribute toward market growth. Shoplifting and other types of thefts usually encountered with in **retail** stores need intelligent and reliable solutions to effectively deal with them. For this very purpose, most **retailers** have been predicted to use ...

"deep learning" logistics

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In search of a practical, predictive analytics

JOC.com - Feb 7, 2018

This might sound a little intimidating, especially when everyone seems to be talking about predictive analytics, yet using other, but related (buzz) phrases, such as machine learning, artificial intelligence, big data, data science, neural networks and **deep learning**. The reality is that recognizing these opportunities is really not ...

Technical Product Manager, Data Science

Built In Chicago - 8 hours ago

The Data Science Product Management role is a multidisciplinary role focused on partnering with internal business teams, data scientists, core engineering and external customers to define a platform strategy, and innovative ways to leverage data science and **deep learning** algos within the FourKites product portfolio.

Young Israeli scientists head to US to showcase work from medicine ...

Cleveland Jewish News - 6 hours ago

"School administrators don't want you to waste your time on **logistics**," Mandelbaum said. "They want you to ... Now pursuing a master's degree in computer science and applied mathematics, Ben Hamu is focused on geometric **deep learning**, a relatively new field with significance for artificial intelligence. She is developing ...

St. Louis Jewish ...

Deutsche Post to Deploy Test Fleet Of Fully Autonomous Delivery ...

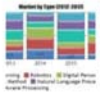
InsideEVs - Feb 7, 2018

"The development of autonomous delivery vehicles demonstrates how AI and **deep learning** are also reshaping the commercial transportation industry. As online shopping ... "Research and development of ecological, economical and efficient transportation will bring dramatic changes to the **logistics** industry. Partnering with ...

Funding Galore: Indian Startup Funding Of The Week [05-10 Feb ...

Inc42 Media - 4 hours ago

We bring to you the latest edition Funding Galore: Indian Startup Funding of the week. This week 27 Indian startups raised about $215 Mn in funding altogether and four startup acquisitions took place in the Indian startup ecosystem. (The startup funding calculations are based on the startups that disclosed funding amount.).



Artificial Intelligence (Chipsets) Market Outlook, Geographical ...

Industry Today (press release) - Feb 6, 2018

The study is segmented by Application/ end users [Transportation & **Logistics**, Metals & Mining & Construction], products type [**Deep Learning**, Robotics, Digital Personal Assistant, Querying Method, Natural Language Processing & Context Aware Processing] and various important geographies like China, Japan, South ...

The era of digital transformation

Technical Review Middle East - Feb 5, 2018

In several areas, **deep learning**, AI and the mega trends and digital transformation already is changing the digital landscape in the Middle East. ... If you look at FinTech as an industry, health care, **logistics** and transportation, there are plenty of application areas where small efficiency is brought about by technology, which ...

A Look Inside the Q4 Earnings Call from Amazon

eSellerCafe - Feb 3, 2018

AWS launched AWS DeepLens, a **deep-learning** enabled wireless video camera that pairs an HD camera developer kit with a set of sample projects to help developers learn machine learning concepts, including computer vision and **deep** ... Amazon will continue to build **logistics** capability all the way to end delivery.

"deep learning" animal husbandry

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SECURE SYNOPSIS: 31 JANUARY 2018 - INSIGHTS

www.insightsonindia.com/2018/02/03/secure-synopsis-31-january-2018/

7 days ago - The first critical step should be that the Department of **Animal Husbandry**, Dairying and Fisheries regulate to limit the non-therapeutic use of antibiotics in poultry. The department ... Advanced machine learning and **Deep Learning** techniques and tools are easily available now on open source platforms. This combined with ...

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https://github.com/hussius/deeplearning-biology 90%

deeplearning-biology

This is a list of implementations of deep learning methods to biology, originally published on Follow the Data. There is a slant towards genomics because that's the subfield that I follow most closely.

Please, contribute to this growing list, especially in categories that I haven't covered well! Also, do add your contributions to GitXiv as well if you can.

You might also want to refer to the awesome deepbio list.

Table of contents

Reviews

These are not implementations as such, but contain useful pointers.

Opportunities And Obstacles For Deep Learning In Biology And Medicine [bioRxiv preprint]

This impressive collaborative review was written completely in the open on Github. It is focused on discussing how deep learning may be able to transform patient classification and treatment as well as fundamental biological research in the future, and what the main obstacles are that could prevent it from happening. A lot of interesting points are brought up here. Together with the review listed below, which has a more technical slant, you will get a good overview of how deep learning is used and can be used in biology and medicine.

Deep learning for computational biology [open access paper]

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Deep learning for computational biology [open access paper]

This is a very nice review of deep learning applications in biology. It primarily deals with convolutional networks and explains well why and how they are used for sequence (and image) classification.

Deep learning for health informatics [open access paper]

An overview of several types of deep nets and their applications in translational bioinformatics, medical imaging, "pervasive sensing", medical data and public health.

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Welcome to fast.ai's 7 week course, ***Practical Deep Learning For Coders, Part 1****, taught by Jeremy Howard (Kaggle's #1 competitor 2 years running, and founder of Enlitic). Learn how to build state of the art models without needing graduate-level math—but also without dumbing anything down. Oh and one other thing... it's totally free!*

"I highly recommend this course. Jeremy is an amazing teacher"

- **Erik Brynjolfsson:** Professor at MIT Sloan; Author of *The Second Machine Age*