Bringing Imaging-Based Artificial Intelligence into Clinical Practice in NHS Radiology

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Declarations:

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Aims of the Session

Explore barriers – real and perceived – which limited the use of AI in clinical practice in the NHS.

- **Consider:**
  - Disconnects between AI in the lab & clinical deployment
  - How we overcame these based on our lived experience

AI in Radiology - Definitions

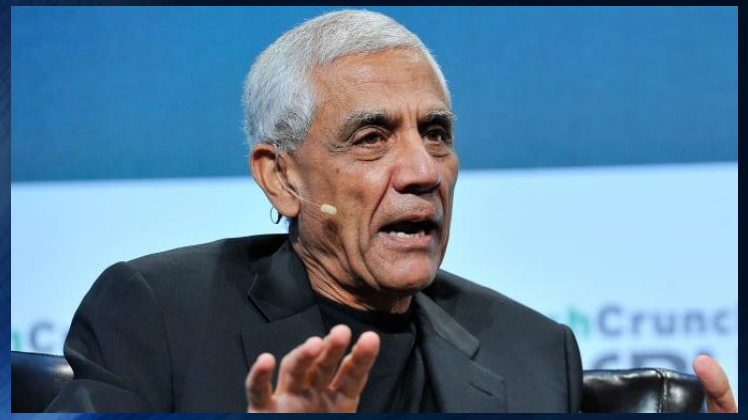
What do we mean by 'AI'

- Artificial Intelligence
  - Artificial Narrow Intelligence
  - Artificial General Intelligence
  - Artificial Super Intelligence
- Machine Learning
- Deep Learning
- Natural Language Processing
- Neural Networks
- Blah Blah Blah

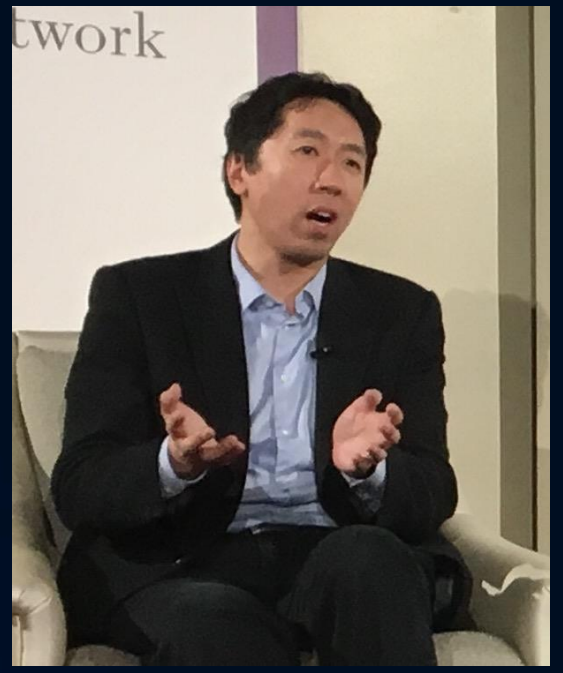
AI in Radiology – The Claims

"quite obvious that we should stop training radiologists" Geoffrey Hinton Nov 2016

"The role of the radiologist will be obsolete in five years," Vinod Khosla Apr 2017



"radiologists should be worried about their jobs". Andrew Ng Nov 2017



AI in Radiology – The Headlines

Global AI Survey: AI proves its worth, but few scale impact

November 22, 2019 | Survey

Most companies report measurable benefits from AI where it has been deployed; however, much work remains to scale impact, manage risks, and retrain the workforce. A group of high performers shows the way.

CheXNet: Radiologist-Level Pneumonia Detection on Chest X-Rays with Deep Learning

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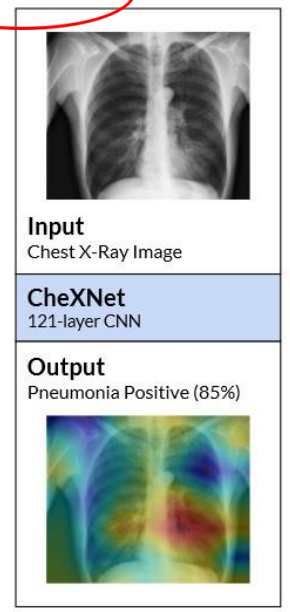

Figure 1. CheXNet is a 121-layer convolutional neural network that takes a chest X-ray image as input, and outputs the probability of a pathology. On this example, CheXnet correctly detects pneumonia and also localizes areas in the image most indicative of the pathology.

1. Introduction

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AI in Radiology – The Scale

In Literature:

- Life science papers about AI/ML: 596 in 2010 to **12,422** in 2019 [1]

Exhibiting 2019:

- The RSNA app listed 176 companies under the AI/ML category
- The AI Showcase had 136 companies

[1] **The state of artificial intelligence-based FDA-approved medical devices and algorithms: an online database**

https://www.nature.com/articles/s41746-020-00324-0

AI in Radiology – The Scale

Regulatory Approval

- **Europe (CE Mark):**
  - 60 Companies with 136 Products [2]

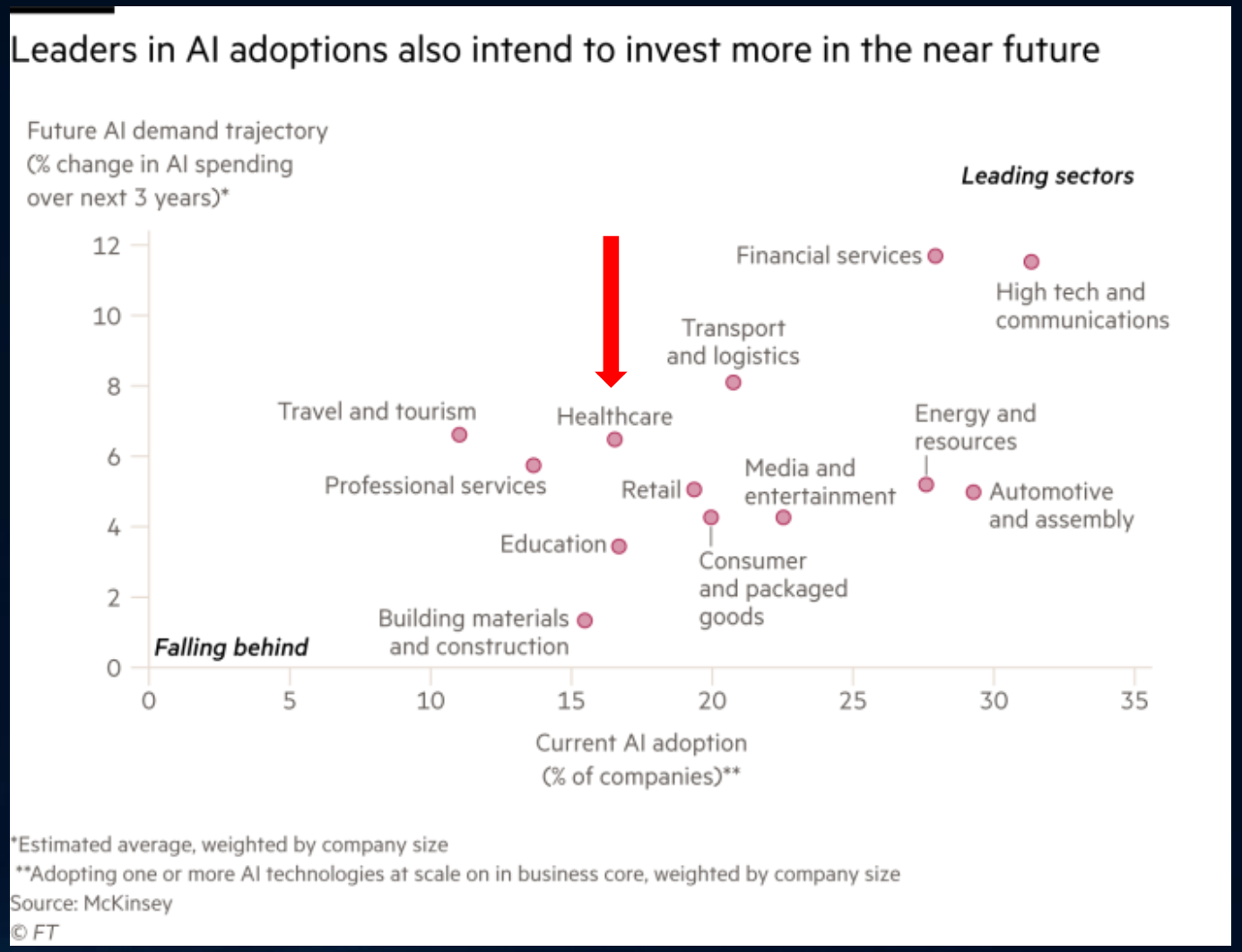
- **USA (FDA):**
  - FDA Clearance: 78 Algorithms [3]
  - FDA Approval: 36 Algorithms [4]

[2] AI For Radiology
https://grand-challenge.org/aiforradiology/about/

[3] **FDA Cleared AI Algorithms – ACR List**
https://www.acrdsi.org/DSI-Services/FDA-Cleared-AI-Algorithms

[4] **Medical Futurist: FDA-approved A.I.-based algorithms**
https://medicalfuturist.com/fda-approved-ai-based-algorithms/

AI in Radiology – The Scope



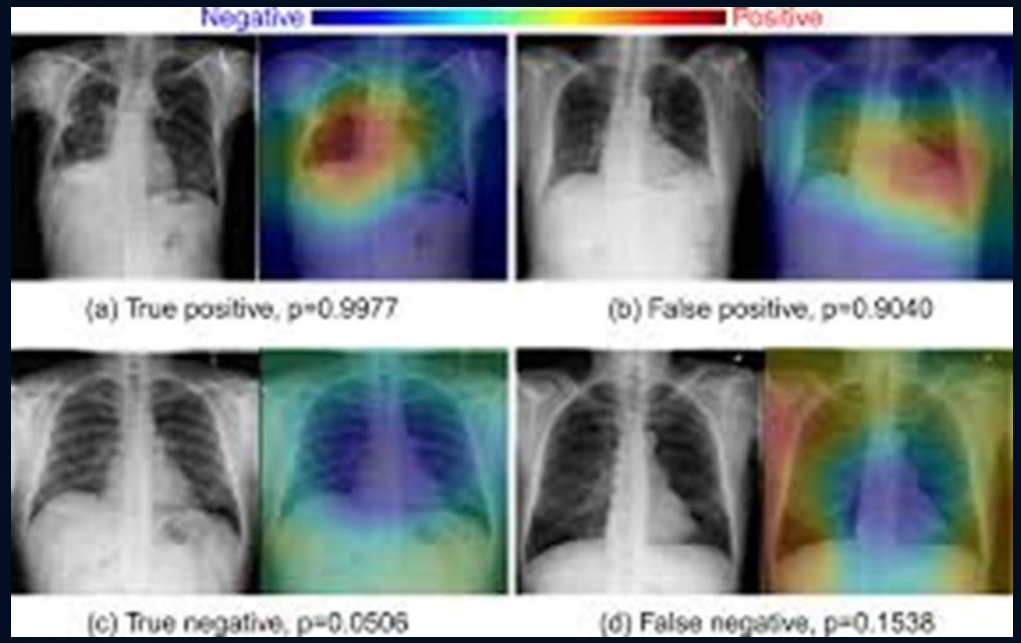
The impact of AI on business and society

https://www.ft.com/content/e082b01d-fbd6-4ea5-a0d2-05bc5ad7176c

AI in Radiology – The Scope

Pitching to VCs for Funding so visual impact & Hype is important

AI in Radiology – The Scope



Pitching to VCs for Funding so visual impact & Hype is important

AI in Radiology – The Perception

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AI in Radiology – Hype is Dangerous

AI Camera Mistakes Linesman's Bald Head For The Ball In Inverness Game

JOSH LAWLESS in FOOTBALL
Last updated 15:02, Friday 30 October 2020 GMT

Scottish football continues to be the gift that keeps on giving - the latest incredible story being that a camera mistook the ball for the linesman's bald head.

In a bizarre incident at a football game in Scotland, an **artificial intelligence** (**AI**) camera continuously tracked a **bald** referee mistaking it for the **ball**. … The commentator had to repeatedly apologise as the camera kept on mistaking the **ball** for the linesman's **head**.

AI in Radiology – The Perception

- Unfortunately that is the depth of knowledge of Radiology for some AI Start-ups:
- “Radiographers take pictures; Radiologists sit in dark rooms and look at pictures”
- This is why it is important to have expert engagement.

Perception – Trust is an issue

Patient Safety Assurance

- Technology failures can directly lead to patient harm
- New Types of Tech – New types of failures…

Perception – Trust is an issue

How do you assess/argue safety?

- Right questions?
- Evidence?
- Concerns to mitigate?

Dealt with by ML QA Models…BUT

- Human Factors…

Perception – Trust is an issue

- Difficult to represent clinical setting in computational models during design

- Gap between clinical advice & what happens to patient at bedside (external variations eg nursing/human input)

THEREFORE: Burden of proof needs to be higher

Mistakes could be fatal

AI in Radiology – Not So Easy…

The Nuances Of Developing AI For Medical Imaging

- Machine learning has shown significant improvement in healthcare.
- Researchers have developed models that can diagnose critical conditions like diabetic eye disease or metastatic breast cancer.
- The computer vision has been even tried for AR assisted surgeries.

But why don't we see more AI in healthcare?

- Challenges are plaguing the ML community.
- Building algorithms is not straightforward.

[5] https://analyticsindiamag.com/nuances-developing-ai-medical-imaging/

Requirements for algorithm development

- Defined clinical question/unmet need
- Proposed features/vectors
- Dataset – training, validation and testing
- Outcome metric/analysis

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AI in Radiology – The Scope

Majority of products in this narrow focus

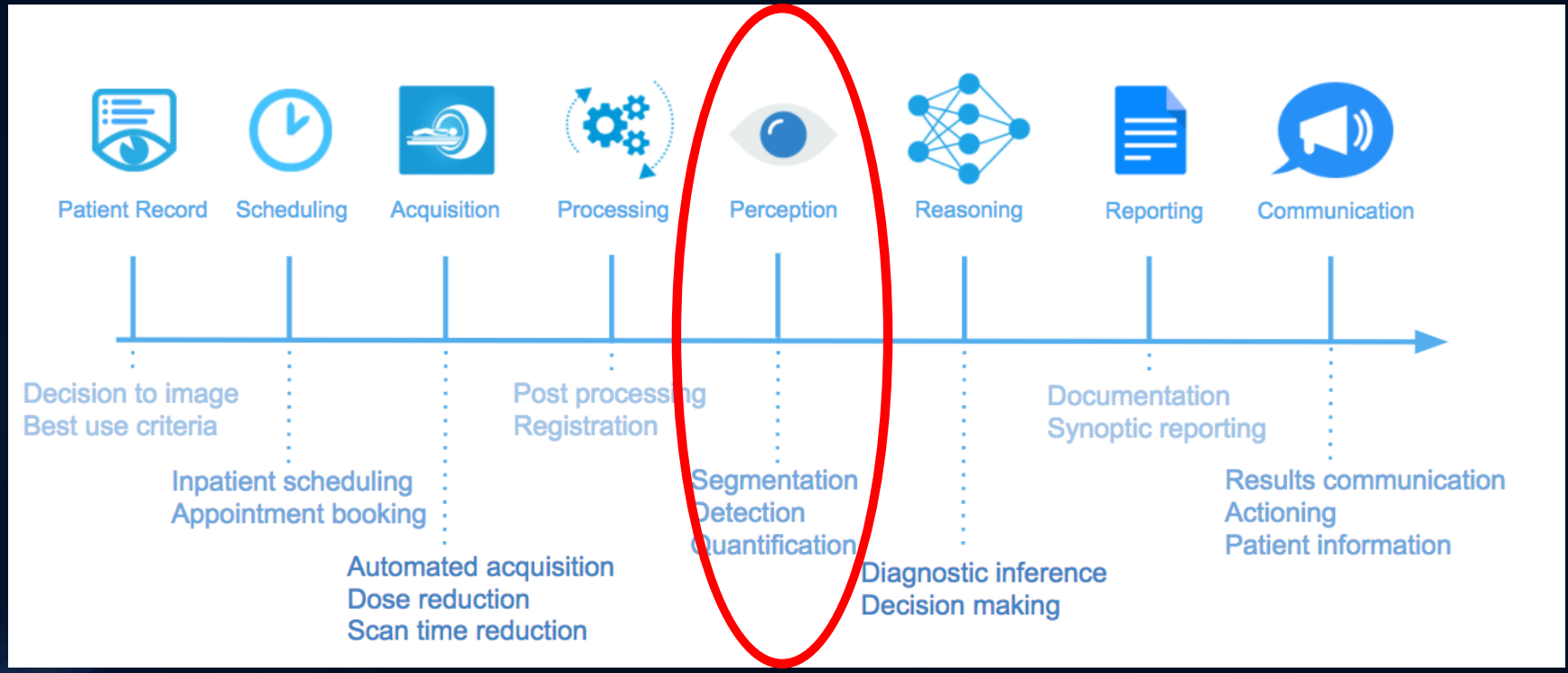

Image courtesy of Dr Hugh Harvey

Still chasing the "wow-factor" vs "most useful" (Boring AI is Good AI ☺)

Defined clinical question

- Number of AI companies aggregating a batch of narrow-focus tools
  - Identify lung nodules on CT
  - Identify Bleeds on CT Brain
  - Identify pathology on Chest X-rays:
    - Pneumothorax
    - Pneumonia
    - Lines/tubes placement
- Limited integration with overall Radiologist workflow
  - Even fewer capable of direct integration with the reports
  - Actual Benefits (beyond the hype)?

Defined clinical question

Pitched/Marketed to…

AI to replace Radiologists

The Radiologists they claim to replace

AI in Radiology – The Perception

AI in Radiology – The Perception

Defined clinical question

REFRAME THE VALUE PROPOSITION!

- Identify pathology on Chest X-rays:
- On Scanner Image Detection
  - Critical findings for urgent care (ER setting)
  - "Normal"detection (automated reporting?) – expedited discharge
  - Detection of lines and drains placement (ICU setting)

AI for the benefit of **CLINICIANS** not radiologists

Defined clinical question

REFRAME THE VALUE PROPOSITION!

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AKA – USE CASE IS VITALLY IMPORTANT

Requirements for algorithm development

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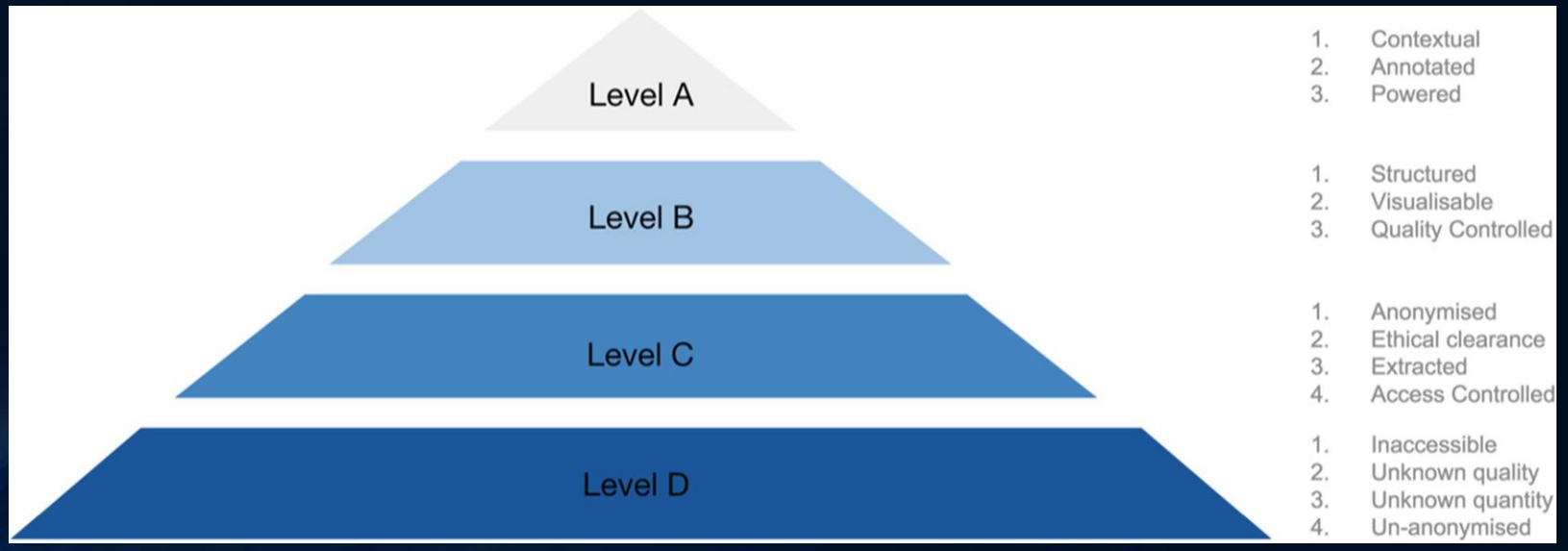
Requirements for algorithm development

Data is key

- MIDaR scale of data quality
  - Structured vs. unstructured
  - Clinical data linked to patient data is unusable
  - Interoperability between clinical sites



Harvey H, Glocker B. A Standardised Approach for Preparing Imaging Data for Machine Learning Tasks in Radiology. In: Ranshaert E, Morozov S, Algra PR, eds. Artificial Intelligence in Medical Imaging. Switzerland: Springer 2019:61-72

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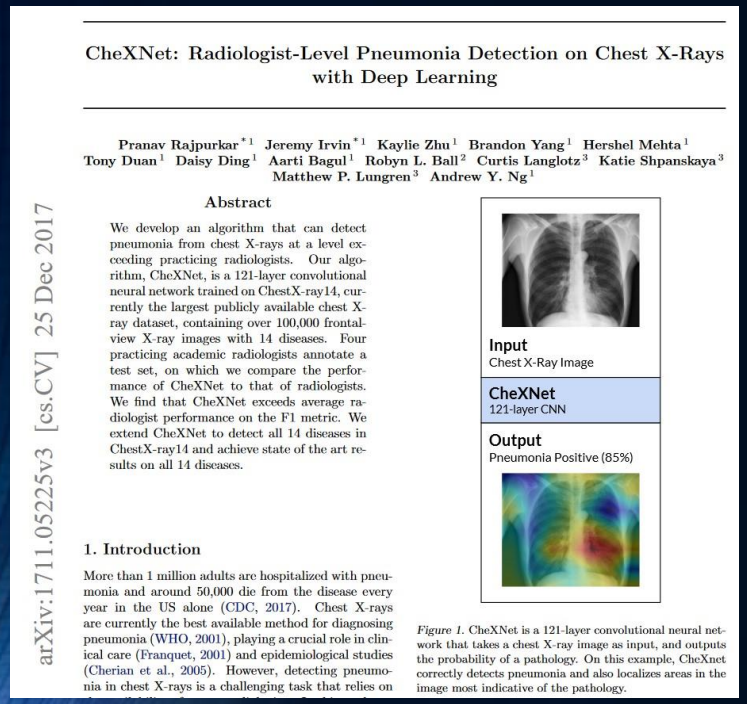

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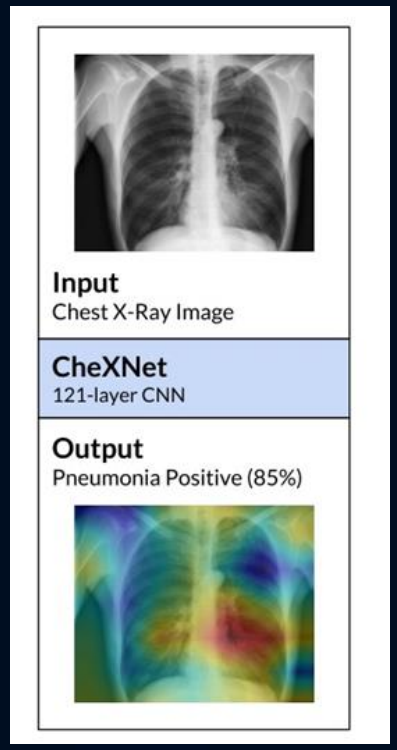
Remember this paper?

"radiologists should be worried about their jobs"

Well…



Hidden confounders:
Significant majority of mobile in-patient CXRs had pneumonia compared to controls…

Zech et al. achieved similar performance by identifying clinical site/equipment

Algorithm likely "learnt" that ***mobile CXR on inpatients had a higher probability of pneumonia***

Variable generalization performance of a deep learning model to detect pneumonia in chest radiographs: A cross-sectional study.

Zech JR, Badgeley MA, Liu M, et al. **Variable generalization performance of a deep learning model to detect pneumonia in chest radiographs: A cross-sectional study.** PLoS Med 2018;15(11):e1002683. doi: 10.1371/journal.pmed.1002683

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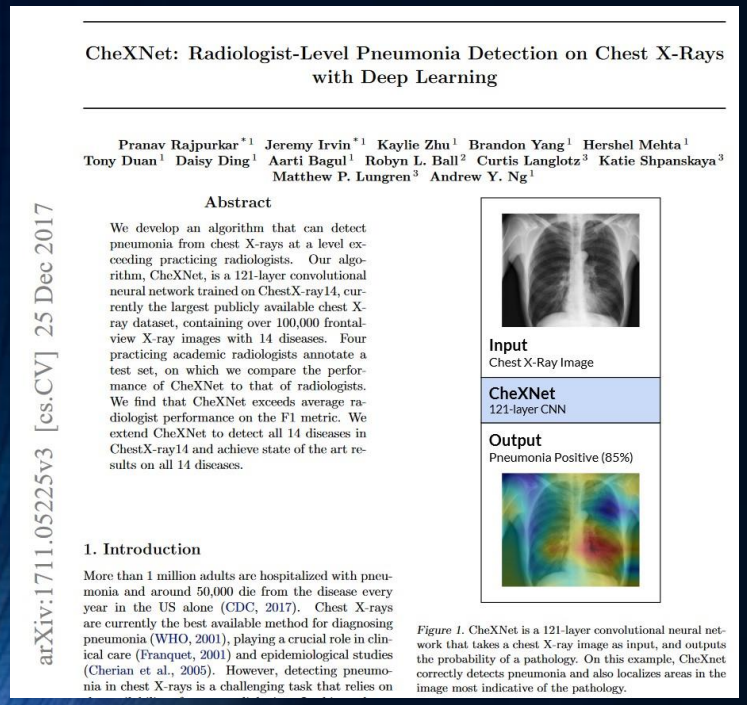

arXiv:1711.05225v3 [cs.CV] 25 Dec 2017

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Limitations:

- Trained on NIH CXR14 dataset
- CXR14 label of pneumonia = positive; remaining = negative

Classification: NIH labels inc. pneumonia, consolidation, atelectasis as separate classes – significant clinical overlap in appearances and management decisions

- CheXNet binary normal/abnormal for pneumonia ONLY
- were patents with pneumonia incorrectly classified as normal?

Other Confounders: Identifying Pneumothorax by identifying Chest Tube on CXR

Requirements for algorithm development

Low availability of high quality annotated datasets

- Poor quality data can lead to:
  - Misdiagnosis
  - Bias
- Context of Labelling is important
- Interpretability Issues

AI in Radiology – Quality of Data Is Important

Fail: IBM's "Watson for Oncology" Cancelled After $62 million and Unsafe Treatment Recommendations

No AI project captures the "moonshot" attitude of big tech companies quite like **Watson for Oncology**. In 2013, IBM partnered with The University of Texas MD Anderson Cancer Center to develop a new "Oncology Expert Advisor" system. The goal? **Nothing less than to cure cancer**.

The first line of the press release boldly declares, "MD Anderson is using the IBM Watson cognitive computing system for its mission to eradicate cancer." IBM's role was to enable clinicians to "uncover valuable insights from the cancer center's rich patient and research databases."

So, how'd that go?

> **"This product is a piece of sh–."**

In July 2018, StatNews reviewed internal IBM documents and found that IBM's Watson was making erroneous, downright dangerous cancer treatment advice.

According to StatNews, the documents (internal slide decks) largely place the blame on IBM's engineers. Evidently, they trained the software on a small number of **hypothetical** cancer patients, rather than real patient data.

Requirements for algorithm development

- Defined clinical question/unmet need
- Proposed features/vectors
- Dataset – training, validation and testing
- Outcome metric/analysis OUT OF SCOPE

AI in Radiology – Concerns at Clinical Level

DATA

- Provenance of Data:
  - Is Training Data Relevant to our Environment?
- Who owns the Data?
  - Commercial Companies benefit from NHS Data then charge to deploy in NHS
- Security of Data?
  - Cloud vs On-Prem
  - Who else might access patient data?

AI in Radiology – Concerns at Clinical Level

GOVERNANCE

- Does the AI have Regulatory Approval
  - Is Approval in line with proposed use?
- Appropriate Data Sharing Agreements?
  - No one wants to set a precedent!
- Central Guidance?
  - No one has done it before so are we doing it properly?
  - No one wants to set a precedent!

AI in Radiology – Concerns at Clinical Level

USE CASE

- Here is a solution now go find a problem for it
  - Has generally been poorly appreciated until recently
  - Wrong groups targeted BUT how to find/access right audience?
    - Need better communication/Collaboration

WORK FLOW

- This will slow me down

AI in Radiology – Concerns at Clinical Level

USUAL NHS ISSUES

- COST
  - Sounds Expensive and we have to pay for clinical care?
  - Value of AI still unproven: Chicken & Egg
- TIME
  - Sounds Complicated and we are busy
  - No one wants to set a precedent!

AI in Radiology – A New Hope

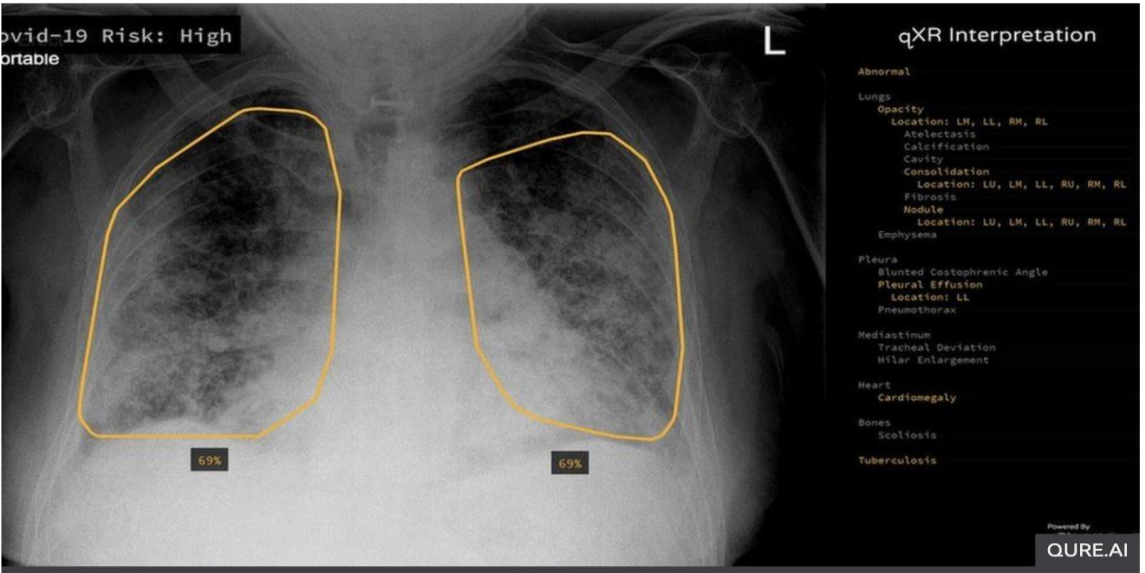
AI in Radiology – A New Hope

How COVID-19 has pushed companies over the technology tipping point—and transformed business forever - McKinsey

A new survey finds that responses to COVID-19 have speeded the adoption of digital technologies by several years—and that many of these changes could be here for the long haul.

[14] https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever?cid=soc-web

The groundbreaking way to search lungs for signs of Covid-19



Chest X-rays at the Royal Bolton Hospital are now being automatically examined by AI

However, thanks to the pandemic, a few British hospitals are now rolling out AI tools to help medical staff interpret chest X-rays more quickly. For instance, staff at the Royal Bolton Hospital, are using AI that has been **trained on more than 2.5 million** chest X-rays, including around 500 confirmed Covid-19 cases.

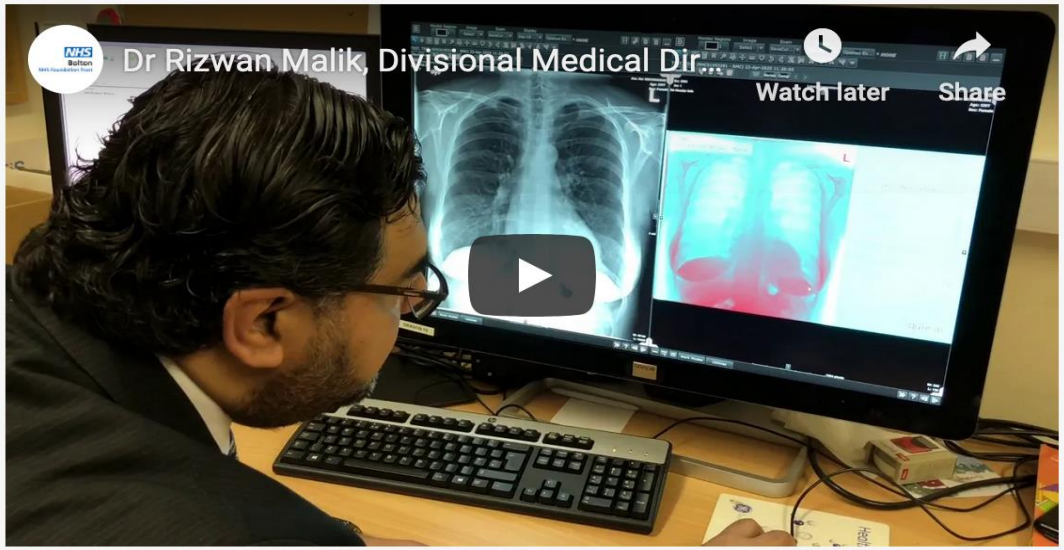
It has been running automatically on every chest X-ray the hospital has carried out for about a week, says Rizwan Malik, a radiology consultant at the hospital. This means more than 100 patients will have had X-rays analysed by the system to date, he estimates. In this case, the algorithm is designed to look for possible signs of Covid-19, such as patterns of opacity in the lungs.

"It basically gives clinicians another tool to help them make decisions - for example, which patients they'll admit, which they'll send home," says Dr Malik, who notes that patient data is processed entirely within the hospital's own network. The software itself was developed by Mumbai-based Qure.ai.

RBH joins forces with Qure.ai to use AI in fight against COVID-19

Bolton NHS Foundation Trust will be the first in the UK to use Qure.ai's technology to help medics monitor COVID-19 progression in patients.

Qure.ai a global player in artificial intelligence (AI)-driven radiology, today announced that it has deployed its advanced diagnostic software at Bolton NHS Foundation Trust, UK. The tool automates the interpretation of COVID-19 proliferation from chest X-rays, making it easier for healthcare professionals to monitor the extent and rate of progression of the viral infection.



Radiology has emerged as a key focus area in the fightback against the COVID-19 pandemic. The chest X-ray is the primary diagnostic tool, in conjunction with basic blood biomarkers. With many of the UK's NHS doctors self-isolating and with some testing turnaround times currently lagging more than 24 hours, the role played by chest X-rays becomes crucial. The Royal College of Radiology recommends the use of AI in image pre-analysis to report abnormalities and alert for emergencies.

AI in Radiology – Concerns at Clinical Level

USE CASE

- *Here is a solution now go find a problem for it*

Specific Clear Use Case & Product that Specifically Addresses

WORK FLOW

- *This will slow me down*

Deployed as CLINICAL DECISION SUPPORT with minimal impact on workflows

AI in Radiology – Concerns at Clinical Level

DATA

- *Provenance of Data:*

  Product Trained on 2.5M cases and retooled on 11k COVID cases

  Deployed around the world AND collaboration in Europe (Italy)

- Who owns the Data? **N/A**
  - Commercial Companies benefit from NHS Data then charge to deploy in NHS
- *Security of Data?*
  - *Cloud vs On-Prem:*

  On-Prem Server

  - *Who else might access patient data?*

  Protected by Trust Firewall (even provider cannot access)

  Engaged Trust CIO/CTO to Lead

AI in Radiology – Concerns at Clinical Level

GOVERNANCE

- *Does the AI have Regulatory Approval*
  - *Is Approval in line with proposed use?*

CE Class II Approved Product

- *Appropriate Data Sharing Agreements?* **N/A**
- *Central Guidance?*
  - *No one has done it before so are we doing it properly?*

Early Open Dialogue with NHSx

Established Governance models (DPIA etc)

Engage Trust Procurement & Governance Teams

AI in Radiology – Concerns at Clinical Level

- **COST**
  - *Sounds Expensive and we have to pay for clinical care?*

OFFSET: Global Pandemic - we need to provide a service! Think differently

- **TIME**
  - *Sounds Complicated and we are busy*

Already had a core group with AI interest

Comms is important for Stakeholder Group

Pandemic – Everyone wants to help

AI in Radiology – A New Hope

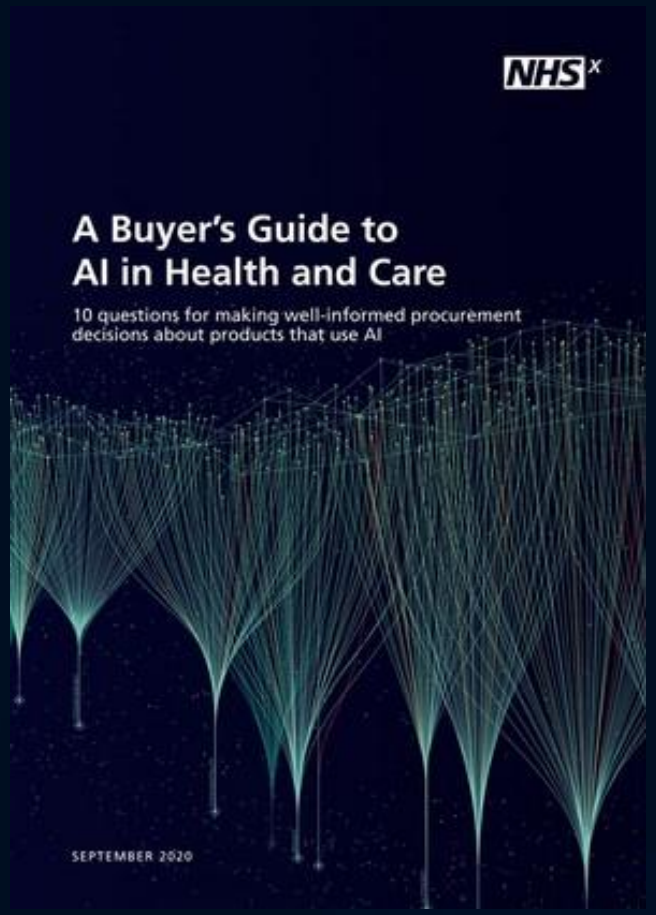
Artificial Intelligence in Health and Care Award

- Run by the Accelerated Access Collaborative (AAC) in partnership with NHSX and the National Institute for Health Research (NIHR)
- £140 million available over three years to accelerate the testing and evaluation of the most promising AI technologies which meet the strategic aims set out in the NHS Long Term Plan.

[17] https://www.england.nhs.uk/aac/what-we-do/how-can-the-aac-help-me/ai-award/

AI in Radiology – A New Hope

NHSx AI Buyers Guide



[18] https://www.nhsx.nhs.uk/ai-lab/explore-all-resources/adopt-ai/a-buyers-guide-to-ai-in-health-and-care/

AI in Radiology – A New Hope

RCR: Integrating AI with radiology reporting workflow

Clinical Radiology
The Royal College of Radiologists

Integrating artificial intelligence (AI) with the radiology reporting workflow (RIS and PACS): Guidance on implementation of AI brought in during the COVID-19 pandemic

Standards

1. AI must be integrated in the reporting (radiology information systems [RIS] and picture archiving and communication systems [PACS]) workflow in such a way that it does not add extra burden to radiologists.
2. The accuracy (sensitivity and specificity) of the AI algorithm must be clearly displayed for radiologists and others making decisions on patient management.
3. AI findings must be communicated to RIS using existing, widely used, global technical standards (HL7).
4. AI findings must be communicated to PACS using existing, widely used, global technical standards (DICOM).
5. The workflow must be robust enough to ensure AI analysis must be complete and available on PACS, before a human reporter starts image interpretation.

Aims of the Session

Explore barriers – real and perceived – which limited the use of AI in clinical practice in the NHS.

- **Consider:**
  - Disconnects between AI in the lab & clinical deployment
  - How we overcame these based on our lived experience

Aims of the Session

Explore barriers – real and perceived – which limited the use of AI in clinical practice in the NHS.

- **Consider:**
  - ***Disconnects between AI in the lab & clinical deployment***
    - Based on lab-centric understanding of AI capability
    - Complexities of real-world implementation had been underappreciated

Aims of the Session

Explore barriers – real and perceived – which limited the use of AI in clinical practice in the NHS.

- **Consider:**
  - ***How we overcame these based on our lived experience***
  - Specific use-case for defined clinical problem
  - Governance
    - No data moves
    - Regulatory compliance
  - Wide buy-in of stakeholders

SUMMARY

(Autonomous) AI to replace Radiologists

AI as Support Tool to Improve Quality & Efficiency

Any Questions?

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HTN AWARDS 2020 WINNER

AI Champions Awards
AIMed Best Covid-19 AI solution
Royal Bolton Hospital
Winner
NHS Bolton NHS Foundation Trust