Medical Applications of Artificial Intelligence: Lessons from Dermatology

Roberto Novoa, MD
Departments of Dermatology and Pathology
Stanford University
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• No relevant disclosures
Objectives

• Discuss applications of artificial intelligence within dermatology
• Highlight challenges and pitfalls to effective and equitable application of AI
This is AI

dermatologists are
  useless
dermatologists are not real doctors
dermatologists are stupid
dermatologists are greedy
dermatologists are horrible
dermatologists are hot
are dermatologists covered by health insurance
are dermatologists expensive
are dermatologists covered by ohip
are dermatologists covered by insurance
This is AI

Google

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This is AI
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https://thispersondoesnotexist.com
Classified as
1st: Epidermal tumor malignant (2.28)
2nd: Pigmented lesion malignant (1.52)
Please snap another image.
Early artificial intelligence

- Teaching a computer to analyze the world
- Decades old → 1956
- Top-down
Early artificial intelligence

- Incredibly fragile
- Would not be able to read “3”
Early artificial intelligence

• Bottom-up
  – Observe the world and its rules, learn from there
  – Out of favor for years
1960s: Neural Networks

- Math equations modeled on human neurons
- Inputs
- If > threshold, “fires”
Advances in AI

• Breakthroughs in artificial intelligence over past 9 years

• Convolutional neural networks + large databases + processing power = **deep learning**

Krizhevsky, Sutskever, Hinton et al. 2012
AI and Dermatology

- 30+ years
- “Handcrafted features” (ex. ABCDEs)
  - Labor-intensive
  - Fragile
Expert systems in dermatology: the computer potential. The example of facial tumour diagnosis.

Finlay AY, Hammond P.

Abstract
The expert system approach to computer diagnosis uses a non-algorithmic method to represent and manipulate an expert's knowledge and reasoning. This information, which may be provided by a dermatologist, is represented by rules in a logic-based computer language in order to provide interactive and explanatory features. The major advantages of using expert system techniques for computer-aided diagnosis in dermatology are that knowledge is made explicit, the heuristic nature of an expert's knowledge can be more easily captured and the more easily readable programs make modification easier. In the example described, the differential diagnosis of nine facial skin tumours was considered. The program, using the language 'micro-PROLOG' in an expert system shell 'APES', consists of 'rules' and 'facts' which define a relationship between patient and symptom, symptom and disease or disease and therapy. The 'strength' of each relationship is defined and 'key symptoms' identified. The system finally offers a diagnosis, an estimate of certainty and simple management advice.

PMID: 3539654
Esteva et al (2017) methods:

- 129,000+ image dataset
  - Internet+Stanford images
  - Variety of labels
- Biopsy-proven databases
- Visual taxonomy
Methods

Esteva et al, 2017


Esteva et al, 2017
Increasing the dataset
Results: Biopsy vs Reassure

Carcinoma: 135 Images

Melanoma: 130 Images

Melanoma: 111 Dermoscopy Images

Esteva et al, 2017
Advances in Derm AI

- Demonstrated excellent performance by CNNs
- Compared different levels of expertise
- Provided clinical information

Man against machine: diagnostic performance of a deep learning convolutional neural network for dermoscopic melanoma recognition in comparison to 58 dermatologists

Haenssle HA et al, 2018
Advances in Derm AI

- Released dataset
- Differential performance based on dataset/skin type
- https://modelderm.com
Human+AI: 2020

- Online *in-silico* evaluation of lesions
- More improvement for novices
- Performed best with showing classes and probabilities
- Confidence and experts
- Faulty AI misled all participants
Advances in Derm AI: 2021

- Google released public facing app for skin conditions
- Significant challenges
  - Representation?
  - Positive predictive value?
Derm Challenges: Absence of Datasets

- Deep learning is **data hungry**
- Giant derm datasets lacking
- Many systems don’t talk to one another
Solutions: Open source databases

- Publicly available
- Standards around images?
- What kinds of images?
- Data collection

ISIC dataset
Challenge: Proper Assessment

- In-silico vs In-vivo
- Parameters (picture quality, lighting, focus, camera type)
- Does it improve care?
- How does it work with clinicians?
Derm Challenges: The Gold Standard (?)

• Histopathology is traditional gold standard
• Elmore et al (BMJ, 2017)
  – Intraobserver agreement of 67% for melanocytic neoplasms (35% for moderate atypia, 63% for melanomas)
• 187 pathologists, 240 lesions
Pop Quiz

- 52 yo male from Argentina
- No prior history of skin cancer
ModelDerm in action

[beta] Please check focus and composition:
Low (0.00); Nonspecific skin lesion

Melanoma: Probably Not;
Observation and follow-up (1,2)

Malignancy prediction: Low (1.0)
q0.00 0.93
0.07mi 0.0M 0.0N 15; v 20180623

MANUAL CROP

Screenshot Close
Under the microscope:
Challenge: Is this melanoma?
Are we over-diagnosing melanoma?

- Rapid increase in melanoma over past 5 decades
Solutions?

- Molecular data
- Multi-pathologist concordance
- AI?
- Clinical outcomes
Challenge: Would this have become a life-threatening tumor?

- Analogies: thyroid cancer, prostate cancer
- Will we detect life-threatening tumors?
- Will mortality decrease?
Challenges: low prevalence $\rightarrow$ low positive predictive value

- 90% specificity, 2% prevalence $\rightarrow$ **16% PPV**

<table>
<thead>
<tr>
<th></th>
<th>Melanoma</th>
<th>Melanocytic nevus</th>
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<tbody>
<tr>
<td><strong>Algorithm positive</strong></td>
<td>19</td>
<td>98</td>
</tr>
<tr>
<td><strong>Algorithm negative</strong></td>
<td>1</td>
<td>882</td>
</tr>
</tbody>
</table>
Solutions: high risk population
Solutions: Better imaging modalities

Delpueyo X et al, 2017

Sanchez G. et al, 2015

Condorelli AG et al, 2021
General challenges in AI: Bias and Confounding

• Factors that lead to systematically incorrect answers
• Present in:
  – Initial datasets
  – Study design
  – Statistical analysis
  – Outcomes
Challenge: Bias

- Example: Rulers
Pitfalls of AI: Bias and Confounding
• Winkler et al (2019) demonstrated in rigorous fashion

• Markings decreased specificity (45%)

• Cropping boosted sensitivity and specificity
Dataset bias examples: racial/ethnic composition

- Need to ensure extensive representation by varied skin types
- Extensive additional work is needed
- Companies have already encountered BIG problems here

Dataset bias examples: racial/ethnic composition

- Released dataset
- Differential performance based on dataset/skin type
- https://modelderm.com
Bias, AI, and Equity

• POC can develop skin cancer
  – Different location distribution, different appearance
• Decreased detection → advanced presentation
• Advanced presentation → Dataset bias → Algorithmic bias → Decreased detection

https://www.onlinetruesformer-beauty-queen-dayanara-torrestories.com/2020/10/
Challenge: Regulatory and Cultural Frameworks

- Different countries, different standards
- When is a test “good enough”? 
- Rapid dissemination of information technology
- Different cultural values around beneficence, avoidance of harm
- “First do no harm” vs “Move fast and break things”

Transformation: marked productivity increases

- Decrease superfluous visits
- Improve diagnosis and management
Transformation: Democratizing access

– Data collection at scale
– Diagnostics at scale
– Diminish health disparities

Bordeaux et al, 2012
Near Future

- Prospective clinical trials
- Likely focus: dermoscopy
- Tools for skin cancer experts
Long term?

- Data collection at scale
- Difficult to predict

http://www.escapistmagazine.com/forums/read/7.410037-This-is-What-The-1940s-Thought-2011-Would-Look-Like#&gid=gallery_1542&pid=1
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