Introduction

Artificial intelligence (AI) generally refers to computerised systems that can make 'good' decisions. Interest in medical AI first arose 15 years after the founding of AI research in 1956[1,2]. For comparison, the British Journal of Dermatology first came to print in 1888[3]. Increasingly, such systems are tackling complex problems historically thought to require human intelligence. Proof-of-concept successes with diagnostic AI[4–6] have fuelled dermatologists' fears of redundancy and what economists term "technological unemployment"[7,8]. This essay will discuss the current capabilities of diagnostic AI in the wider context of the dermatologist's role and whether dermatology is uniquely vulnerable to automation. External factors that may stall the adoption of technology into the field will also be highlighted.

What diagnostic AI is currently available?

The predominant diagnostic AIs are convolutional neural networks (CNNs). The predecessors to CNNs were modelled on the biological neuron as described by McCulloch and Pitts in 1943[9]. These artificial neurons sum multiple inputs and give a probabilistic output that can be used for classification tasks. Millions of these neurons organised into layers vastly improves the accuracy of classification. CNNs train on large datasets of known input-output pairs, then calculate and minimise any error. They 'evolve' the ability to recognise minute non-linear relationships that are infeasible to program. Added bias values, and the connection strength between neurons, are retrospectively adjusted to optimise output. The data flow through CNNs mimics the hierarchical progression of representation seen in the visual LGN-V1-V2-V4 ventral stream[10,11]. Accordingly, CNNs excel at image recognition. In 2012, a breakthrough CNN halved the error rate of competitors to win the ImageNet competition[12]. By 2014, the winning GoogLeNet CNN halved this again to within

2% of the estimated 5.1% human error rate[13,14]. Pre-existing CNNs are further trained on clinical image databases to hone their

accuracy with diagnostic classification.

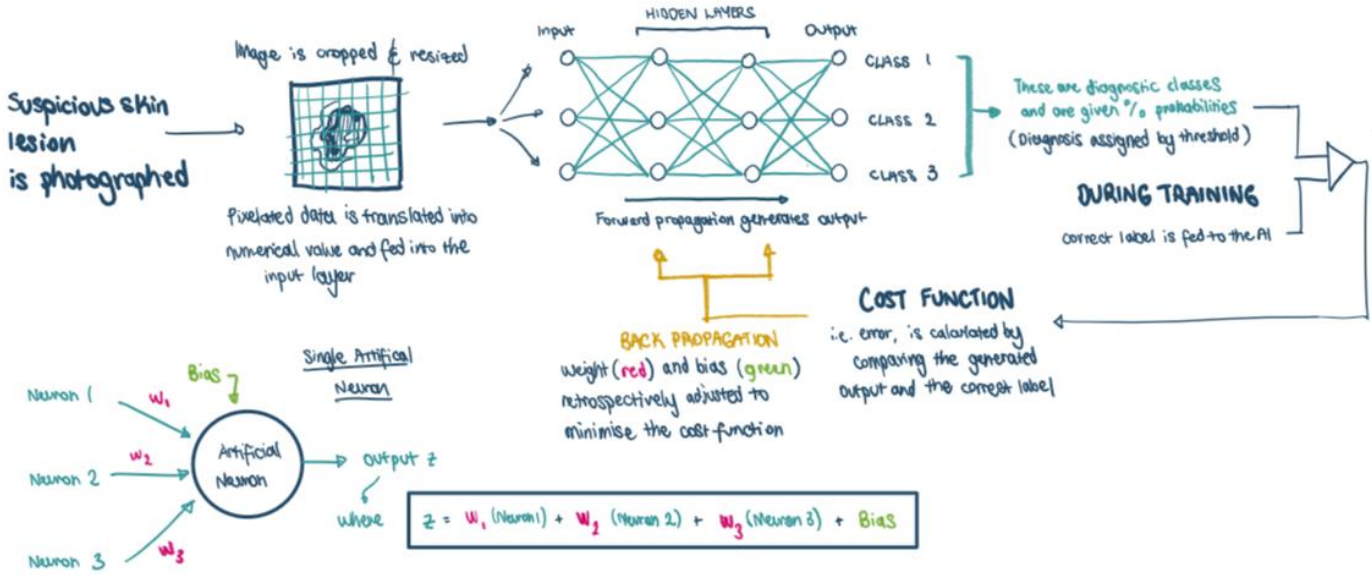

Fig.1 – Simplified overview of Neural Networks

What can diagnostic AI currently do?

Using CNNs, diagnostic AI is proficient at classifying images of skin lesions. Currently, AI is able to accurately distinguish at least 9 skin disease categories[4] and outcompetes dermatologists at specific clinical detection tasks[4–6]. The majority in a group of 21 dermatologists chose to inappropriately biopsy more false cases and falsely reassure more true cases of malignant melanoma compared to a retrained variant of the GoogLeNet CNN[4]. Dermatologists are outcompeted in trials using standard images[4] and dermoscopy[4,5] images. Regardless of whether clinical context was available, dermatologists as a whole still fall behind the accuracy of AI predictions made on dermoscopy alone[5].

There is continual development of new AI with ever greater sensitivity, specificity, and utility. Whereas a 2017 AI used hundreds-of-thousands of images[4], similar performance was

obtained with a 2018 CNN using fewer than 5,000 images and accurately classifying a greater number of skin tumour types[6].

What do dermatologists do?

Skin conditions are prevalent in the UK and affect over 50% of the population annually[15]. Dermatologists see a fraction of those who are referred from primary care. This equates to around 0.8 million patients in England and Wales[15,16].

The role of the dermatologist includes hosting specialist clinics, participating in multidisciplinary team meetings, overseeing specialist treatments, advising on hospitalised dermatological comorbidity, teaching junior staff and medical students, carrying out clinical audits, regular appraisals, and academic research[17]. Surgery makes up a third of the workload in dermatological specialist care[15,17]. The diagnosis and management of skin cancers make up 50% of GP referrals and 50% of the total dermatological workload[15,16,18].

Will AI replace dermatologists?

To completely replace dermatologists, AI would need to supersede dermatology specialists in more than just spot diagnosis. Given the wide-ranging responsibilities of the physician/surgeon dermatologist[17] this is not imminent. A 2013 report by the Oxford Martin School deemed that 47% of the US labour market was at high risk of automation. In comparison, of 700 occupations listed, the physician/surgeon was ranked 15th least likely to be automated in the near future.

Still, competition from AI either imminent or distant is almost a certainty. Modern medicine can ill-afford to overlook the improvements to patient care that machine-learning promises. In 2018, Prime Minster Theresa May launched a new initiative utilising AI to reduce cancer related deaths by 2033[19]. The data needed to train AI is more available, and wearable

technology is increasing that diverse database[20]. The ethics of data collection and storage are beyond the scope of this essay but suffice to say that while contentious it is unlikely to halt.

AI could increase demand for specialists by widening the patient population and triaging entry to dermatology services. Authors suggest using telemedicine or smartphone apps[4]; most melanomas are discovered outside of the clinic by patients and family members[21]. Primary care utilising AI as a screening tool could significantly save resources and improve detection rates. Skin conditions are the commonest new presentation to GPs[22]. 30% of subsequent referrals are at the request of the patient[16]. Triage seems an appropriate use of AI diagnosis's high confidence and narrow focus.

However, if AI diagnosis is superior, then why have dermatologists reconfirm cases an AI has triaged? With given conditions and the same visual information, AI will detect more cases and inappropriately treat fewer patients than the dermatologist, and studies suggest clinical context does not change this [5,23] This agrees with what is known about human judgement; neither absolute experience nor amount of information correlate with validated accuracy[24]. Contrary to clinicians' beliefs, their diagnostic judgement can be adequately modelled linearly, assigning value by number of symptoms[24]. AI aside, a logistical regression model outcompeted physicians diagnosing acute coronary syndrome[23]. What AI has yet to develop is reliable breadth. The slim advantage human dermatologists have is their broad understanding of skin that, metaphorically, AI has traded for diagnostic depth.

Is Dermatology uniquely vulnerable?

So far, the successes of AI have clustered around image-recognition CNNs. As such, the imaging-heavy specialities (i.e. radiology[25–27] and ophthalmology[28]) have been fruitful

testing grounds for AI. Dermatology is not far behind. Furthermore, visual diagnosis (later confirmed by biopsy) is a significant proportion of dermatologists' workload. Requests for diagnosis form between 31% and 59% of dermatology referrals[16]. With the lack of dermatological expertise in primary care[16] and a shortage in dermatologists[18] then an increasing role for AI may be welcome relief. This is poignantly topical, when referrals for and deaths from melanoma are spiking demand[16,18].

The third of dermatology comprised of surgery remains safe for now. Robotics is advancing AI-assisted microsurgery[29] into the mainstream, but there are few developments with surgical automation[29]. Whatever the reason, as one commentator said of the fully automated surgeon[30], "[for now] it can't be done."

Acceptance

Alongside demonstrations of efficacy, AI will have to be accepted by the regulator, the public, and the profession. Unforeseen legal, cultural, and political barriers could stall the current momentum behind development and cast diagnostic CNNs into a new "AI winter"[31].

The Regulator

Without industrial precedent, it is unclear how regulators will oversee medical AI[25,27,32]. Draft guidance suggests that the FDA will regulate decision-making AI as medical devices[33]. The complications of approving deep-learning systems are two-fold. First, the predictive reasoning of neural networks is notoriously difficult to analyse, though regulators have previously approved drugs with unclear mechanisms[27]. Second, regulators need to assess systems which are designed to constantly be rewritten. Commentators generally agree there will be regular re-approval of AI systems to ensure long-term safety[27,32].

The Public

Reasons why AI diagnosis is likely to be popular with patients are discussed above. This is particularly so as melanoma rates rise and as specialist dermatology services are in high demand[16]. Nevertheless, public opinion is often poor when automation is explicit. In the field of aviation, Boeing's chief technology officer referenced public perception as the main obstacle to fully automated airplanes[34].

The media will inevitably influence public perception of AI. Coverage of AI has shown a reporting bias favouring industry sources which exaggerate the potential of their products[35]. Bias also arises from political opinion, with left-leaning outlets emphasising consequences leading to technological unemployment[35].

The Profession

Dermatology has been wary but welcoming of AI. Threatened by possible automation, other specialities have not. SEDASYS was an automatous sedation system that promised to reduce complication rates for endoscopy but was seen as "an effort to replace anaesthesia services"[36]. SEDASYS was long opposed by professional groups such as the American Society of Anaesthesiologists and ultimately was withdrawn in 2016 because of "poor sales"[37]. AI like all innovations is imperfect, and a rejection by the dermatology community could impede development.

Conclusion

AI has shown proficiency with specific diagnoses, but dermatologists are needed to oversee and translate these diagnoses into holistic care. There are still technological and regulatory hurdles to overcome but indefinitely withholding the benefits of AI from patients is difficult to justify. By conceding ground to AI diagnosis, dermatologists can continue further their role and improve patient care by dedicating more time to counsel, treatment, or research. If

indeed dermatologists' days are numbered, then the count might have tumbled but is slowing. The Pandora's Box of AI has been opened but this need not spell the end of dermatologists.

Word Count: 1500

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