When the digital Doctor needs to admit "I don't know"

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Abstract

The meteoric rise of AI in general and Deep Learning in particular is generating great excitement throughout academia and commerce, and in particular in medicine[Top19, Wac15]. With some some high-profile claims [] that AI will soon replace humans in many medical specialties.

In this position paper we present an alternative view. We contrast *Artificial Intelligence* with *Intelligence Augmentation* and argue that the second is more likely to benefit the patient than the first. We provide evidence to this argument and present a vision in which easier decisions are delegated to computers, while the more difficult ones are handled by humans.

Introduction

Digital technology is causing a sea-change in all parts of the medical profession. In particular the meteoric rise of AI in general and deep learning in particular raises the possibility that doctors will be replaced computers [Muk17]. The father of deep learning, Geoff Hinton, said in 2017: "It's just completely obvious that that in ten years deep learning is going to do better than Radiologists ... They should stop training radiologists now".

Other deep learning researchers provide a more nuanced perspective. Sebastian Thrun [Muk17, EKN+17] argues that "... deep learning devices will not replace dermatologists and radiologists. They will *augment* professionals, offering the expertise and assistance".

Using computers to augment human intelligence rather replace it, is, at the same time, both heady and boring. On the heady side, consider cyborgs whose anatomy is part human, part artificial and can with equal ease solve complex equations or write poetry. On the mundane side, think of smartphones that are quickly becoming an inseparable part of our person.

The idea of using computers to augment or amplify human intelligence has a very long history. The acronyms AI (Artificial intelligence) and IA (Intelligence Amplification or Intelligence Augmentation) have both become popular in the early 1960's[Ash57, Eng62]. These days, the acronym AI is popular, while the

acronym IA is not. However, Sebastian Thrun's statement indicates that the idea of Intelligence augmentation is still on people's mind. We suggest bringing it back.

What would IA look like when applied to medicine? We argue that one important ingredient is to endow AI agents with a degree of humility. Specifically, to allow classifiers, such as DNNs, to say "I don't know".

Labels, ground truth and testing

Yoav : I think this and other technical sections should appear in a separate text box.

Roughly speaking, machine learning (ML) can be divided into *unsupervised* learning and *supervised* learning. In both, the task of the learning algorith is transform a set of *examples* into a *model*. In unsupervised learning the examples are undifferentiated raw measurements. In *supervised* learning, which is our main concern here, each example consists of an *input* and a *label*. In the work of Esteva et al [EKN+17] on classification of skin cancer the input is an image of a skin patch and the label is "benign" or "melignant".

Typically, the labels are provided by a human expert. These labels define the *ground truth* and the goal of the learning algorithm is to make predictions that diverge as little as possible from the ground truth. As discussed in the next section, ground truth is usually not available in regular medical practice. In this section we point out a problem with the ground truth use in [EKN+17].

Esteva et al [EKN+17] set out to show that ML can performs as well as or better than expert dermatologists. This meant that they needed to use for ground-truth a label that is more objective than a dermatologist. To that end they used the diagnosis of a biopsy as ground truth. There is no argument that this is a better ground truth than the opinion of a dermatologist.

The problem with this design is that under normal circumstances, patients get biopsied only if the dermatologist thinks there is a chance of melignancy. Therefor, the set of biopsied examples is biased towards melignancy. It is likely that using a classifier trained in this way on an unfiltered stream of patients will increase the number of patients unnecessarily getting a biopsy.

Uncertainty in medicine

Yoav : The different sources of uncertainty in medical diagnosis.

- **The diagnostic process of elimination**
- **Data Quality, Calibration, resolution** Discuss issue as placement of sensors, lighting when analyzing skin lesions. Sensing back for re-testing.

Hiding Uncertainty

- **Psychological reasons** Both doctor and patient prefer the projection of certitude.
- **Protocols**
- **diagnostic devices** Secrecy of the internal code limits the trustworthiness of the alarms.
- **Alarm Fatigue**

Uncertainty in Machine Learning

Yoav : In box: uncertainty versus accuracy using ROC curves

Committees, Agreement, Easy and Hard cases Our approach for distinguishing easy and hard cases.

The semantics of "I don't know" Based on conforming / contradictory experience. Not on conditional probability.

Agency and Augmentation

Yoav : Doctors need to adapt. Why would doctors prefer to adapt than to resist? What is the migration path for augmentation in medicine?

- **Computer aided diagnostics** Especially with very large data: ecg for 14 says....

  Pathology.
- **Dissemination of expertise** Computers, trained by experts, can help novices. Serves a function similar to score-cards.

  Teaching young diagnostics
- **Confidence, Trust and adoption of technology**

Summary

References

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