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The advance of technology can make the public uneasy. Although the advantages may be easy to see, it is still a strange new world, something different, something unknown. There is even more fear of the unknown in healthcare, wherein a patient's very life is placed at the mercy of technology. Leeuwenhoek's interest in microscopes and the world underneath those microscopes led to a revolution in healthcare, expanding the physician's means of sensory input to the microscopic level. But at the time such a microscopic world was very much unknown; it required a certain amount of adaptation on the part of the doctor and the patient to accept the microscope as a means for effective health care. Today, we are perhaps on the verge of, if not already in the midst of, another medical revolution: the sensory capabilities of today's doctors can be vastly enhanced through the use of computer vision technology. Going a step further, computer vision along with machine learning and artificial intelligence has the potential to not only enhance the physician's vision like the microscope, but expand his mind by enhancing his thinking process. Such technology could even reach the point where the modern idea of the physician becomes obsolete. But the question is: at what point does the computer trump the physician–at what point does society hand over the healthcare reins to the computer?

The goal of computer vision in healthcare is not to precisely replicate the human decision process–that would be a fruitless endeavor–but rather to use the advantages of the computer to form a better diagnosis. By their nature, computers operate in a fundamentally different way than humans. They have different strengths and weaknesses, and thus the use of computer vision in healthcare should attempt to exploit these strengths and minimize the effects of the weaknesses. Today, computer vision is already being used in healthcare for tasks that are repetitive, or involve processing a large amount of information–tasks that humans struggle with. The computer does much of the grunt work, and essentially acts as a valuable colleague of the doctor. The system gives the doctor a second opinion that he might otherwise not have. Additionally, a massive amount of information, from for example a 3D brain scan, can be processed by the computer in a quick and efficient manner. On the other hand, the human physician must slowly wade through the information deluge, delaying the diagnosis or perhaps leading to an error. These inherent advantages, combined with the growing research in machine learning and artificial intelligence could lead to a computer system that is comparative with or even superior to human diagnosticians.

One can imagine a computer doing just as well as a human doctor, but that itself does not give sufficient impetus for change; computer vision needs to be better than the human doctor. There are additional advantages stemming from the software nature of computer

vision that humans themselves are not capable of. Today even the most talented doctor can only reach a relatively small number of patients; it is simply not possible to use his talents for a larger section of the population. However, a single computer vision algorithm could be used to the benefit of millions of patients without any loss in performance. Additionally, the best doctors could be used as advisors in the development of the algorithms, or could be used to manually label training images. In essence, the expertise of many doctors, perhaps each an expert in a different narrow field, can be pooled into a single computer vision system, thus, making it possible for such a system to produce a better result than any one doctor could. Furthermore, the latest medical advancements could be quickly pushed to the software, rather than relying on the human physician to stay up to date on the most recent advances. Finally, the software nature of computer vision allows it to be disseminated in more remote areas where access to an expert diagnostician may be greatly limited.

Given these advantages, at what point do we choose to use the computer vision system in lieu of the expert physician? From an engineering point of view it is perhaps trivial to determine an objective metric to judge the computer. One can imagine using precision-recall curves, F-score, classification accuracy, or the like to compare a computer vision algorithm with the physician. If the computer proves to yield more accurate diagnoses, then the computer should be used as the diagnostician, otherwise more work is to be done. Although an objective metric is certainly a prerequisite, alone it will not bring widespread adoption. Often technical advancements do not see widespread adoption not because of any inherent technical limitations, but simply because society is unwilling to accept such technological advancement. Does classification accuracy truly trump the inherent cleverness, the intuition, the decision making process of the human physician? There is a human connection with a doctor, an element of trust, a feeling that the doctor sympathizes with the patient and will do his best. In contrast, a computer is cold, lifeless, calculating. The computer has no feelings, it does not truly care, it only runs the arithmetic operations that have been assigned to it. The question is not can computer vision do better from an accuracy point of view, but rather will the public accept a doctor's decision if that decision, even if only in part, was made by a computer? Will the average person accept a diagnosis from Dr. 01010011 01100001 01101101?

The acceptance of computer vision for healthcare diagnosis will be truly tested in the inevitable event of an error. What happens when the computer makes an error and causes unneeded health problems? Or even more chilling, what happens when the decision of a computer is directly responsible for a death? Is society okay with such a system having a non-zero error rate? Who is to blame? The programmer? The company? The hospital? It is easy to imagine the media firestorm and subsequent societal overreaction in such an event. Society perhaps gives much more scrutiny when it comes to machines than humans. It is easy to understand how a human could make a mistake, but we expect the machine to be perfect. We expect the computer to turn on everyday, and when it doesn't we become furious. Perhaps as technology continues to envelop our lives, and people become more educated about technology, some understanding can be reached as to why technology fails. At its most basic, technology makes mistakes because people make mistakes. Rather than the doctor making the mistake, the software developer is now making the mistake. It must

also be realized that healthcare diagnosis is an inexact science. Doctors make educated guesses. Computers will too, even after a slew of complicated algorithms, be doing nothing more than making educated guesses. And guesses, no matter how educated they are, are not always right.

We have seen how the use of computer vision in healthcare may change society, but so to may computer vision change the role of physician himself. As computers begin to do more and more diagnostic work the physician will become something completely different from what he is today, but he will become no less important. The physician will have the expertise to use the advanced computer vision tools to their full potential and collect information from multiple sources to come upon the best diagnosis. He may become that necessary link between human and machine. The physician may also serve as the last safe guard, the last line of defense, to correct any sort of gross misdiagnosis. Even if this role becomes unnecessary from a technical point of view, patients will feel more comfortable with direct human interaction.

The grand hope is that a computer vision based diagnostics can yield better results, while at the same time being more cost effective in a era of ever increasing healthcare costs. However, in contrast to the adoption of other technologies, the adoption of computer vision in healthcare may be slow because diagnostic decisions may carry extraordinary consequences. In essence, to determine whether computer vision can replace the human diagnostician is not so much a question of technology, but rather a question of sociology. Will society accept the reality of inevitable computer error? Computer vision in healthcare will only be widely adopted if the public accepts the idea of placing diagnostic decisions outside the realm human ingenuity and inside that of computer technology. Only then will computer vision become the gold standard for medical diagnosis.