(When) Will Computer Vision Replace Diagnostician's Eyes as Gold Standard?

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There is always a question arising about whether it is possible for computer vision to -at some point- substitute diagnostician's eyes gold standard. Many experts agree that computer vision studies are not ready to replace the position yet. But does the discussion end there? Not really.

This essay will discuss the limitation of diagnostician as a human and in the other hand explain more about the possibilities of development in computer vision technology and medical imaging for example.

Limitation of Human's Eye

To understand the limitation of human's eye, we need to know first the basic characteristic of human visual system. As a natural habit of human, eyes have also certain limitations. A lot of studies try to explain this limitation. Some of the important points as follows:

1. Image representation / Object Recognition
   Human visual system work based on object recognition, means that an image is interpreted based on object visually seen in the image. The pattern recognition system is very dominant that images is analyzed only based on recognized object appeared.

2. Data reduction, Less detail
   Not all data received by human visual system is utilized. Only about 4% of the whole visual information is used. It means the performance of human visual system is considered to be low that process the data with the ratio 1:25, loss more than 96% of the data. Human's eye interpret the image globally and loss most of the details of an image.

3. Limited Resolution, Limited Speed
   Human's eye can only deal with certain level of resolution (some study said it is around 2000x1000). Any higher resolution than its capability will not be distinguish-able by human visual system. This issue arises also in the field of 3D technology, experts believe the

technology is already in the edge of its development that further improvement in the resolution will not give any benefit because of the limitation of human's eye when processing it. Human eye also have limitation in dealing with image with speed of movement. Human eye can only follow the change of the images in certain level of speed (around 120fps), and that's how cartoon movie was able to be developed at the beginning.

4. Subject-experienced influence

Human visual system analyzes the image based on objects he/she recognized. It forces the brain to interpret the image based on their prior knowledge which may come from experiences or learning process happened before. This interpretation leads to subjectivity of each person in interpreting an image. One person may have different concepts of understanding, compared to other person with different background and experiences.

5. Redundancy

Personal interpretation of an image makes it possible that a person can see something that actually not exists in the image. Pattern recognition as the dominant process in the human visual system is urged to find any related features seen in the image and try to capture object based on his/her own interpretation. It is more like a fantasy. This explains why sometimes we see a black shadow between trees in the jungle, or face in a wood.

6. Low robustness

Human visual system really depends on the condition of human body state. When we are tired, get fatigue, not feeling well or even in a weak condition, the visual system might also being disturbed. This influences the robustness of the human visual system if the analysis is done with different time and different condition of humans' body.

Computer Vision Characteristic

To be able to compare with human visual system, it is now our time to see the computer vision system. Computer vision can be generally described with these characteristics:

1. Pixel-Representation

Computer vision sees an image as digital data represented as pixel. It means that the whole process is based on pixel, not as object or pattern.

2. Lossless data storage

   With computer vision we can utilize the whole data gained from the image acquisition process. It gives us flexibility to work in certain level of detail as we need. We can use and store the whole data for analysis or we can compress and use only certain data contained in the image, depends on our purposes.

3. Precision and objective measurement

   With detail information and pixel-wise processing, computer vision can provide us a robust system in measurement, objective analysis, and precise calculation of parameters in the image. The measurement can be done in a very detailed manner and provide accurate result.

4. Training and learning ability (Pattern Recognition)

   Computer vision has also capability to resemble human visual system by training and learning process. A diagnostician is valued for their experiences and learning process that build their expertise. Here, the computer vision can also do the process in an effective and efficient way; and also faster.

5. Quick. Large amount of Data

   No doubt that computer vision is able to do processing in a very short time and also can handle huge amount of data in a very long, continuous and non-stop time.

Development of Medical imaging Technology

As the implementation of computer vision in the medical field, medical imaging has become an important and crucial tool for better diagnosis and effective cures in patient care nowadays. A nationwide survey of physicians in *Health Affairs* revealed that among all diagnostic medical imaging equipment, CT and MRI are the most important modern medical innovation.

The development of medical imaging equipment grows fast as the result of advancements of computer vision technology. The evolution of medical imaging equipment spread out from x-ray to

nuclear imaging. The improvement in imaging technology has contributed to the improvement of patient healthcare. No wonder some of innovator in this field had been rewarded Noble prizes as Hounsfeld & Cormack in 1979 for the invention of *Computed Tomography Scan*, and also Lauterbur & Peter Mansfield in 2003 for developing *Magnetic Resonance Imaging* technique. Medical imaging has enabled physicians to diagnose diseases earlier, decrease hospitalization and replace invasive surgeries.

However, despite all of its benefits, many experts believe that we have not optimized the use of medical imaging yet. One indication is the fact that too many unnecessary or repeat exams are performed; inappropriate utilization of the equipment. Even though medical imaging is generally an extremely safe technology, inappropriate medical imaging creates significant direct and indirect economic costs. The technology nowadays also still dealing with some issues as radiation and potential toxic from agents (for example contrast agents).

Will Computer Vision Technology Replace Diagnostician's Eyes as Gold Standard?

From the description above, it is clearly seen that somehow somewhat, the human's visual system has several limitation that computer vision still can be developed to cover up this limitation. Computer vision -for example medical imaging-, have unlimited range of improvement, but human's eyes not. Human's eye is just human's eye just the way it is now, before and then.

The question is not about "*will it replace diagnostician's eyes as gold standard*", It certainly will. The question now is *when*. Once the advancement of computer vision can cover up all the limitations possessed by the human visual system, then it is the moment when computer vision technology replaces the diagnostician's eyes as gold standard.

References
1. Michael F. Deering. *The Limits of Human Vision*, 2nd International Immersive Projection Technology Workshop, Sun Microsystem, 1961.
2. Pat Basu. *Medical Imaging: The Good, the Bad and the Ugly*, Stanford University Press, 2009.