Toward Data Driven Medicine

This paper will introduce how artificial intelligence based diagnostic assistance technology will change and revolutionize the healthcare market, with particular focus on applications in medical imaging. The accuracy of diagnostic support solutions has shown stunning improvement with the recent advances in deep learning technology, and more attempts to implement such developments in the clinical environment are being made. The reason behind such trends can be found in the rapid improvement of computing power, better performing algorithms and the systematic gathering of medical data. Considering that many of the previous diagnostic support solutions have not been welcomed by clinicians, these changes are quite meaningful.

Now lets look into artificial intelligence based solutions that will solve problems in the clinical environment and provide practical help to the medical team.
With the worldwide trend of decreasing birth rates and increasing life expectancy, most OECD countries will become a Super aged society by 2030. The worldwide proportion of those over age of 65 is expected to increase from the 8.2% of 2015 to 17.6% in 2060. As the average spending on healthcare of the elderly is about three times that of the total average, a rapid increase in healthcare spending is expected. The medical spending of the elderly population in South Korea has also been increasing over 11.2% each year since 2000, topping the overall average of 8.6%. [1]

Along with the aging population, increase of income and education levels led to a change in perspective and increase in demand for healthcare. Moreover, due to change in lifestyle, pollution, psychological stress and other health hazards, it is predicted that healthcare demands will continue to increase.

OECD health statistics show that the supply of healthcare professionals are not meeting the demands despite the continuous increase in the number of doctors per 1000 people. In the case of South Korea, we have 2.2 doctors per 1000 people, which is the lowest of the member countries.[2] The situation is similar in the United States where it is predicted that there will be a shortage of 40,000 to 10,000 doctors by 2030. Hence, to increase the efficiency of healthcare, nationwide effort is being put into areas such as digital healthcare. [3]

Lack of resources lead to a decrease in the quality of healthcare, which is evident in the 2016 report from the Canadian Institute of Health Research which showed that 39% of the patients coming to A&E have a waiting time over 4 hours. (11% in developed nations) [4] Although new surgical techniques and drugs are important, increasing the efficiency to solve the chronic lack of resources and improve the availability of healthcare should not be overlooked. Therefore, new attempts, such as implementing artificial intelligence to address the problems in the healthcare sector is needed.
Artificial intelligence has been a topic of interest for a long time and applications in robotics and expert systems has been the main focus. With the recent advances in deep learning, broader applications of artificial intelligence have become possible, such as the healthcare sector. Many companies such as IBM Watson and MedyMatch are introducing artificial intelligent solutions that suggest cancer therapy or detect pathology from medical images. The global IT giant Google has also published a paper in JAMA with Stanford in November 2016, which showed impressive results (AUC 0.990) in detecting diabetic retinopathy and macular edema by training an artificial intelligence with 120,000 images. To reiterate, the performance of Google’s artificial intelligence is equivalent to that of some of the best ophthalmologists, surpassing that of the ‘normal clinician’. However there are limitations to these studies. Because the training is based on labels provided by multiple doctors, small details detected by a few doctors will not be learned. Furthermore, because of the characteristic of deep learning, the specific reasoning behind the results are unclear, which may be difficult to accept for some doctors and patients. As a result, even with the results of the paper, they are concluding that artificial intelligence can not replace doctors. Unlike other domains, we need to be more careful when applying artificial intelligence to healthcare. In the process of implementation to the clinical environment there may be issues with resistant doctors, responsibility once a problem rises and much more. Then how should artificial intelligence be used in healthcare?

New opportunities in the medical field using AI technology

Application field of AI technology, siemens 2016

Exper Systems  Autonomous Robots  Digital Assistants  Embedded Systems  Neurocomputers
Artificial Intelligence as a Tool

As mentioned before, we need a powerful tool to increase the productivity of the medical staff in order to cope with the increase of medical demand. From this perspective, artificial intelligence can be of great help in improving the work flow. Considering that most studies indicate that artificial intelligence will not be able to completely replace doctors, it can be a solution to a more efficient clinical environment. Especially in the field of medical imaging, where reading of X-rays, CT and other image modalities can become repetitive, the potential of artificial intelligence is great. If artificial intelligence can replace the reading of these repetitive simple images, the productivity of the medical staff will greatly increase.

Market Prospective of the AI based Diagnostic solutions

Artificial intelligence as a tool means that it will be used to support the diagnosis made by the medical staff. But will there be a market for this? The market size for medical imaging devices has increased rapidly and reached 35.6 billion USD recently. However, it has gone into a mature state where the potential for growth has decreased (annual growth 2 – 6%). Also, the top three companies (GE, Siemens, Philips) has formed an oligopoly, where it is very difficult for new companies to reform the market. However, due to the medical devices that are being used already, more and more medical images are being digitalized and stored every day. Therefore, of the 18 billion USD medical image diagnosis market, the diagnostic support solutions market (1 billion USD in 2018) is showing a faster growth rate than that of imaging devices. [6] Therefore the AI based diagnostic support solutions can be seen as a verified market which can lead to an increase in the overall market for medical images.
Innovations from Diagnostic Support Solutions

There are three prerequisites to create a good AI based diagnostic support solution in the field of medical images: availability of well organized medical images, computing power capable of processing large data, and a verified algorithm. PACS (Picture Archiving and Communications System) has been implemented in hospitals in South Korea a long time ago. Since the introduction of a charge for using PACS in the national health insurance, the rate of PACS usage has increased rapidly to a near 100% in case of general hospitals. Such rates are higher than any other country in the world. Also, there is a huge demand for radiology in South Korea where the CT and MRI frequency is higher than the OECD average. The impressive development in GPU (Graphics Processing Unit) technology, together with the network environment in South Korea, is providing a infrastructure well fit for processing large amounts of data. Finally, the depth of understanding in deep learning technology of domestic start-up companies. In particular, VUNO used its’ self developed deep learning engine – VUNO NET – to place 5th in the ImageNet Challenge in 2015 while competing against Google, Microsoft and Amazon.[7] Based on such technology, VUNO has continued collaborative research with the major hospitals in South Korea to produce a diagnostic support solution that can actually be implemented in the clinical environment. As mentioned before, domain knowledge is very important in Medicine. Good performance is not necessarily a good solution, and collaboration with the medical staff who actually provide healthcare is key in creating the right solution. As a result of such collaborations, VUNO has created 3 representative diagnostic support solutions for medical images: Bone Age Solution for reading the bone age from a child’s hand X-ray, Chest X-Ray Solution for detecting pathologies in chest x-rays taken for screening purposes, and Chest CT Solution for detecting lung nodules. We are conducting research on other medical image modalities as well. We are not just doing research but actively working on creating a solution that can pass medical certifications and receive insurance coverage.
Opportunities in Radiology

The reason why VUNO is focused on X-rays and CTs (Computed Tomography) is in the market potential. The number of X-ray and CT scans in South Korea is already higher than the OECD average and the annual rate of increase of 12% is also higher than the OECD average. Especially, the number of imaging devices per population is more than twice of the OECD average. The incidence of diagnostic X-ray scans is also continuously increasing. In 2011, there was around 42 million X-ray scans taken domestically with an annual increase of 8.3%, and the insurance coverage was 200 billion KRW with an annual increase of 9.2%. Of these scans, 64% are chest X-rays, 19% is cervical, and 17% was tarsal bone scans. Furthermore, the number of patients scanned in 2016 is 30 million which is 60% of the total population. Such statistics show the clinical importance of chest X-rays. However, the millions of scans have to go through the 3,500 radiologists (2017).

In a very crude analysis, this means each specialist radiologist have to report over 50 X-rays every day. [8]

To address the inefficiency in X-ray reporting, VUNO focused first on bone age analysis. Bone age analysis is a solution that can dramatically decrease the amount of time spent by automatically detecting the bone age. Previously, bone age analysis which is used in detecting growth defects, was done by the G.P. (Greulich-Pyle) Method where doctors have to compare the image to a standard document. This caused a massive delay in reporting which impaired it’s value in diagnosis. To solve this issue, VUNO collaborated with Asan Medical Center, which is one of the biggest hospitals in South Korea, to train a deep learning model with over 10,000 images. The result was a tool that can provide results with over 96% accuracy in seconds, saving the reporting time of radiologists by 40%. This was recently published in the American Journal of Roentgenology 2017. [9]
Maintaining Accuracy while increasing the speed of reporting

As seen in the case of our Bone Age solution, the direction of VUNO’s diagnostic support solution is clear: to provide an AI based support tool to help doctors report medical images faster. Another case is the Chest X-ray analysis solution. This solution provides a normal/abnormal result from screening, and further provide data that will help doctors make their diagnosis. Chest X-rays are often used as a first line tool in diagnosis, and the rate of human error is quite high. Also because other image modalities such as ultrasound and CT scans are often required, it is difficult for doctors to spend a long time in reading X-rays. Therefore, using a AI based screening tool can be useful in decreasing the time spent by doctors and also decrease the chance of human error. Collaborative research with major domestic hospitals show that the VUNO Chest X-ray solution has an accuracy similar to that of clinicians in classifying normal and abnormal scans. It is also able to do primary screening for major finding including nodules, consolidations, pleural effusion, opacity, and pneumothoraces. Because our solution shows the suspected abnormality and the suspected location, it can improve the reporting speed of clinicians.

The Lung Nodule Solution is a solution that detects lung nodules from chest CT scans which shows high accuracy based on technology that we have had since the founding of VUNO. Unlike X-ray scans, CT scans are composed of 100 to 200 slices which require a more in depth analysis technology.

A to Z for implementing AI in hospitals

Well processed data is needed for developing all of the solutions mentioned previously. Because AI is teaching computer models with large amounts of data, we need a data set that can be considered the Ground Truth. In other words, we need data with labelled lesions. Most hospitals have image reports but not lesion labels. To address this issue, VUNO has been developing and providing labelling tools tailored for each purpose. We also have a Viewer and Reporting system that focused on user friendliness, which means that we have an End-To-End Solution for collaborating with hospitals.
Healthcare Innovation has already begun

Apart from medical images, VUNO is developing AI solutions for bio-signal analysis and speech to text analysis specialised for medicine. Especially for bio-signal analysis, we have developed the DeepEWS (Early Warning System) that can predict Cardiac Arrest within 24 hours with a high accuracy in collaboration with Sejong Hospital, which is the most well known cardiology specialist hospital in Korea. This tool is currently being used for research purposes and provides a high accuracy based on four main bio-signals (Heart Rate, Respiratory Rate, Body Temperature and Systolic Blood Pressure). [10] Our medical speech analysis solution can solve the inefficiency of having someone transcribe the report from recordings. When a transcriber uses our solution, the cut the time required by half of what it takes now. As such, we are trying to use AI to improve workflow productivity, and as it always has, change will happen quicker than we think.

“The future is already here. It’s just unevenly distributed.”

- William Gibson
Journey to Data Driven Medicine

VUNO is comprised of individuals who understand AI technology and the healthcare market. We are trying to solve the inefficiency existing in the healthcare system with artificial intelligent technology. There are various problems, but the solution is always in the field. To us, the data is our field, and we wish to collaborate with hospitals to invigorate the data. Many problems in healthcare are above geography or ethnicity. Although we are currently focused on collaboration with domestic hospitals, we believe that there are no borders to data. A model that works well in the local area will work well globally. As we get insight from data, people will see what AI driven Medicine is from VUNO. Our journey will continue until the day AI becomes an invaluable tool for the medical doctors and enhance the quality and availability of healthcare for everyone.
References

[1] Research on conversion factor by different types of medical institution, KIHASA, 2014