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Artificial Neural Networks in Medicine

Z. T. Kocsis[1]

[1] Széchenyi István University, Department of Information Technology
Egyetem Tér 1, 9028, Győr, Hungary
e-mail: kocsis.zoltan@ga.sze.hu

Abstract: In recent years, Information Technology has been developed in a way that applications based on Artificial Intelligence have emerged. This development has resulted in machines being able to perform increasingly complex learning processes. The use of Information Technology, including Artificial Intelligence is becoming more and more widespread in all fields of life. Some common examples are face recognition in smartphones, or the programming of washing machines. As you may think, Artificial Intelligence can also be used in medicine. In this study I am presenting the relationship between machine learning and neural networks and their possible use in medicine.

Keywords: neural networks; medicine; surgery; patient; learning; healthcare

1. Introduction

People are able to learn from their acts, to interpret any mistakes they may have made, and thus to improve a series of repeated actions. However, people are not able to perform a series of actions in succession several times in a row exactly the same way. You may correct the previously committed mistake; however, another error might surface in the process. Nowadays, artificial intelligence systems developed for 'learning' that are capable of solving a pre-programmed problem with the help of a computer have become more and more common.

Artificial intelligence must have a problem-solving algorithm that helps it adapt to the problem. Artificial Intelligence (AI) is still being researched to enable computers to perform tasks that require human thinking, that is, self-learning.

In health care, it is almost impossible to find an area where human thinking is not needed. For example, to set up diagnose and a possible cure based on a patient's complaints human problem solving is necessary.

There are great opportunities for artificial intelligence during surgery. However, performing a surgery is not enough it must also be planned very carefully. There is a great need for the physician's experience and knowledge in both planning and implementing. However, surgery does not end well in all cases. Complications may occur during the operation, and a poorly performed surgery can lead to serious health damage, which also need to be treated by a physician.

The use of AI is already widespread in health care, used for example for collecting data about certain parts of the body, and for comparing surgical results and methods, and also for making suggestions based on these.

AI has several branches. In health care, machine learning is the one that can be used the best. In the following chapters, I am going to explain machine learning, and illustrate some specific examples of cases in which it could be applied in the healing process.

2. Machine learning in medicine

From a scientific point of view, machine learning is nothing more than making the machines suitable for making decisions with the help of the available data and situations using a learning algorithm. The biggest problem is how to create an algorithm that can learn the most effectively. There are two types of machine learning that are distinguished: supervised learning and unsupervised learning. They can be used well in health care [6].

2.1. Supervised learning

In supervised learning (Figure 1) we know the expected goal, that is, we want to teach the algorithm for a specific case. A good example fort this is the handwriting recognition software. We know what a word means, even if it is not written by the same person. The aim here is to recognize the different ways of writing and to identify words. A well-known example is the face recognition application found in mobile phones. Human faces are different but have the same features that AI can recognize. Supervised Learning focuses on grading, that is, selecting the pre-programmed known ones, classifying them, and finding the best of the selected items.

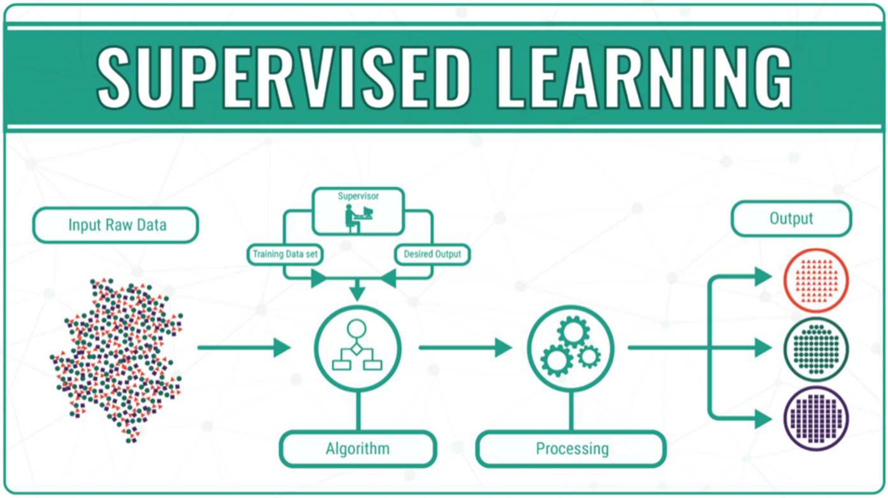
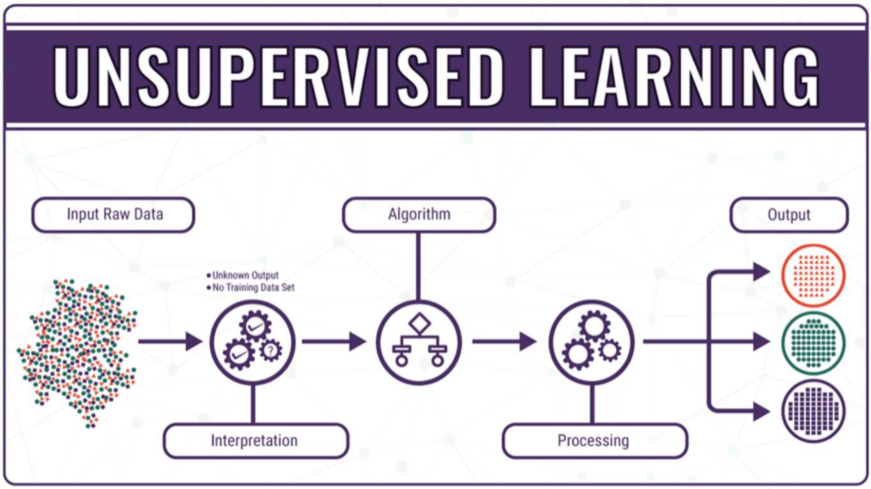


Figure 1. Supervised learning [15]

There are also cases in medicine that can be suitable for supervised learning. [1] In radiology, e.g. this method can be used to analyse a chest radiograph. The doctor knows which deformations he has to look for in the X-ray, so the computer can be programmed to look for these deformations as well (e.g., to recognize bone fractures). Supervised learning can be used by cardiologists to estimate risks. It is able to approach the risks posed by doctors in heart disease, but it also raises new risks that doctors would not notice. There are many other examples in medicine, but it can be seen that supervised learning might be widely used.

2.2. Unsupervised learning

Unsupervised or not supervised learning is a much more difficult task. Here we do not know what kind of outcome we expect, that is, we do not have anything specific. The algorithm tries to find the naturally occurring patterns or groups in the data. The results obtained are much more difficult to evaluate than in supervised learning because we do not know exactly what we want to see as the end result. We can only guess if the new results are useful in some way or not.



Fiugre 2. Unsupervised learning [15]

Unsupervised learning in health care is best used in precision medicine. The essence of precision medicine is to examine the subject as a whole. The patient's genetic characteristics, organ and emotional determinants and medical history are all taken into account. Thus, it is possible to redefine each therapeutic treatment. Another area of application may be for heart patients in the recognition of myocardial inflammation.

3. Machine learning in healthcare

3.1. Diagnosis with machine learning

In actual clinical practice, machine learning usage is limited. I would like to highlight two literature references. In the first case, cardiovascular diseases were tried to be diagnosed, while in the other they tried to diagnose cancer by machine learning. [1] [2] [7] [11]. The diagnosis was attempted by a classification method, where two groups were created. The task was to develop a model that can distinguish between the two classes. However, this is not easy because there are many symptoms that occur not only in patients with heart disease or cancer. The diagnosis was resolved with the help of a neural network.

The artificial neural network models some properties of the biological neural network taken from nature. This is an information tool capable of distributed operation. The neurons in it represent the same operational elements and are arranged in an orderly manner. It has a learning algorithm that defines a learning process based on a sample and the way the information is processed. It must also have an algorithm that makes it possible to process the information it has acquired.

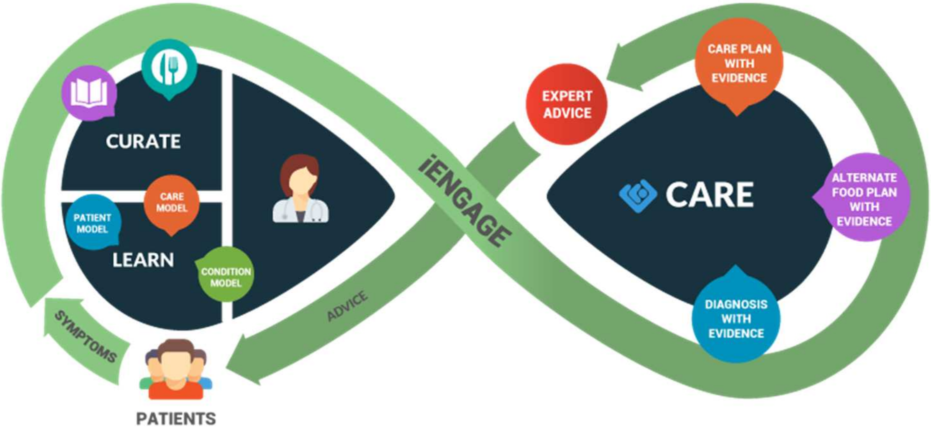


Figure 3. Machine learning in medicine [16]

Another example can be found in stroke research. Stroke is the fourth most common cause of death among adults. Stroke is a brain disorder that occurs when the blood supply to our brain deteriorates to an extent that results in the destruction of brain cells there. Early detection of this disease is an extremely difficult task, but it is essential for successful recovery. Machine learning contributes greatly to the timely detection of this disease. Between 2011 and 2014, a medical team in New York called for the Deep Learning machine learning method to detect the disease. [3][8] The essence of Deep Learning is that the machine can interpret an ever increasing amount of data quickly and accurately. It differs from traditional Artificial Intelligence (AI) by processing data step by step and the classification is performed by the algorithm as well.

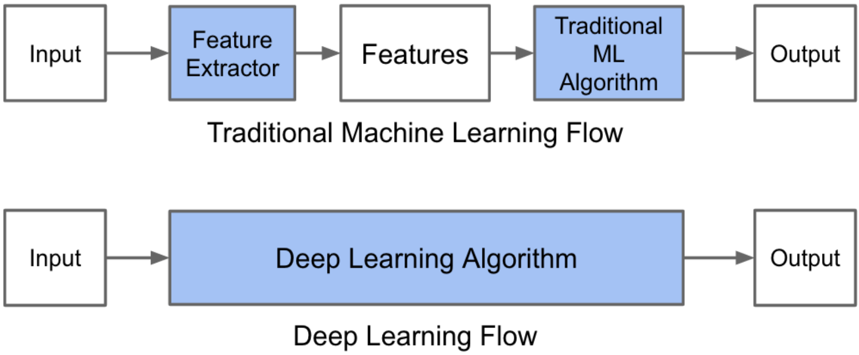


Figure 4. Machine learning vs. Deep Learning [17]

A total of 114 randomly selected patients were included in the study. Patients were given CT scans to identify the stroke. Based on these CT scan images a medical team made a diagnosis. The doctors have divided the images into two groups. One group became the data set from which the neural network could learn and the other group was the test set. With the help of these, a Deep Learning neural network capable of working in a 3-dimensional image was created based on the opinion of doctors on CT scans. The developed model was tested with the help of the set of test kits, by comparing the diagnosis established by the algorithm to the diagnosis of the medical team. Finally, the system has created a computer generated heat map to predict the possibility of infarction (Figure 5).

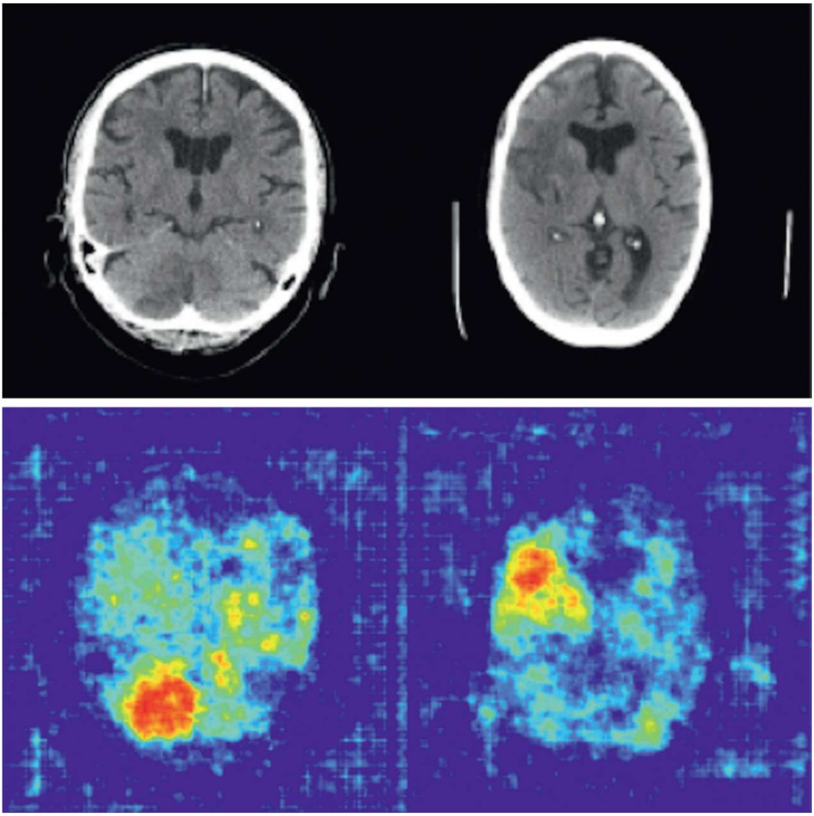


Figure 5. Computer generated heat map [3]

3.2. Machine learning during surgery

During surgery, doctors not only need to pay attention to the outcome of the operation, but also to the movement of the tools they use within the body. The movement of surgical instruments is monitored by the doctors' sight, and it is their responsibility to set their direction and position of these tools. By the automation of the traceability of devices, better surgical results can be achieved [9] [10].

There is already a so-called machine vision, which means that with the help of a camera the machine "sees" and processes the incoming images with the help of a software. In medicine, machine vision is an effective tool for tracking surgical instruments. Since they are controlled by software, altering them is unnecessary [4].

Machine vision tracking systems have been used for minimally invasive surgeries (MIS). The tracking of the tools was used both in 2 and 3 dimensions. The essence of these operations is that the intervention can be done with minimal cutting or possibly without cutting. Since the size of the cut is minimal, the accuracy of in-patient navigation is extremely important. Figure 6 shows a device for surgery.

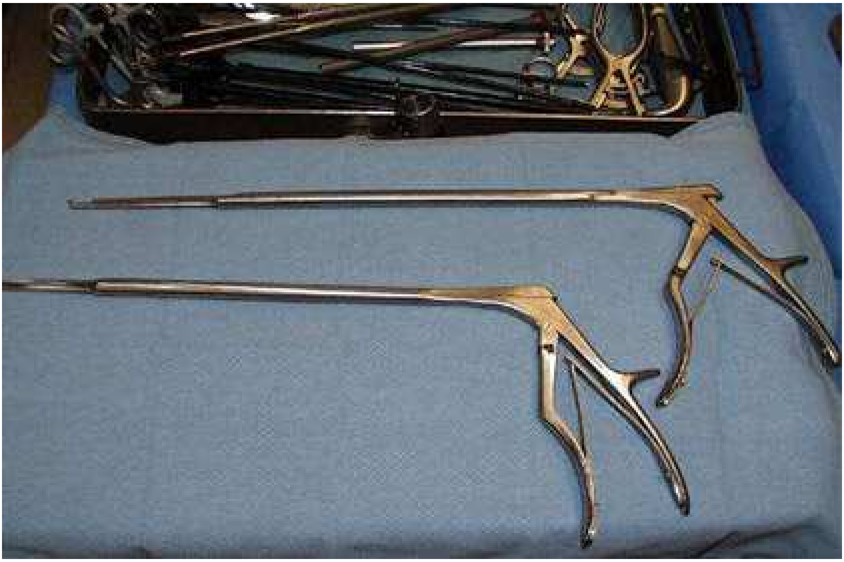


Figure 6. Minimal invasive surgery tool [12]

During surgery, the doctor only sees an image coming from an endoscope, which makes it difficult to coordinate the device and feel the depth. Nowadays, the data needed to track the device is acquired by electromagnetic, optical and vision-based techniques. Electromagnetic tracking techniques are costly and have a complicated tracking algorithm. In contrast, vision-based systems operate much more efficiently and less costly. Software fitted to the camera can measure the position of the camera and monitor the device accordingly, so there is no need to change the device on the surgical procedure or the device used for surgery. During surgery, the position of the end of the device should be measured, which is not an easy task due to continuous movement. Tracking the tool was solved by machine vision and a neural network specifically developed for the task. This created a system that monitored the device with good results and immediately informed the physician performing the surgery (Figure 7).

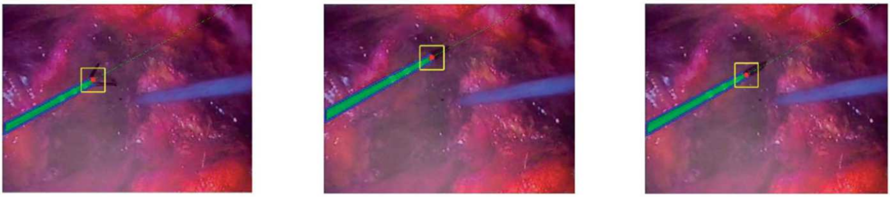


Figure 7. Tracking detection [4]

3.3. Deep Learning and Computer Tomography

So far we have mainly looked at examples of machine learning in only 2 dimensions. However, CT images can provide 3-dimensional images that contain useful information about human anatomy that can be used to diagnose and support surgery and therapies. [5]

Recognizing and separating human body parts play a critical role in the interpretation of CT images. In the traditional sense, they all have to be done by radiologists, but these are time-consuming tasks and require great care. These could be automated, that is, using automated image recognition software, which would, on the one hand, take the burden off the doctors' shoulder and on the other hand be faster and more reliable.

This task is challenging in several respects, because medical imaging procedures never give back the 100% exact image of body parts, so it is not possible to create a precise mathematical model for identifying body parts. Another disadvantage of CT is that it is not possible to set a contrast on a recording as a conventional camera, so there will be blurred boundaries between the individual parts of the body. CT images can be made from every part of the body, but every shot requires different settings, so if you want to recognize each part of the body with a specific method, you should make a special method for each option.

Convolutional neural network (CNN) was used to implement CT image segmentation and solve various problems. [5] [13] [14] In all cases, CT images are made in 2 dimensions, which represent the patient in horizontal or vertical sections, slices. The radiologist should be able to interpret these images and, if necessary, create a 3-dimensional image in the head to determine the specific problems.

However, the diagnostic software is able to combine the slices of CT scans both horizontally and vertically into a 3-dimensional image. From the 3-dimensional images thus obtained, a neural network of problems can already determine the individual parts of the body (Figure 8).

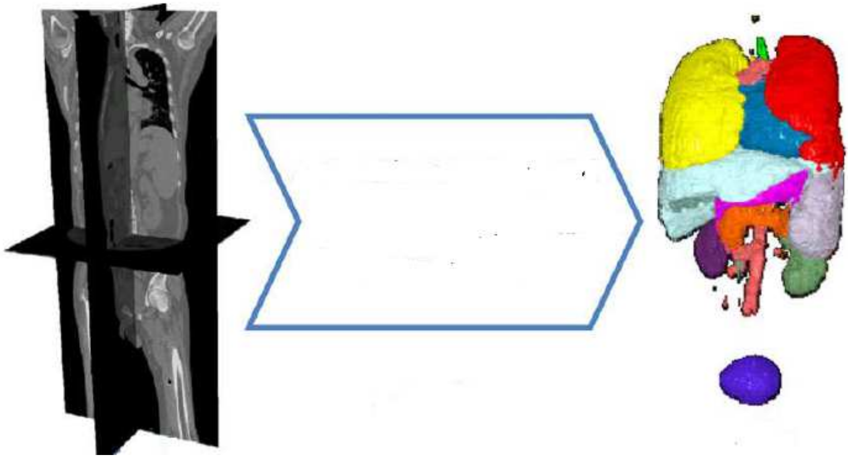


Figure 8. 2D to 3D CT image [5]

Figure 8 shows how the 3-dimensional image and how the individual body parts are reunited from the individual slices of the CT images (vertical and horizontal). With the help of colours, each part of the body can easily be recognized. However, the neural network can be taught for one kind of problem, so you don't have to recognize every part of the body at the same time. The teacher data set must be specified for the given task, so it will only recognize that part of the body.

4. Conclusions

Based on these new procedures we can say that machine learning is a great help for doctors, both in diagnostics and in surgery.

The method also greatly facilitates the processing of CT images, since even an experienced physician may not notice something in the image being examined. Unlike a physician, a software developed for a particular problem is able to focus specifically on the problem, so it does not have to deal with other distractions. If you use a neural network to do this, it will fix itself after every task that it has solved, i.e. it will be more accurate and reliable.

Apart from diagnostics, machine learning can be used during surgery too. In the case presented, the aim was to follow the surgical device and to make it more accurate. In contrast to the tools used so far, the use of the neural network did not require any modification of the surgical intervention or the device. I think neural networks can be used to determine a specific surgical area and intervention scenario.

In connection with my research, I also investigate what kind of mechanical learning or neural networking has already been used in spinal surgery and how I could use this information in reaching my goal

References

[1] Rahul C. Deo, MD, PhD, Machine Learning in Medicine, Circulation 132 (2015) pp. 1920-1930. doi:10.1161/circulationaha.115.001593

[2] D. Wang, A. Khosla, R. Gargeya, H. Irshad, and A. H. Beck, Deep Learning for Identifying Metastatic Breast Cancer, arXiv preprint (2016) pp. 1-6. arXiv:1606.05718

[3] Ashley N. Beecy, Qi Chang, Khalil Anchouche, Lohendran Baskaran, Kimberly Elmore, Kranthi Kolli, Hao Wang, Subhi Al'Aref, Jessica M. Peña, Ashley Knight-Greenfield, Praneil Patel, Peng Sun, Tong Zhang, Hooman Kamel, Ajay Gupta and James K. Min, A Novel Deep Learning Approach for Automated Diagnosis of Acute Ischemic Infarction on Computed Tomography, JACC: Cardiovascular Imaging 11 (11) (2018) pp. 1723-1725. doi: 10.1016/j.jcmg.2018.03.012

[4] Zhao, Z., Voros, S., Weng, Y., Chang, F., and Li, R., Tracking-by-detection of surgical instruments in minimally invasive surgery via the convolutional neural network deep learning-based method. Computer Assisted Surgery, 22 (sup1) (2017) pp. 26-35. doi:10.1080/24699322.2017.1378777

[5] Zhou, X., Takayama, R., Wang, S., Hara, T., and Fujita, H., Deep learning of the sectional appearances of 3D CT images for anatomical structure segmentation based on an FCN voting method. Medical Physics, 44 (10) (2017) pp. 5221-5233. doi:10.1002/mp.12480

[6] Obermeyer, Z., and Emanuel, E. J., Predicting the Future — Big Data, Machine Learning, and Clinical Medicine. New England Journal of Medicine, 375 (13) (2016) pp. 1216-1219. doi:10.1056/nejmp1606181

[7] Cabitza, F., Rasoini, R., and Gensini, G. F., Unintended Consequences of Machine Learning in Medicine. JAMA, 318 (6) (2017) pp. 517-518. doi:10.1001/jama.2017.7797

[8] Leung, M. K. K., Delong, A., Alipanahi, B., & Frey, B. J., Machine Learning in Genomic Medicine: A Review of Computational Problems and Data Sets. Proceedings of the IEEE, 104 (1) (2016) pp. 176-197. doi:10.1109/jproc.2015.2494198

[9] Smith, L. N., Smith, M. L., Fletcher, M. E., & Henderson, A. J., A 3D machine vision method for non-invasive assessment of respiratory function. The International Journal of Medical Robotics and Computer Assisted Surgery, 12 (2) (2015) pp. 179-188. doi:10.1002/rcs.1669

[10] Din, N., Smith, P., Emeriewen, K., Sharma, A., Jones, S., Wawrzynski, J., Saleh, G. M., Man versus Machine: Software Training for Surgeons—An Objective Evaluation of Human and Computer-Based Training Tools for Cataract Surgical Performance. Journal of Ophthalmology 2016 (3548039) (2016) pp. 1-7. doi:10.1155/2016/3548039

[11] Würfl, T., Ghesu, F. C., Christlein, V., and Maier, A., Deep Learning Computed Tomography. Medical Image Computing and Computer-Assisted Intervention -- MICCAI 2016. Lecture Notes in Computer Science, Springer, Cham, 9902 (2016) pp. 432-440. doi:10.1007/978-3-319-46726-9_50

[12] George D. Picetti, Basic Introduction to Minimally Invasive Spine Surgery [cited 2019.01.22] URL: https://www.spineuniverse.com/treatments/surgery/minimally-invasive/basic-introduction-minimally-invasive-spine-surgery

[13] Van Ginneken, B., Setio, A. A. A., Jacobs, C., and Ciompi, F., Off-the-shelf convolutional neural network features for pulmonary nodule detection in computed tomography scans. 2015 IEEE 12th International Symposium on Biomedical Imaging (ISBI) (2015) pp. 286-289. doi:10.1109/isbi.2015.7163869

[14] Li, W., Cao, P., Zhao, D., and Wang, J., Pulmonary Nodule Classification with Deep Convolutional Neural Networks on Computed Tomography Images. Computational and Mathematical Methods in Medicine 2016 (6215085) (2016) pp. 1-7. doi:10.1155/2016/6215085

[15] Ronald van Loon, Machine Learning Explained: Understanding Supervised, Unsupervised, and Reinforcement Learning [cited 2019.01.22] URL: https://datafloq.com/read/machine-learning-explained-understanding-learning/4478

[16] COGNUB Decision Solutions, Healthcare with Machine Learning [cited 2019.01.22] URL: http://www.cognub.com/index.php/health-care-2/

[17] Adil Moujahid, A Practical Introduction to Deep Learning with Caffe and Python [cited 2019.01.22] URL: http://adilmoujahid.com/posts/2016/06/introduction-deep-learning-python-caffe/