1 Minute Speech

This project outlines the process to create a neural network that can effectively segment surgical tools from their surrounding background. The motivation to create this neural network is to address the need of a guide that will mitigate the effects of misrecognition of artifacts in a picture by a surgeon during a minimally invasive surgery operation. With support from Synaptive Medical Inc. and Robarts Research Institute, the neural network will be trained to segment distinct medical images. The neural network will segment a photo taken during an experiment on a pig's brain in the regular color of the image and in a fluorescent blue to see if the neural network is effective in a fluorescence-guided surgery.

Taken from a Modus V exoscope by Synaptive Medical Inc, 300 images were manually segmented to act as training data for the neural network. The network was implemented using Keras and Python. The neural network took 2 hours to be trained and the same training data was inputted to see how accurate the prediction from the neural network was compared to the manual segmentation. The neural network faced a challenge in segmenting fluorescent blue images, but the challenge was overcome when the training images were converted to grayscale via MATLAB. To see how the network faced different scenarios, a new video was segmented. There were four categories within the testing data: regular illumination with one surgical tool, fluorescence blue with one tool, regular illumination with two tools, and fluorescence blue with two tools. The accuracy was measured using the DICE coefficient for 20 random images in each of the four categories. The accuracy stayed at about 95% through all the tests and the speed was remarkably fast. Every image took less than 0.12 seconds to be segmented with an approximate resolution of 600 x 800 pixels.

There are many opportunities for this neural network to become more accurate and increase efficiency. Firstly, a more advanced neural network with multiple layers would be ideal for problems such as severe motion blur. Secondly, if the neural network was exposed to more training data and scenarios, the accuracy would increase significantly and would reduce the chances of false positives or negatives. Finally, if the manual segmentations were more precise, the predictions conducted by the neural network would be more accurate.

3 Minute Speech:

In recent years, there has been a growing trend towards the usage of robotic surgeries in the medical field. According to a report on minimally invasive surgery performance errors, nearly 30% of surgical complications are caused by misrecognition during operations. This entire project falls under the scope of a certain type of surgery called Minimally invasive surgery. This type of surgery is where a doctor uses a variety of techniques to operate to lower blood loss and have much faster recovery rates. To start off, it is necessary to understand what medical images are and why they play a part in this project. A medical image is a collection of measurements in two-dimensional or three-dimensional space. These images are used for something called segmentation. Medical image segmentation is the process of extracting the desired object from a medical image. This makes the image a lot simpler and transforms the medical image into something meaningful. There are a multitude of benefits regarding medical image segmentation including assisting doctors with diagnosing and making decision in critical scenarios. However, some surgeries use something called fluorescent dye which is named fluorescence guided surgery to assist in locating objects. A neural network is a subfield of machine learning which is a subfield of artificial intelligence. Neural networks are referenced off the human brain where there are

thousands of neurons that are interconnected with each receiving inputs, processing them, and generating an output. There are 5 main components of a neural network: input, weight, bias. Activation function, and output. inputs are multiplied to the weights and then added in the summing junction along with the bias value. After that the activation function is applied and the output comes out. This is shown in the diagram here. This one simple equation and diagram resembles a perceptron, and a neural network is made of plenty of perceptrons. An output of one perceptron could be the input of another. With all this information, what is the objective of this project is what you may be thinking. The objective is to develop a neural network that will accurately segment surgical tools from their background. This technology will assist surgeons during MIS. Since some surgeries use fluorescent dyes, it is important that the neural network can segment those types of images as well along with multiple tools.

The first step was to segment surgical tools from the background to act as an input object for the network to learn from. There was a video given by Synaptive Medical Inc. and through MATLAB, the video was broken down into 300 images. These 300 images were manually segmented through ITK SNAP, and the training data was inputted into the network. The machine learned for two hours and then was inputted into the network to check the accuracy. After the neural network seemed to be accurate, a new video was broken down and inputted into the neural network to test the accuracy. The DICE coefficient was used to compare the amount of area the neural network caught compared to the amount it missed. The DICE was used for 20 images in each category: pink and blue with one tool and pink and blue with two tools.

The neural network reported 95% in most tests. Each image took about 0.12 seconds to get segmented which demonstrates exceptional speeds along accuracy. Fluorescent blue images, motion blur and the low amount of variety from the training data all affected the accuracy of the neural network and are possible opportunities of improvement. If a more advanced neural network was used, false segmentations could've been avoided.

As seen from the project, it is clearly shown that neural networks have the potential to revolutionize the field of surgery.

7 Minute Speech

In recent years, there has been a growing trend towards the usage of robotic surgeries in the medical field. There are many benefits associated with these minimally invasive surgeries like reduced blood loss, smaller incisions, and much faster recovery rates. Sometimes fluorescent dyes are used, fluorescence guided surgery. However, one of the main challenges a surgeon faces with a robotic surgery is the surgeon's limited vision. According to a report on minimally invasive surgery performance errors, nearly 30% of surgical complications are caused by misrecognition during operations. Think of performing surgery as driving a vehicle. Driving has recently begun to implement artificial intelligence to lower human error traffic accidents by features that predict safe driving lanes based on obstacle recognition. Imagine if the exact same technology was used as a guide to support a surgeon's experience and skills.

To start off, it is necessary to understand what medical images are and why they play a part in this project. A medical image is a collection of measurements in two-dimensional or three-dimensional space. These images are used for something called segmentation. Medical image segmentation is the process of extracting the desired object from a medical image. This makes the image a lot simpler and

transforms the medical image into something meaningful. There are a multitude of benefits regarding medical image segmentation including assisting doctors with diagnosing and making decision in critical scenarios.

To create a type of artificial intelligence that can act as a guide, it is necessary to know the types of AI. Artificial intelligence is a term used to classify a machine that mimics human intelligence. However, there are subfields within subfields inside of artificial intelligence.

Machine learning is a subfield of artificial intelligence. It is the capability of a machine to imitate human behavior. First, data is inputted. The more data that is put inside, the more accurate the program becomes. Next, AI trainers choose a machine learning model to use, supply the data, and the computer model will train itself to find a pattern. This is how google translate was designed along with Google's search engine. Humans can perform that task but will never be able to match the speed and scalability of Google's machine learning algorithms. However, there are even further subfields within machine learning.

A neural network is a subfield of machine learning and will be the AI used for this project. Neural networks are referenced off the human brain where there are thousands of neurons that are interconnected with each receiving inputs, processing them, and generating an output. Neural networks are used for three main purposes: classification, sequence learning, and function approximation. Classifications tasks are tasks that call for labeled datasets for supervised learning. This is their best use and neural networks excel here as they can quickly apply labels while identifying patterns in hundreds of images. Sequence learning is a machine category that uses data sequences as input or output. Things like text stream and audio files are sequence learning. Function approximation is where a function is approximated by neural networks to match on examples of inputs and outputs. Each neural network is created for a unique reason as the depth, number of hidden layers, and input/output capabilities of each node are different. There are many types as seen on the report. There are 5 main components of a neural network: the input, weights, bias, activation function and output. The inputs are multiplied to the weights and then added in the summing junction along with the bias value. After that the activation function is applied and the output comes out. This is shown in the diagram here. This one simple equation and diagram resembles a perceptron, and a neural network is made of plenty of perceptrons. An output of one perceptron could be the input of another.

Deep learning is a subfield of neural networks that have many layers. They process extensive amounts of data. An example would be an image recognition system.

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There were 4 software used: Keras, MATLAB, ITK SNAP, and Python. Keras and Python was used to implement the network, MATLAB was for any processing, and ITK SNAP was for manual segmentation. Of course, a laptop was needed to use these 4 programs.

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video was broken down into 300 images. These 300 images were manually segmented through ITK SNAP. The next step was to input the training data into the machine via Keras, Python, and MATLAB. The machine learned which took about two hours. After two hours, the same train segmentations were inputted into the network to check the accuracy of the prediction segmentations. These images were beforehand turned to grayscale via MATLAB so that the network would distinguish through color intensity rather than color variance and would improve segmentation accuracy. After the neural network seemed to be accurate, a new video was broken down and inputted into the neural network to test the accuracy. The DICE coefficient was used to compare the amount of area the neural network caught compared to the amount it missed. The DICE was used for 20 images in each category: pink and blue with one tool and pink and blue with two tools.

The neural network reported amazing accuracy, around 95% in most tests. In particular, the network exhibited a higher accuracy when identifying under normal conditions. Each image took about 0.12 seconds to get segmented which demonstrates exceptional speeds along accuracy. Images that were colored pink and with two tools had the lowest drop. While segmenting blue images, the network struggled the most, likely from color variance issues. There was also an issue of motion blur which may have created false segmentations. Another possible reason for the accuracy might have been from the training data only being from one video. It also appears that the neural network had issues when more tools were added.

As seen from the project, it is clearly shown that neural networks have the potential to revolutionize the field of surgery. Some opportunities to improve the project would be to add more training data, use a more advanced neural network model so motion blur doesn't affect as much, and to improve the accuracy of the manual segmentations.