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D01-1121-0081-16

INTERNSHIP PROJECT REPORT

Submitted for the course: Summer Project

Internship

By

SNEHASHIS CHATTERJEE

D01-1121-0081-16

Done at:

RAD365 Technologies Inc

CERTIFICATE

This is to certify that this project report entitled, 'Implementing Deep Learning in the field of Radiology and Health Care using Python' that is being submitted by Snehashis Chatterjee, a bonafide student of 'Institute of Radio Physics, University College Of Science and Technology, University of Calcutta', Reg No. D01-1121-0081-16 for 'Summer Project Internship 2019' is a bonafide record of work carried out under my guidance and supervision. The contents of this internship, in full or in parts, neither have been taken from any other source nor have been submitted for any other course.

Place: RAD365 Technologies Inc, 7th Floor, 37/1 GN Block, Asyst Park, Sector V, Bidhannagar, Kolkata, West Bengal 700091

Period: June 03th 2019 to July 10th 2019

Signature of the student: _____

(SNEHASHIS CHATTERJEE)

Signature of the Instructors and project guides:

_____

(Mr. Nirendu Konar, Project Guide)

_____

(Mr. Aloke Kumar Dey, CTO at RAD365)

Acknowledgement

The project, ‘Deep Learning in Medical Health care’ has provided me with ample scope of learning through collaborative activities. I wish to place on record my words of gratitude to Dr Sanjib Pal for being the enzyme behind my internship programme. I consider myself fortunate to work under Mr.Nirendu Konar whose scaffolding made project-based learning quite joyful. I am grateful to him.

Dr Tapan Kumar Biswas, Mr.Upasak Pal, have rendered important suggestions for the improvement of the project work. I cannot help acknowledging their continuous guidance and contributions with gratitude.

I express my sentiment of gratitude to my parents, my friends for their continuous support and motivation.

I am also thankful to my teachers who have helped me to carry out the project work.

Signature of Student

Introduction

In this summer internship, I developed some very effective and useful Deep Learning CNN based models for various datasets.

The first project is a multiclass classification problem, where I develop a Transfer learning based CNN model for four classes (1 for meningioma, 2 for glioma, 3 for pituitary tumour 4 for Normal).

The second project is a binary segmentation problem, where I develop an Encoder-Decoder based CNN model for segmentation.

The third project is a multiclass segmentation problem, where I develop an Encoder-Decoder based CNN model for segmenting spinal cord from MRI image.

The fourth project is a segmentation problem, where I develop an Encoder-Decoder based CNN model for four classes (1 for meningioma, 2 for glioma, 3 for pituitary tumour 4 for Normal) segmentation.

Technologies Involved

In this summer internship, I developed all the Deep Learning CNN models in Python Programming language. During this Internship, I used Python Keras, Scikit-learn, Opencv, Skimage, Numpy, Pandas, and Matplotlib etc libraries.

The models are developed in Dell Laptop, configuration: 32GB DDR4 RAM, 200GB SSD, NVIDIA GEFORCE 1050TI GPU.

Python:

Python is an interpreted, high-level, general-purpose programming language. Created by Guido van Rossum and first released in 1991, Python's design philosophy emphasizes code readability with its notable use of significant whitespace.

Libraries:

Keras:

Keras is an open-source neural network library written in Python. It is capable of running on top of TensorFlow, Microsoft Cognitive Toolkit, Theano, or PlaidML. Designed to enable fast experimentation with deep neural networks, it focuses on being user-friendly, modular, and extensible.

Scikit-learn:

Scikit-learn (formerly scikits.learn) is a free software machine learning library for the Python programming language. It features various classification, regression and clustering algorithms including support vector machines, random forests, gradient boosting, k-means and DBSCAN, and is designed to interoperate with the Python numerical and scientific libraries NumPy and SciPy.

Numpy:

NumPy is a library for the Python programming language, adding support for large, multi-dimensional arrays and matrices, along with a large collection of high-level mathematical functions to operate on these arrays.

Pandas:

In computer programming, Pandas is a software library written for the Python Programming language for data manipulation and analysis. In particular, it offers Data structures and operations for manipulating numerical tables and time Series.

Matplotlib:

Matplotlib is a plotting library for the Python programming language and its numerical mathematics extension NumPy. It provides an object-oriented API embedding plots into applications using general-purpose GUI toolkits like Tinker, wxPython, Qt, or GTK+.

Opencv:

OpenCV is a library of programming functions mainly aimed at real-time computer vision. Originally developed by Intel, it was later supported by Willow Garage then Itseez.

Skimage:

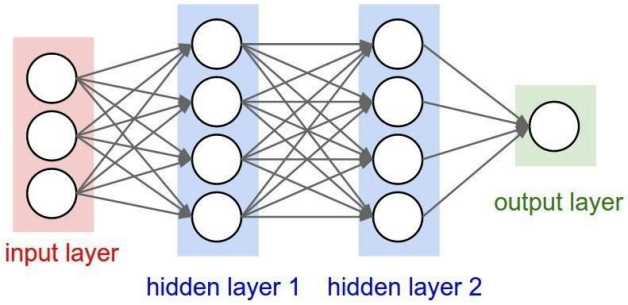
Scikit-image is a Python package dedicated to image processing and using natively NumPy arrays as image objects. For basic image manipulation, such as image cropping or simple filtering, a large number of simple operations can be realized with NumPy and SciPy only.

Brief introduction about Radiology

Radiology is a medical speciality that uses medical imaging to diagnose and treat diseases within the human body. A variety of imaging techniques such as X-ray radiography, ultrasound, computed tomography (CT), nuclear medicine including positron emission tomography (PET), and magnetic resonance imaging (MRI) are used to diagnose or treat diseases. Interventional radiology is the performance of usually minimally invasive medical procedures with the guidance of imaging technologies such as X-ray radiography, ultrasound, computed tomography (CT), nuclear medicine including positron emission tomography (PET), and magnetic resonance imaging(MRI).

Brief introduction about Deep learning

During recent years, deep learning has become somewhat of a buzzword in the Tech Community. We always seem to hear about it in the news regarding AI, and yet most people don't actually know what it is! In this article, I'll be demystifying the buzzword that is deep learning and providing an intuition of how it works. Deep Learning Algorithms use something called a neural network to find associations between a set of inputs and outputs. A neural network is composed of input, hidden, and output layers — all of which are composed of "nodes". Input layers take in a numerical representation of data (e.g. images with pixel specs), output layers output predictions, while hidden layers are correlated with most of the computation.



Advantages of Deep learning-based systems

Deep learning has turned applications that previously required vision expertise into engineering challenges solvable by non-vision experts. Deep learning transfers the logical burden from an application developer, who develops and scripts a rules-based algorithm, to an engineer training the system. It also opens a new range of possibilities to solve applications that have never been attempted without a human inspector. In this way, deep learning makes machine vision easier to work with, while expanding the limits of what a computer and camera can accurately inspect.

Deep learning in healthcare is the use of complex algorithms and software to estimate human cognition in the analysis of complicated medical data. The primary aim of health-related AI applications is to analyze relationships between prevention or treatment techniques and patient outcomes.

Project 1:Design a Classification model using Deep Learning CNN network for Brain tumours (Multiclass)

Dataset Description:

This brain tumour dataset contains 3064 T1-weighted contrast-enhanced images from 233 patients with three kinds of brain tumour: meningioma (708 Glioma (1426 slices), and pituitary tumour (930 slices). Due to the file size limit of the repository, we split the whole dataset into 4 subsets, and achieve them with Zip files with each .zip file containing 766 slices. The 5-fold cross-validation Indices are also provided.

This data is organized in the Matlab data format (.mat file). Each file stores a struct containing the following fields for an image: l: 1 for meningioma, 2 for glioma, and 3 for pituitary tumour data.PID: patient ID cjdata.image: image data cjdata.tumorBorder: a vector storing the coordinates of discrete points on tumour border. For example, [x1, y1, x2, y2...] in which x1, y1 are planar coordinates on the tumour border. It was generated by manually delineating the tumour border. So we can use it to generate binary images of tumour masks. cjdata.tumorMask: a binary image with 1s indicating tumour region. Later I add some 'Normal Healthy' brain images and make it a 4 class classification dataset.

Technologies Involved:

- For Deep Learning Model Development: Keras
- For image preprocessing: Opencv
- For image storing and visualization: Numpy, Matplotlib

Network Architecture:

I used the VGG16 network, pre-trained on image net weights and fine Tuned this network. Transfer learning is a machine learning technique where a model trained on one task is repurposed on a second related task. Transfer learning is the improvement of learning in a new task through the transfer of knowledge from a related task that has already been learned.

Results:

This is a multiclass classification project, where 1 for meningioma, 2 for glioma, 3 for pituitary tumour 4 for Normal.

The final testing accuracy is 87%.

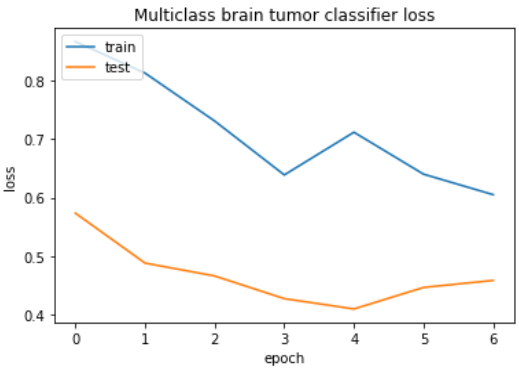
The test confusion matrix and test classification report are given below:

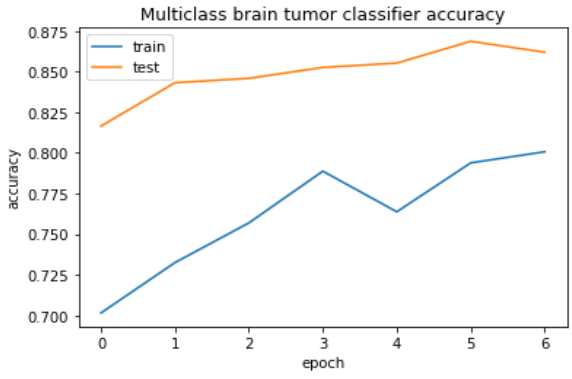
```
Confusion matrix:
[[ 15   0   0   0]
 [  0 131  30  11]
 [  0  22 233   3]
 [  0   3  10 177]]


Classification report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        15
           1       0.84      0.76      0.80       172
           2       0.85      0.90      0.88       258
           3       0.93      0.93      0.93       190

    accuracy                           0.88       635
   macro avg       0.90      0.90      0.90       635
weighted avg       0.88      0.88      0.87       635
```





Project 2: Design a Segmentation model using Deep Learning CNN network for Brain tumours (Binary segmentation)

Dataset Description:

This brain tumour dataset contains 3064 T1-weighted contrast-enhanced images from 233 patients with three kinds of brain tumour: meningioma (708 Glioma (1426 slices), and pituitary tumour (930 slices). Due to the file size limit of the repository, we split the whole dataset into 4 subsets, and achieve them with Zip files with each .zip file containing 766 slices. The 5-fold cross-validation Indices are also provided.

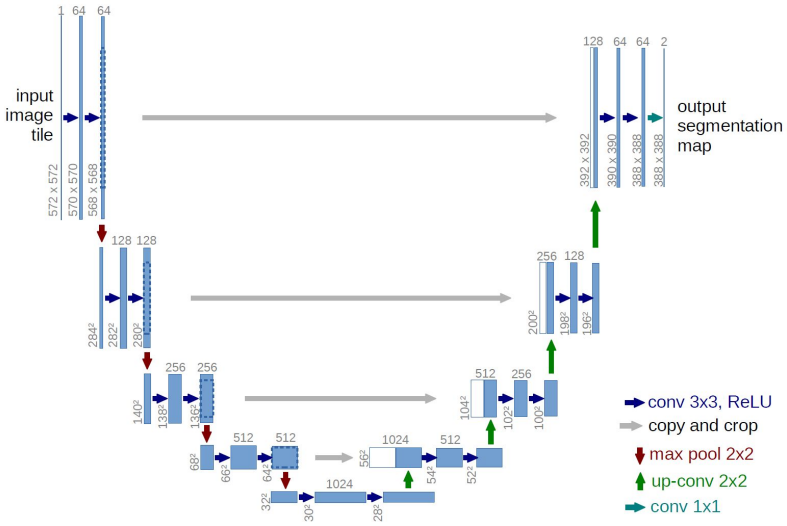
This data is organized in the Matlab data format (.mat file). Each file stores a struct containing the following fields for an image: data.label: 1 for meningioma, 2 for glioma, and 3 for pituitary tumour data.PID: patient ID cjdata.image: image data cjdata.tumorBorder: a vector storing the coordinates of discrete points on tumour border. For example, [x1, y1, x2, y2...] in which x1, y1 are planar coordinates on tumour border. It was generated by manually delineating the tumour border. So we can use it to generate binary images of tumour masks. cjdata.tumorMask: a binary image with 1s indicating tumour region. Later I add some 'Normal Healthy' brain images and make it a 4 class classification dataset.

Technologies Involved:

- For Deep Learning Model Development: Keras
- For image preprocessing: Opencv
- For image storing and visualization: Numpy, Matplotlib

Network Architecture:

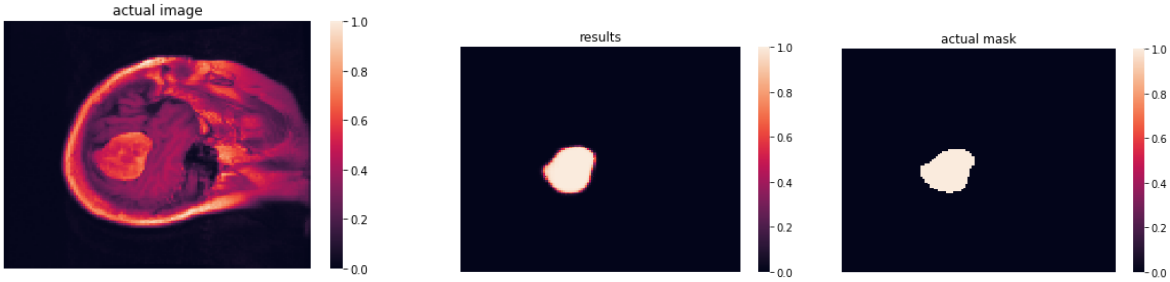
I used an Encoder-Decoder based 'Unet CNN model for Segmentation.

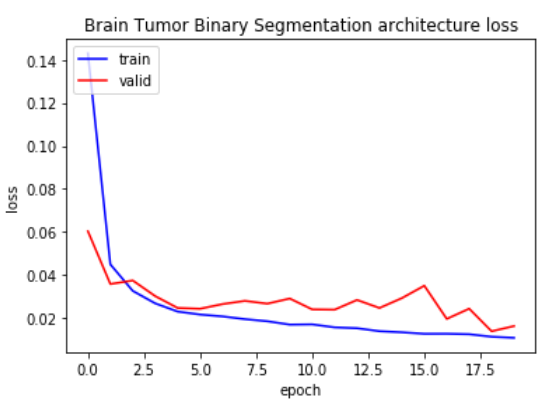


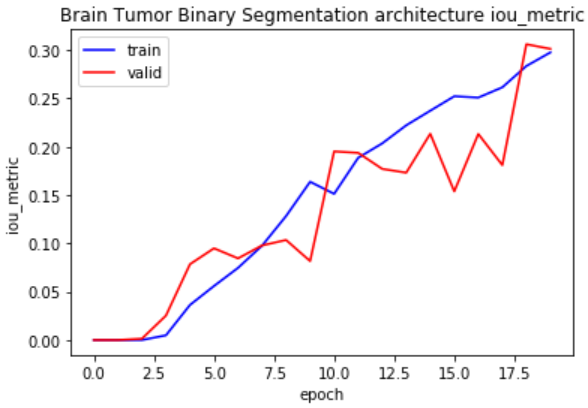
Results:

My output metric is IOU score and loss function is IOU loss.

Some output result in test cases are shown below:







Project 3: Design a Segmentation model using Deep Learning CNN network for spinal cord

Dataset Description:

The dataset contains MRI images of backbone skeletons. The Dataset is divided into two parts: images and mask. Image set contains total backbone MRI skeleton images and the mask set contains only spinal cord images.

Project target segments spinal cord bones from total backbone images.

Technologies Involved:

- For Deep Learning Model Development: Keras
- For image preprocessing: Opencv
- For image storing and visualization: Numpy, Matplotlib

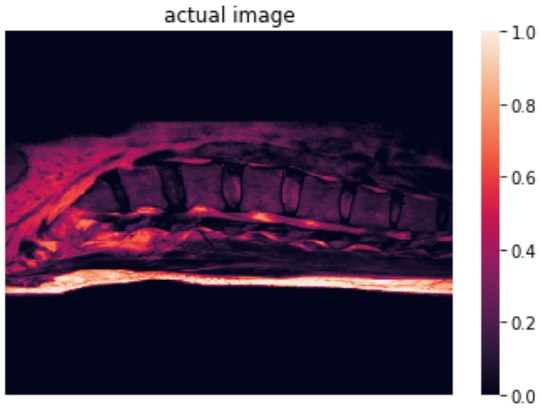
Network Architecture:

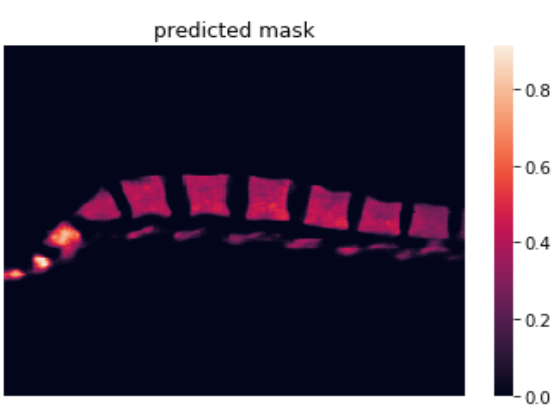
I used an Encoder-Decoder based ’Unet’ CNN model for segmentation.

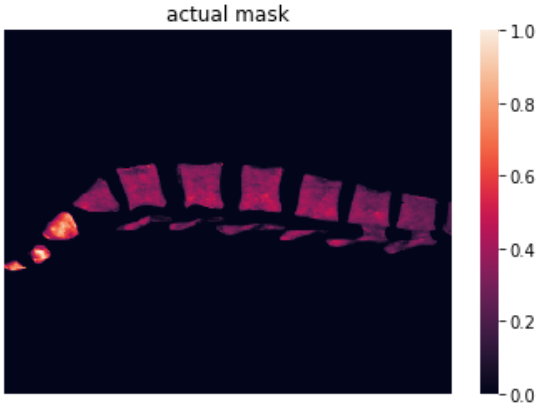
Results:

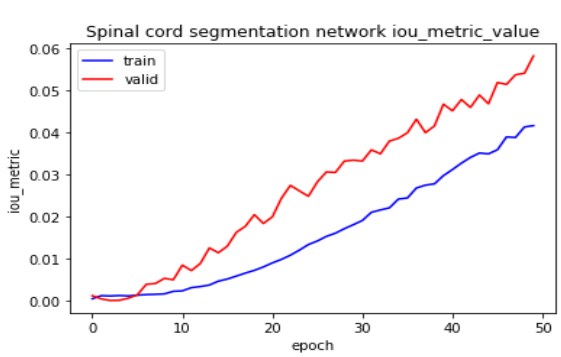
My output metric is IOU score and loss function is IOU loss.

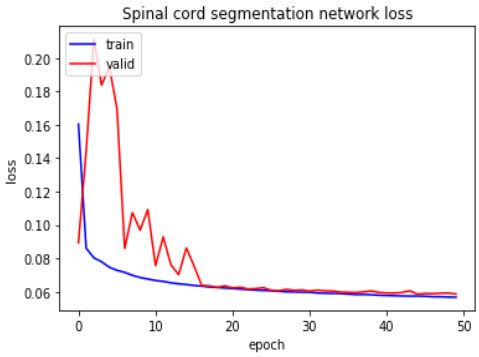
Some output result in test cases are shown below:


actual image
1.0
0.8
0.6
0.4
0.2
0.0


predicted mask
0.8
0.6
0.4
0.2
0.0


actual mask
1.0
0.8
0.6
0.4
0.2
0.0


Spinal cord segmentation network iou_metric_value
train
valid
iou_metric
epoch


Spinal cord segmentation network loss
train
valid
loss
epoch

Project 4: Design a Segmentation model using Deep Learning CNN network for Brain tumours (Multiclass)

Dataset Description:

All images are stored assigned 16-bit integers, but only positive values are used. The manual segmentations (Truth) of the patient images have the following four different labels:

- 1 for necrosis
- 2 for edema
- 3 for non-enhancing tumour
- 4 for enhancing tumour
- 0 for everything else

The evaluation is done for 3 different tumour sub-compartments:

- Region 1: complete tumor (labels 1+2+3+4 for patient data, labels 1+2 for synthetic data)
- Region 2: Tumor core (labels 1+3+4 for patient data, label 2 for synthetic data)
- Region 3: Enhancing tumour (label 4 for patient data, n.a. for synthetic data)

Technologies Involved:

- For Deep Learning Model Development: Keras
- For image preprocessing: Opencv
- For image storing and visualization: Numpy, Matplotlib

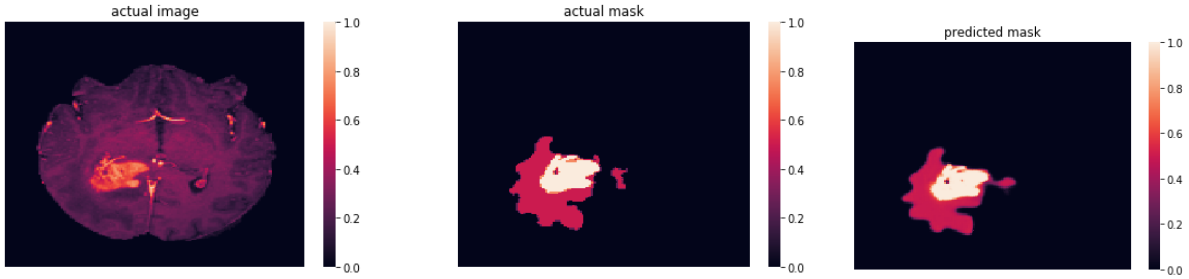
Network Architecture:

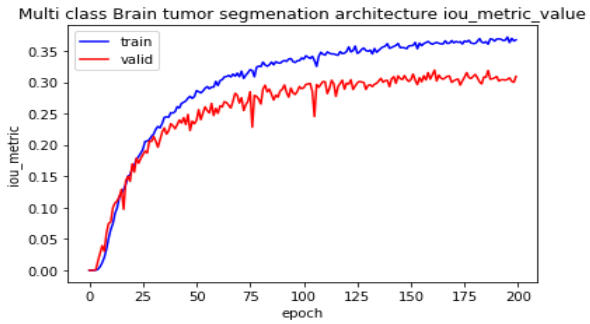
I used an Encoder-Decoder based ’Unet’ CNN model for Segmentation.

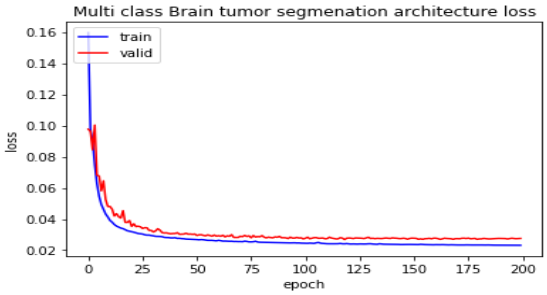
Results:

My output metric is IOU score and loss function is IOU loss.

Some output result in test cases are shown below:


actual image
actual mask
predicted mask
1.0
0.8
0.6
0.4
0.2
0.0


Multi class Brain tumor segmenation architecture iou_metric_value
train
valid
iou_metric
epoch
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
0
25
50
75
100
125
150
175
200


Multi class Brain tumor segmenation architecture loss
train
valid
loss
epoch
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
25
50
75
100
125
150
175
200

Future Prospects of Deep learning in the Healthcare field

With an increase in the use of AI, more care may become available to those in developing nations. AI continues to expand in its abilities and as it is able to interpret radiology, it may be able to diagnose more people with the need for fewer doctors as there is a shortage in many of these nations. The goal of AI is to teach others in the world, which will then lead to improved treatment and eventually greater global health. Using AI in developing nations who do not have the resources will diminish the need for outsourcing and can use AI to improve patient care. For example, Natural language processing, and machine learning are being used for guiding cancer treatments in places such as Thailand, China and India. Researchers trained an AI application to use NLP to mine through patient records, and provide treatment. The ultimate decision made by the AI application agreed with expert decisions 90% of the time.