Image Processing and Machine Learning for Tumor Detection Using MRI Images

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Abstract

Bacterial Based Cancer Therapy is a new cancer treatment where bacteria are genetically engineered to induce the production of the anti-cancer drug from within the tumor. Previous research tracked the progression of the treatment by observing Diffusion-Weighted MRI scans. By combining a convolutional neural network with traditional image processing techniques, we develop a method to automate the analysis of the MRI images.

Method

Several image processing algorithms were compared and then each individual image processing technique was tested separately on the original MRI images. Various techniques from the algorithms were then used to create a new, more efficient algorithm for processing the images. The provided data set consisted of 42 MRI images of the tumors, so various augmentations were performed to grow the data set from 42 to 14,400 to train a U-Net. The convolutional neural network was used to predict a binary mask of the tumor and crop the images and was finally integrated into the existing algorithm, replacing the preprocessing step and omitting the necessity to manually perform these operations.

Method

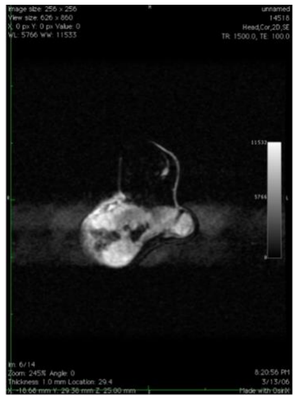
The final algorithm consists of three steps: Preprocessing, which utilizes the U-Net, processing, which performs various morphological operations, contrast adjustments, and binary thresholding, and the postprocessing step where the total volume of the tumor, dead tumor tissue, and live tumor tissue are calculated to determine the effectiveness of the cancer treatment.

U-Net

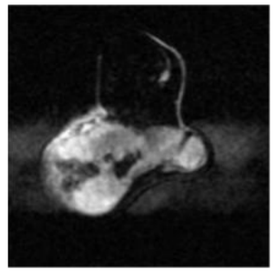
The U-net predicts a binary mask that represents the shape of the tumor in an MRI image. After the neural network identifies the tumor, the image is cropped, and processing techniques are applied. First, MRI images, scaled at 860 x 632 x 3, are read as grayscale and subsequently reduced to 860 x 632. The center of brightness is found using the following equation, where *Irc* denotes the pixel value of the image *I* at row *r* and column *c*. The program then crops a 400 x 400 image centered around (Centerx , Centery) and resizes the image to 224 x 224 .

Results

The neural network was trained on a total of 14400 images and was able to identify tumor pixels with a testing accuracy of 97.81 percent.

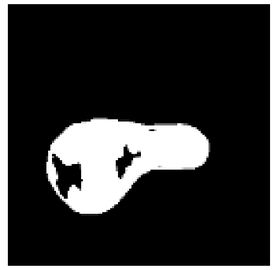


Original 860 x 632 x 2 MRI Image

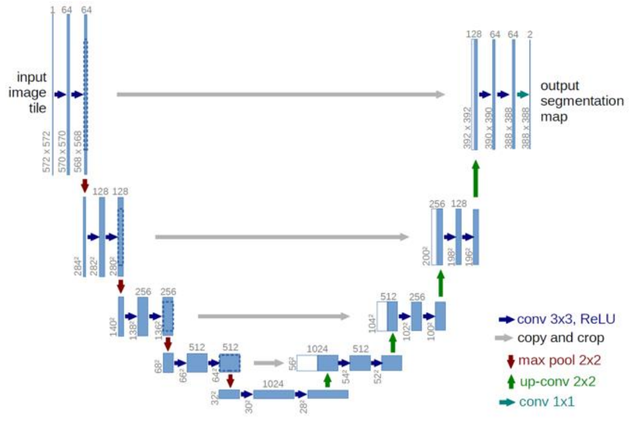


224 x 224 Image after preprocessing of U-Net

Mask Predicted by the U-Net



Tumor with Dead Regions Identified



Conclusion & Future Work

Using a convolutional neural network to identify tumor tissue in an MRI scan and image processing techniques to isolate living tumor tissue, we track the progression of salmonella-mediated cancer therapy and eliminate the need for expert analysis. We note that our initial data set of 42 images may lack the diversity needed to generalize our neural network and may lead to an overtrained network. Future work can take advantage of a larger initial dataset and improve on the ability to generalize our process. Additional work would include refining the algorithm and combining the U-Net, programmed in Python, with the processing and post-processing steps that were implemented in MATLAB.

Data Set	Dead Tumor Volume	Percent of Dead Tumor
1	52102 pixel^3	69.8287%
2	86940 pixel^3	36.9973%
3	27445 pixel^3	21.6479%
4	20605 pixel^3	13.2723%

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