Automatic Segmentation of Hepatocellular Carcinoma Based on Deep Learning and Convolutional Neural Networks (CNN)

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Introduction

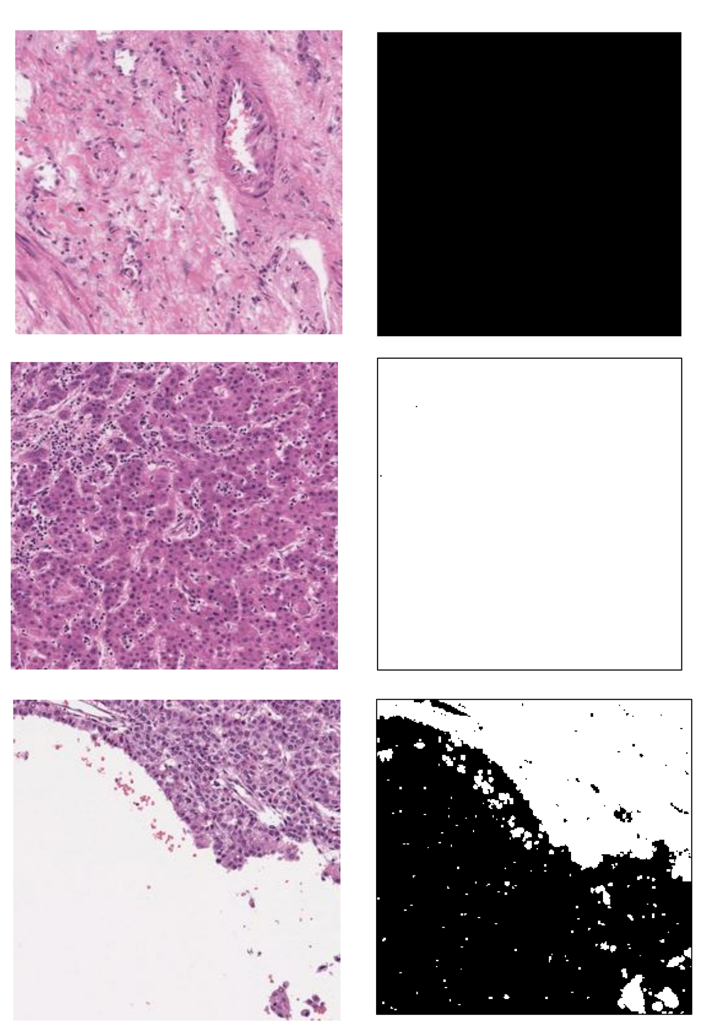
- The liver is a vital organ often associated with metastatic spread of cancer. 90% of primary liver cancer is represented by Hepatocellular Carcinoma (HCC), as the number of HCC cases have increased by 75% from 1990-2015, and it is amongst the leading sources of cancer mortality globally [1].
- The viable tumor burden can be defined as the ratio of viable tumor area to the whole area of the tumor, and it is required to evaluate response rates for chemotherapy [1].

The goal of this project is to use Whole Slide Imaging (WSI) to produce an algorithm for automated detection of liver cancer by

1. Segmenting the cancerous area

2. Estimating the viable tumor burden[1]

- WSI data given is annotated by pathologists by providing masks that cover the non-cancerous parts and isolate the cancerous parts. These images were cropped into multiple patches for data augmentation.



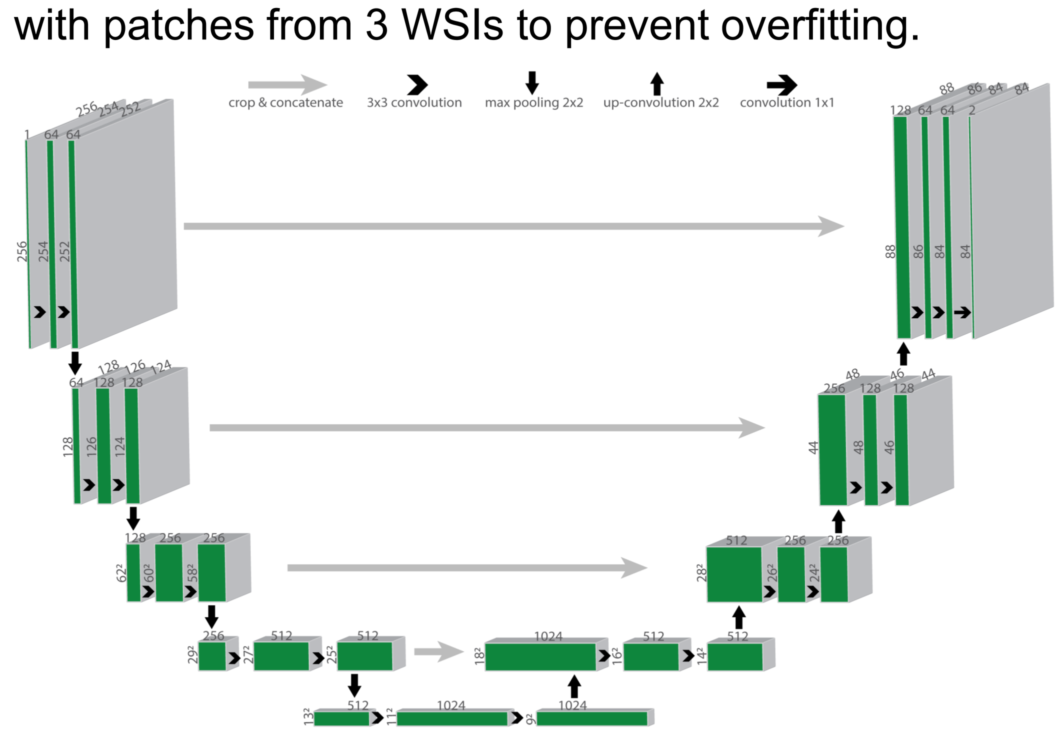
Non-cancerous part of liver and its mask

Cancerous part of liver and its mask

Partially cancerous part of liver and its mask

Methodology

- **Dataset** : The dataset, including the masks and the WSIs, was divided into 2 groups :
  1. Training set (3 WSIs = 6,616 patches)
  2. Validation set (20% of the training set = 1,323 patches)
- **Data preparation**: The WSIs were converted to grayscale and all of the data were down-sampled by a factor of 4. These images were then chopped into smaller patches of size 256 x 256 which were fed to the U-Net architecture.
- **U-Net training** : U-Net is a fully convolutional neural network that was developed for biomedical image segmentation. Its architecture was modified and extended to work with fewer training images and to yield more precise segmentations [2]. The network was trained with patches from 3 WSIs to prevent overfitting.



The U-Net architecture used in this project

- **Validation** : The results obtained after training were validated with the original mask, and hyper-parameters were adjusted to optimize the similarity of the two.

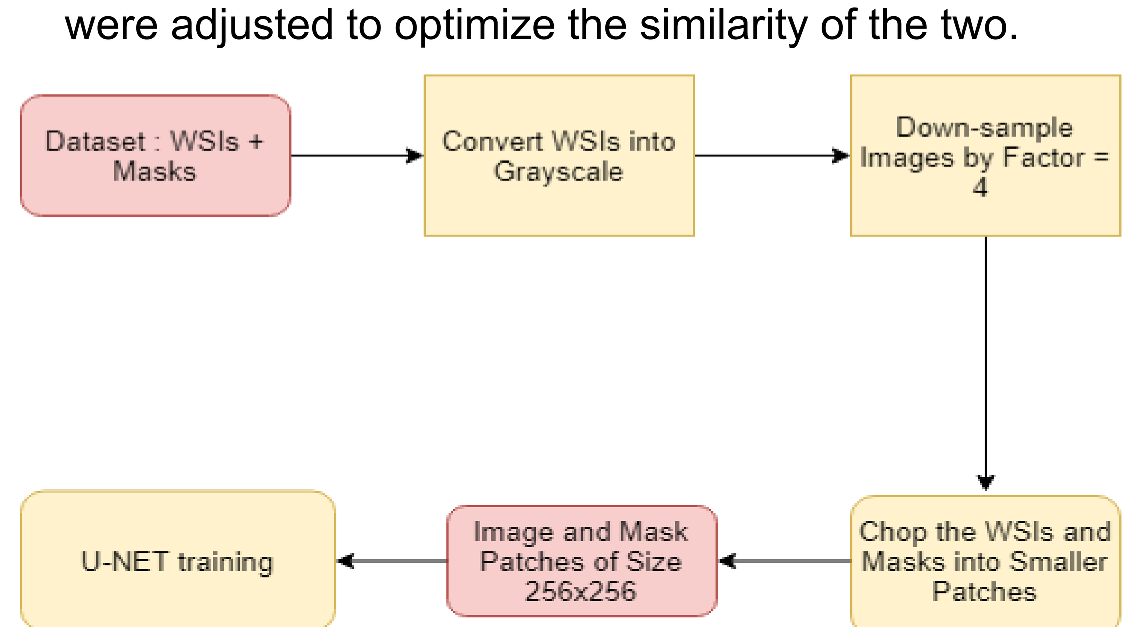
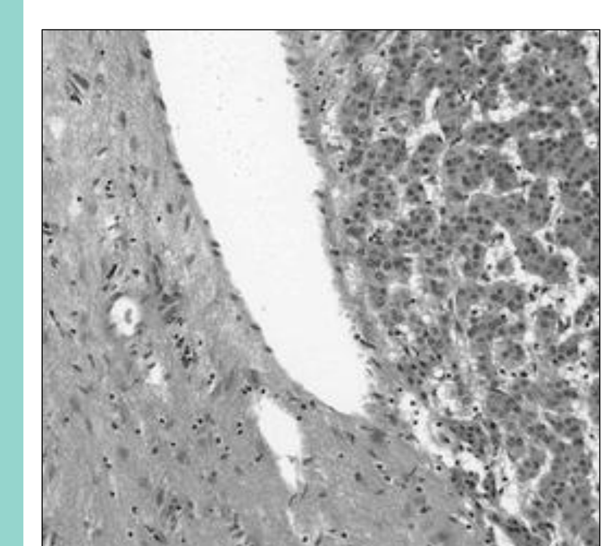


Illustration of the data preparation steps

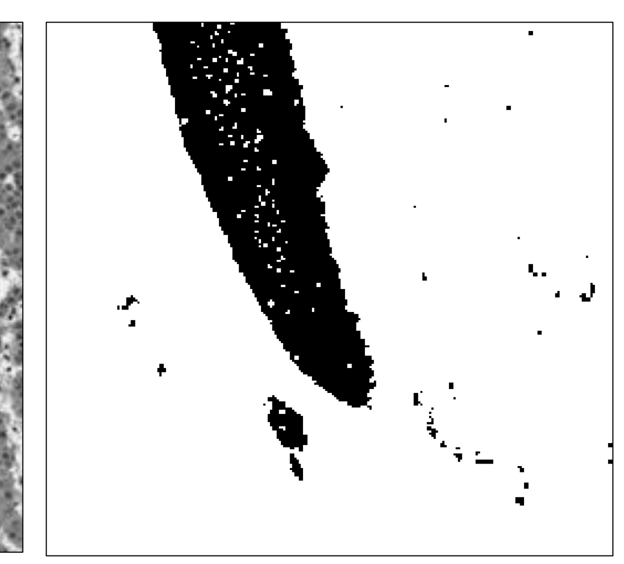
Results

- To determine the accuracy of the results, the Dice Similarity Coefficient (DSC) was determined. DSC is a tool used to determine the difference between two samples, the generated mask and the ground truth mask [3].

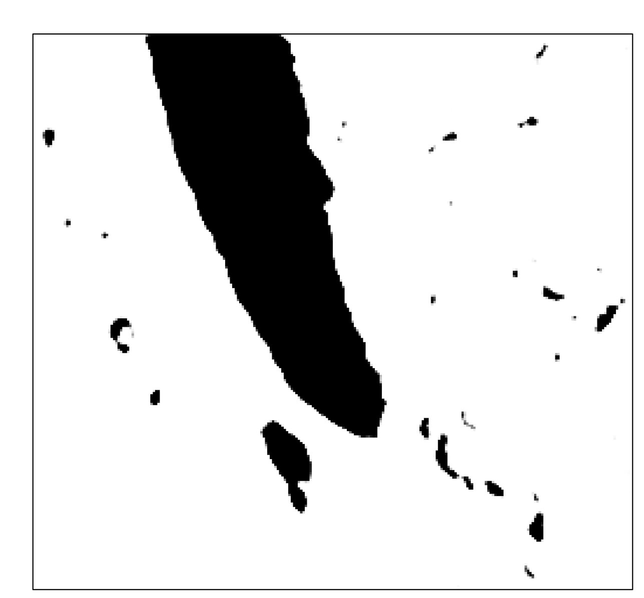
The highest regional overlap using the DSC metric obtained in this project using 3 WSIs and 6613 patches was 0.62, or 62%.



Original WSI sample in greyscale



Ground Truth Mask

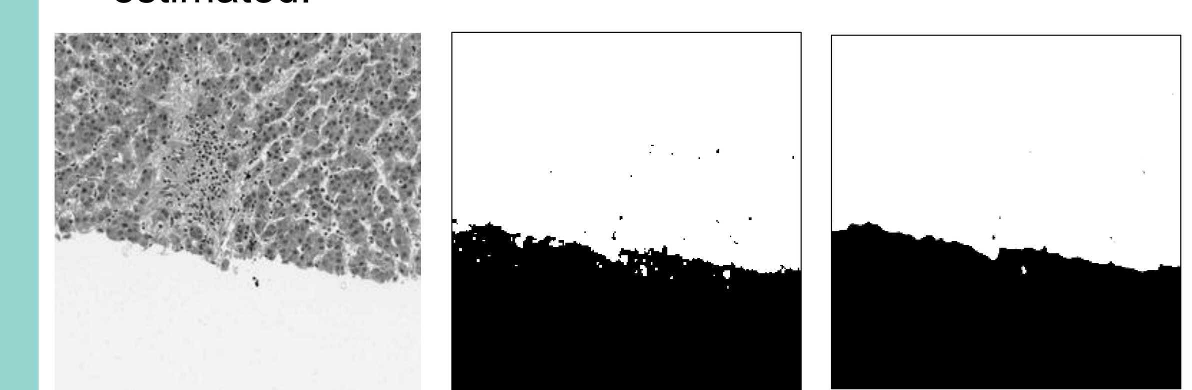


Predicted Mask

- As shown above, the UNET algorithm was able to segment the cancerous area and produce an acceptable mask.

Conclusion and Future Work

- U-Net was trained to perform cancer segmentation of the liver using WSI data provided by Seoul National University Hospital
- Study demonstrated that using this method, a minimum Dice Coefficient of 0.62 can be obtained.
- These results will be improved upon in the future by using more data images changing the hyper-parameters accordingly, while ensuring overfitting is prevented.
- With further training, it is expected to see the Dice Coefficient increase, which in turn would mean increased accuracy.
- In the future, the viable tumor burden will also be estimated.



Original WSI sample

Corresponding Ground Truth Mask

Predicted mask with parameters used to obtain a DSC of 0.62

References

1. “PAIP 2019: Liver Cancer Segmentation,” Grand Challenges in Biomedical Image Analysis, 2019. [Online]. Available: https://paip2019.grand-challenge.org/Dataset/. [Accessed: 01-Aug-2019].
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Acknowledgements

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