NATIONAL INSTITUTE OF TECHNOLOGY
KARNATAKA, SURATHKAL

AUTO-SEGMENTATION OF BRAIN TUMOUR IN MRI

Department of Electronics and Communications

MINOR PROJECT
EC788

FAHEEM V
232SP007

OVERVIEW

- Introduction
- Problem Statement
- Objective
- Dataset Analysis
- U-Net
- Methodology
- Results

INTRODUCTION

- 5-year relative survival rate for a cancerous brain tumour is almost 36%
- Types of tumours
  - Primary and Secondary (metastatic) tumours
  - Malignant (cancerous) and benign (non-cancerous) tumour
- Severity of symptoms depends on size and position of tumour
- Imaging techniques - MRI, CT Scan, etc

Every year 40,000 to 50,000 patients are diagnosed with brain tumour in India : Dhingra

RN KHERA
CHANDIGARH, JUNE 7

To create awareness on "World Brain Tumor Day" surgical neurology experts from Paras Hospitals Panchkula addressed the media today. Present on the occasion were Dr. Anil Dhingra Associate Director Neuro & Spine Surgery, Dr Ajay Bisht Consultant Neuro Surgery and Dr Sonia kapil, Associate consultant Neuro Anesthesia from Paras Super Specialty Hospital Panchkula.

Addressing the media, Dr. Anil Dhingra said, "June 8th is celebrated as world Brain tumor day. This day was initiated by German Brain tumor Association in the year 2000 with the aim to spread awareness about this lethal disease. Several researches have been going on for the treatment of Brain tumors. Brain tumors are devastating lesions that affect the nerve centre of the body. All our functions, from eating to speaking to walking etc, and all our emotions, from love to hate, are controlled by the brain, the spinal cord and nerves that are intimately connected. The brain is housed in a rigid shell (skull) and body maintains a rather homogenous atmosphere, air conditioned & shock proof, inside the skull.

Abnormal growth of tissues inside the skull leads to the formation of a "tumor" which causes local destruction and pressure on surrounding normal tissues." Unlike the widespread defeatist ... about brain tumor, many patients of the disease can be cured with current advances in technology and early detection, doctors said on the World Brain Tumor Day. Explaining further he said, "These tumors can be malignant (cancerous) or benign (non-malignant). Malignant brain tumors, mostly, arise from brain matter (intrinsic) and can only be controlled for variable periods of time – after using all the various modalities of treatment available (surgery followed by radiotherapy and chemotherapy).

But they differ from cancers of rest of body in that they do not metastasize (i.e. spread to other parts of body). Benign tumors, on the other hand, originate mostly from ...

INTRODUCTION

WHY AUTO SEGMENTATION?

- Early and accurate detection is crucial in treatment planning
- Time efficient
- Enhanced precision
- Ability to Process Large Volumes of Data
- Reduced inter observer variability

PROBLEM STATEMENT

Manual segmentation of brain tumours presents significant challenges, including inter-observer variability, time inefficiency, susceptibility to human error, limited scalability, and difficulties in handling heterogeneous or big datasets

NATIONAL INSTITUTE OF TECHNOLOGY
KARNATAKA, SURATHKAL

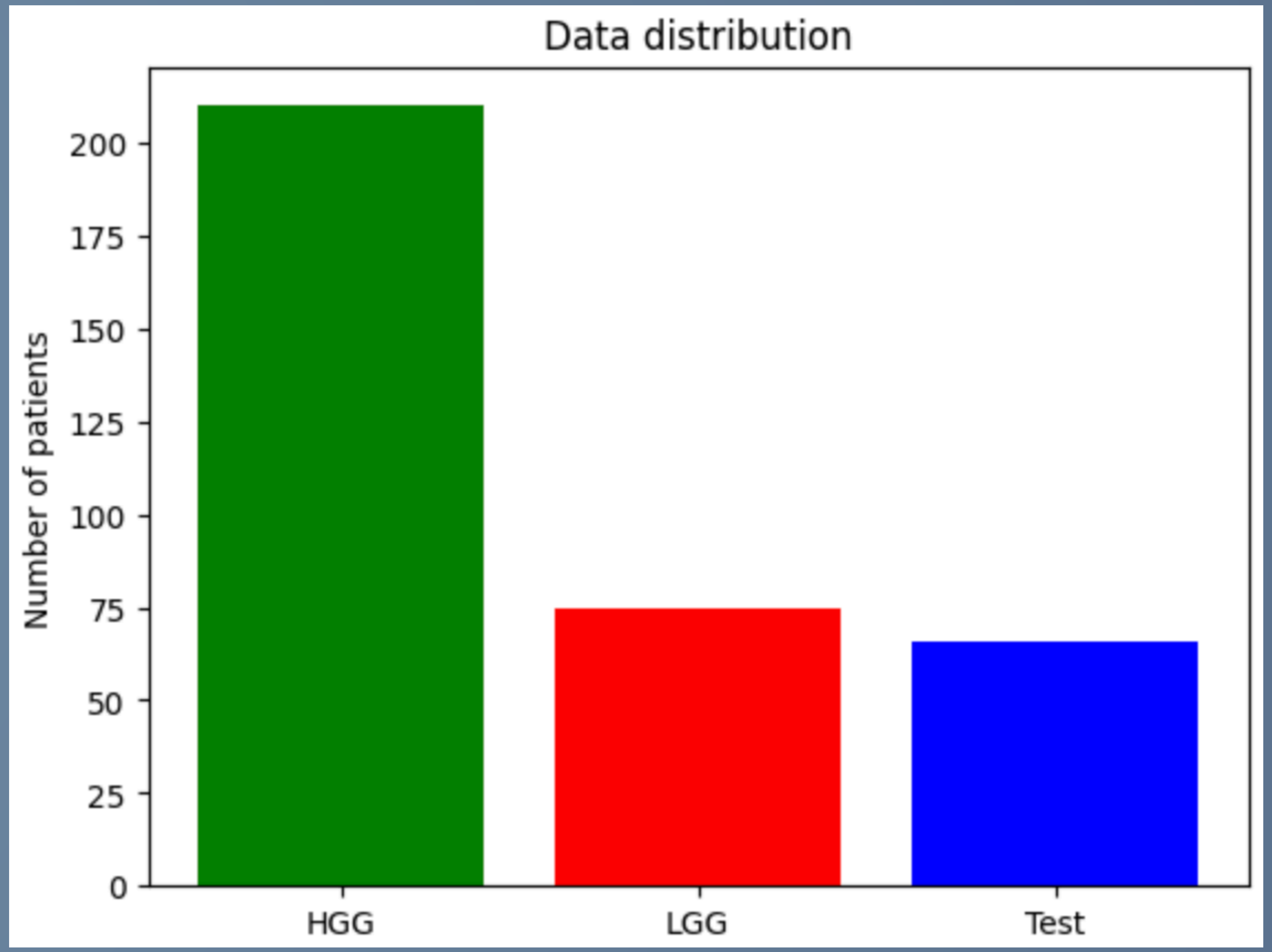
OBJECTIVE

“To build deep learning model for auto segmentation of brain tumour in MRI ”

DATASET ANALYSIS

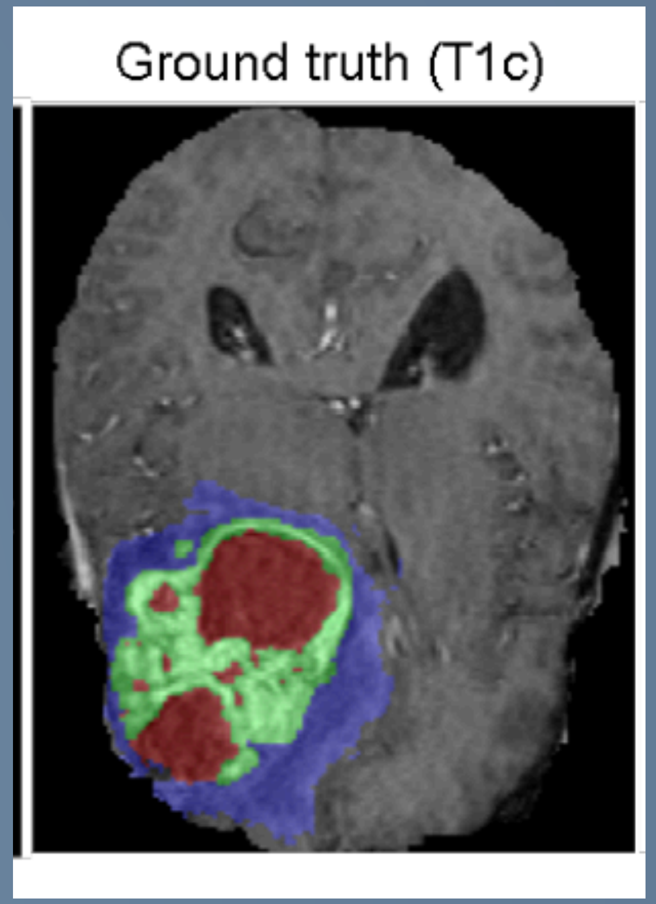
MICCAI BRATS 2018

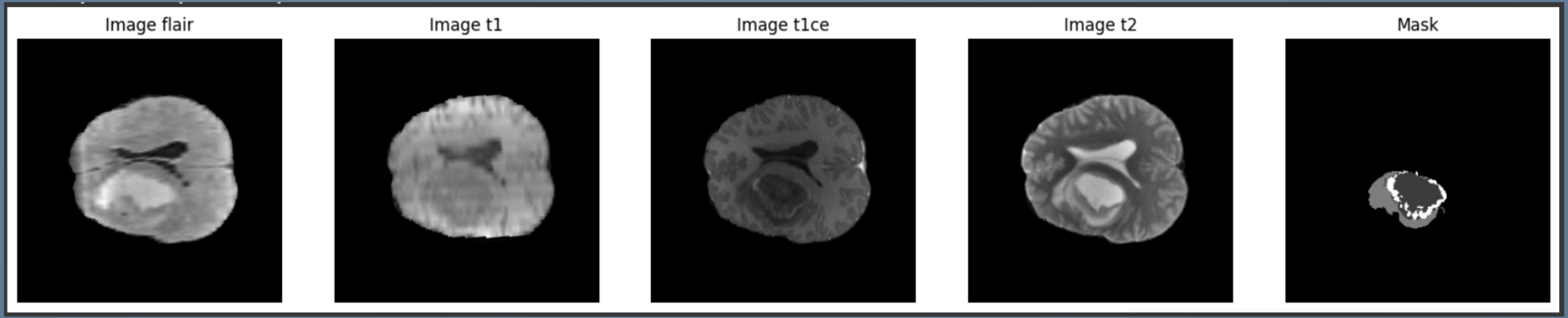
- Benchmark dataset for BT detection algorithms assessment
- Data for two grades of glioma
  - HGG: High-Grade Glioma
  - LGG: Low-Grade Glioma
- Training data size- 210 HGG, 75 LGG   Testing data size- 67
- Survival data (Age, Survival, ResectionStatus)



DATASET ANALYSIS

- 4 modalities (T1-weighted, T2-weighted, FLAIR, T1-weighted with contrast)
- Volumetric data - 240 x 240 x 155
- Nifty images

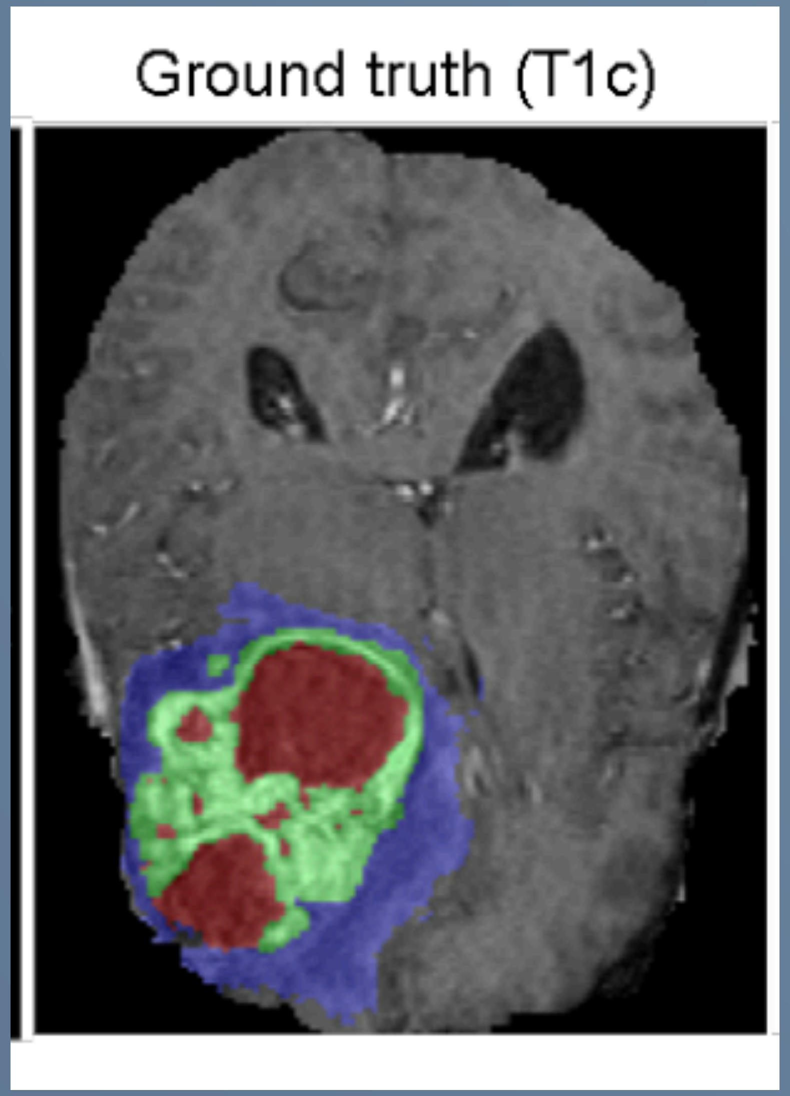


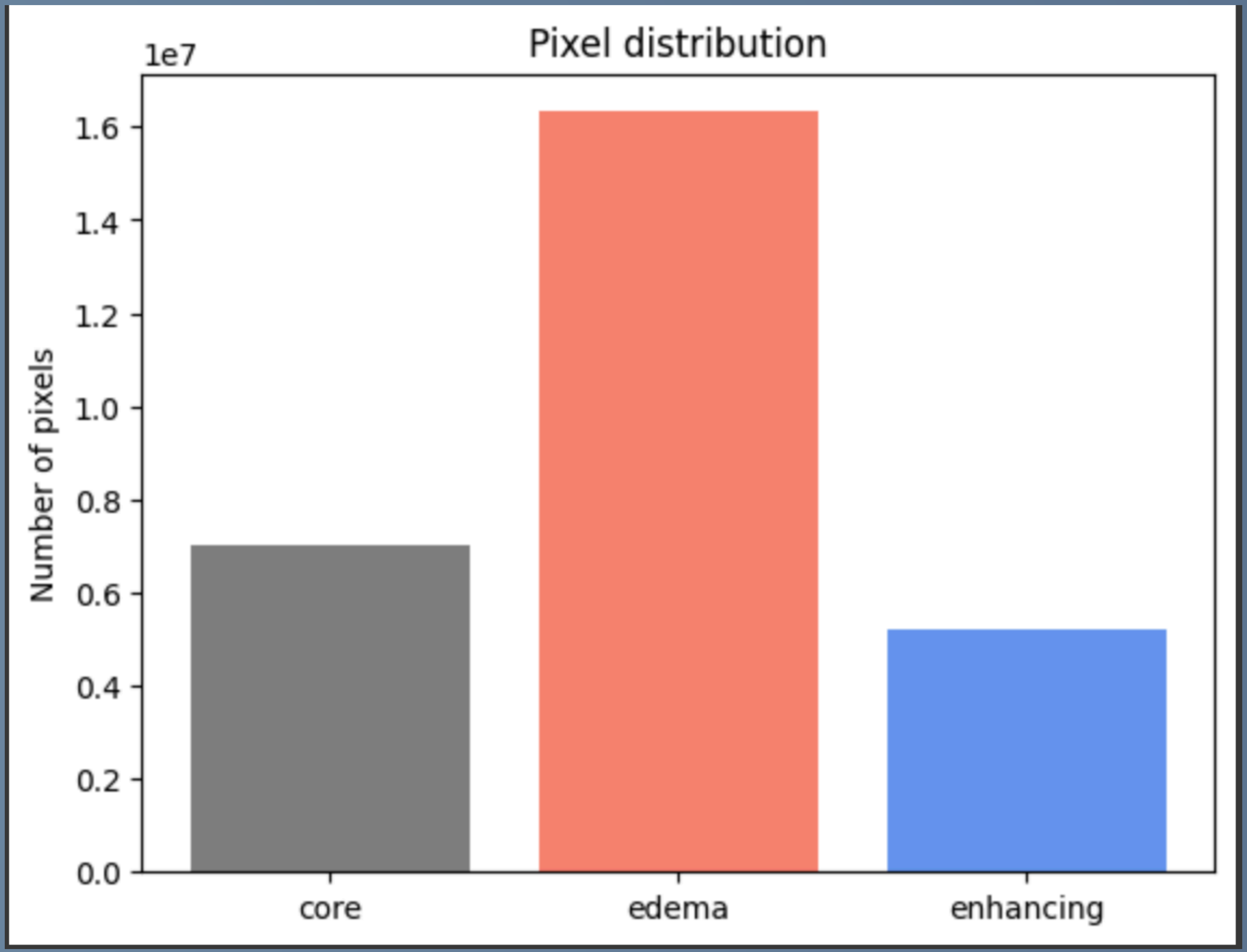


Sample images from dataset

DATASET ANALYSIS

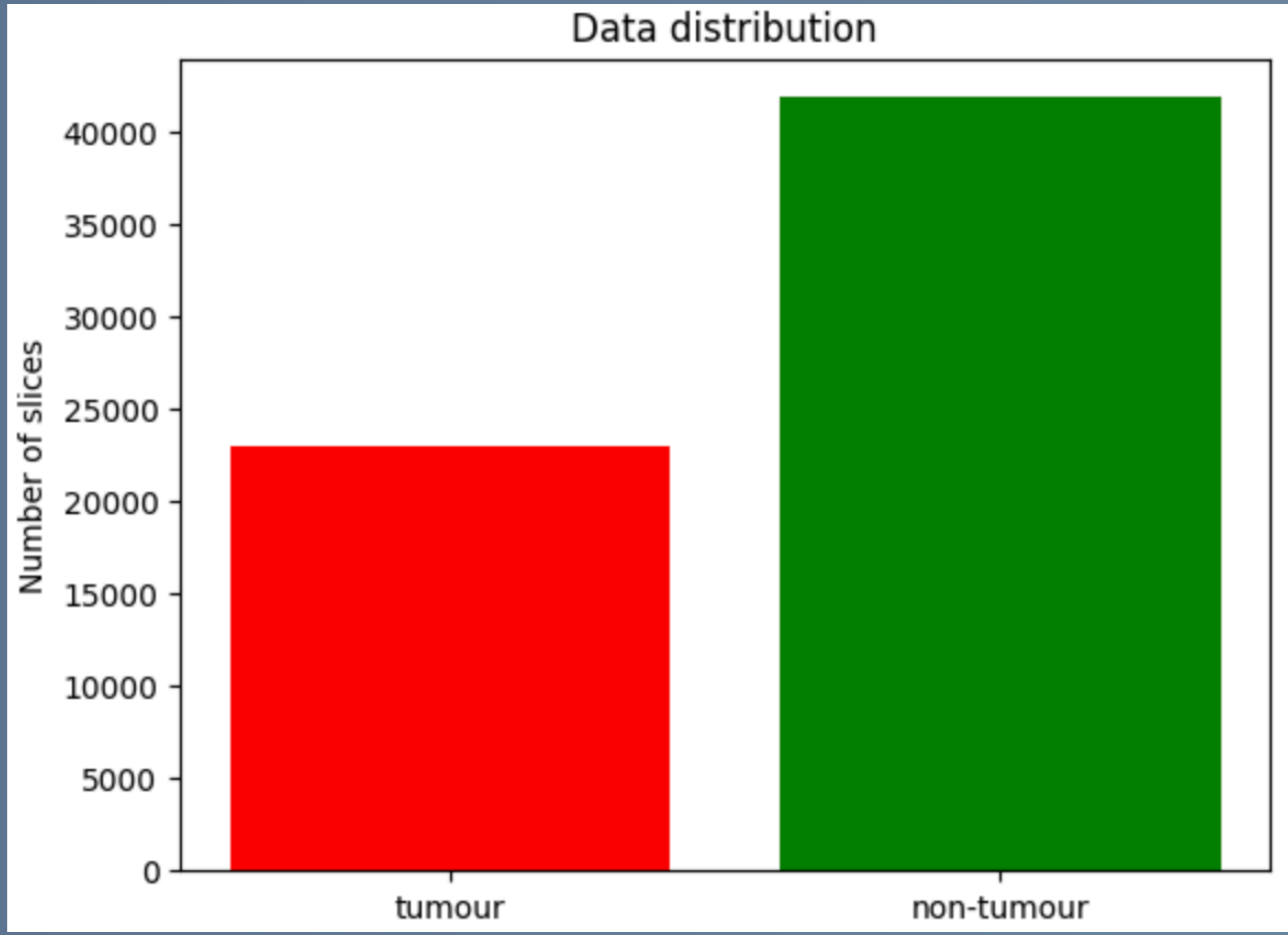
- Different tumours as different labels
  - Edema - blue (class label 2)
  - Enhancing tumour - green (class label 4)
  - Non enhancing & necrotic tumour - red (class label 1)



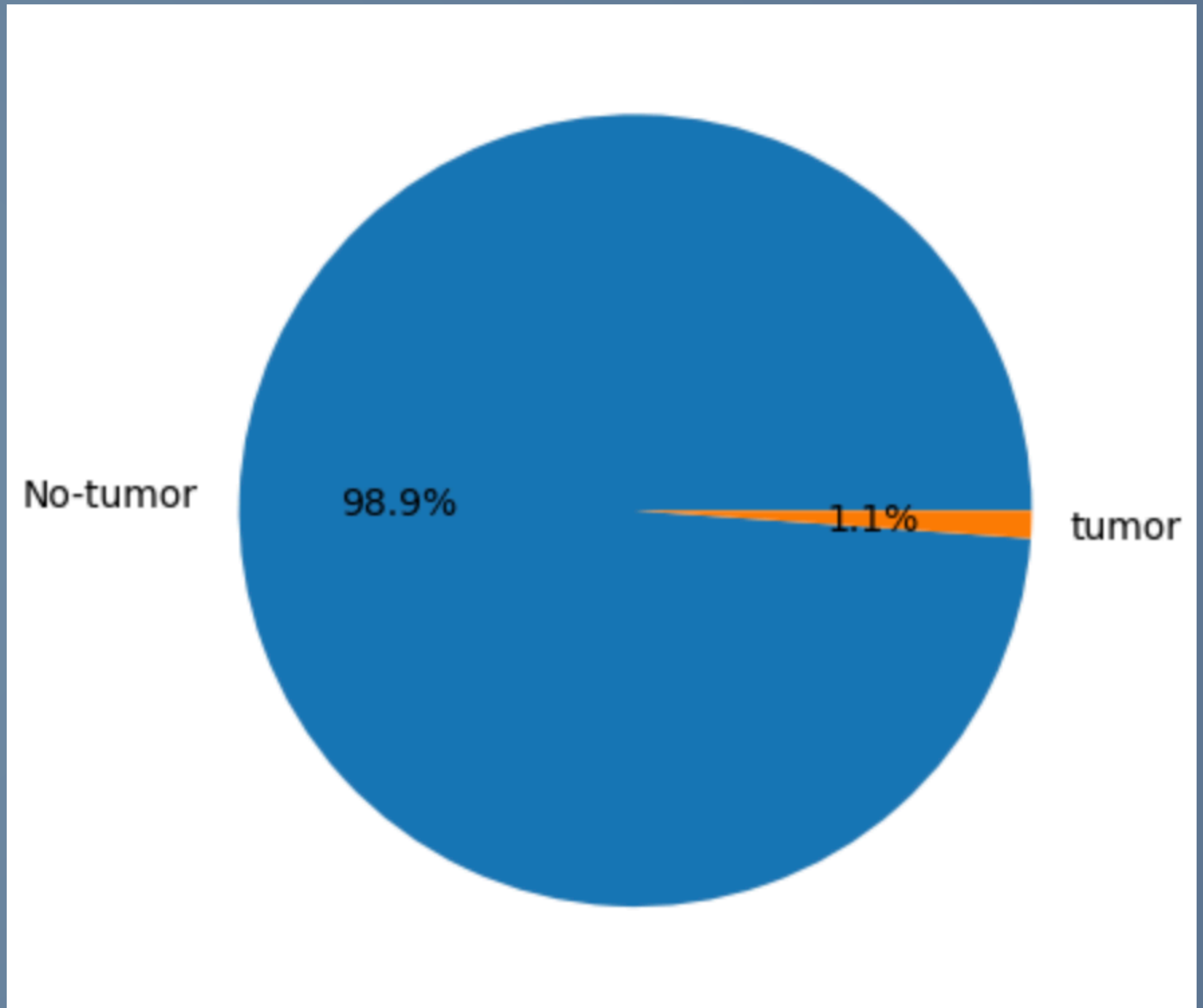


Pixels with 3 different type of tumour region

DATASET ANALYSIS

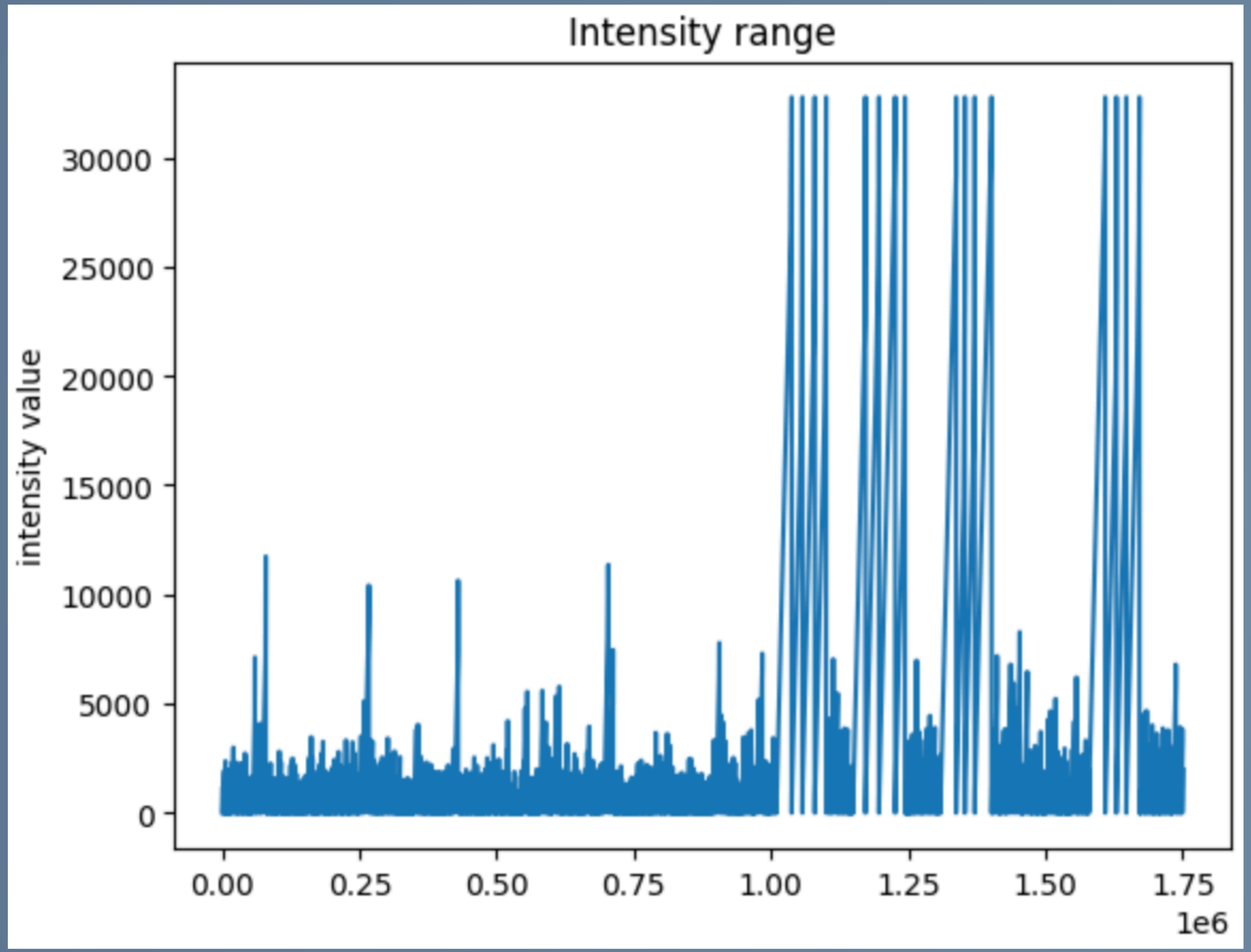


Slices with foreground data vs no foreground data

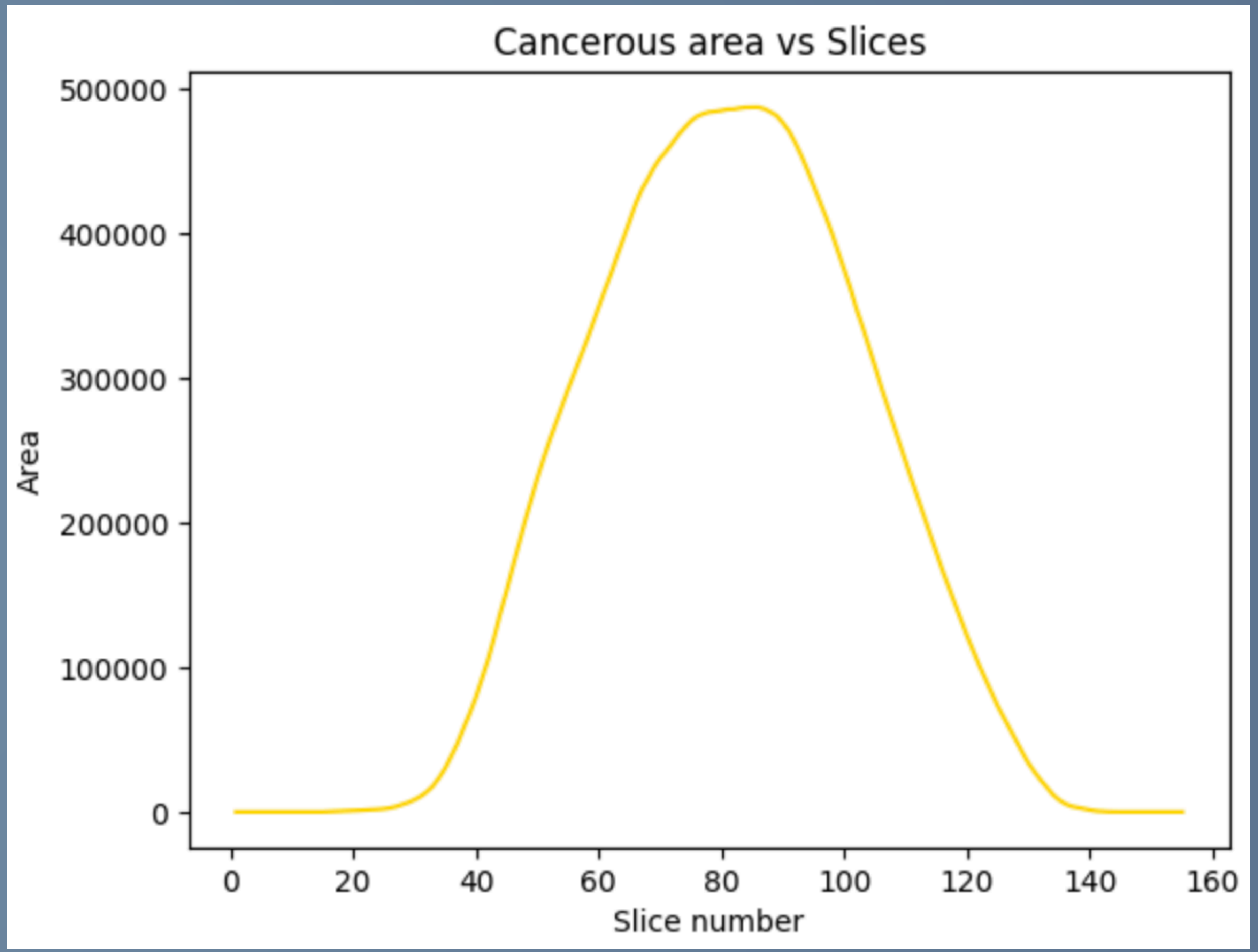


Tumour pixels vs non tumour pixels

DATASET ANALYSIS



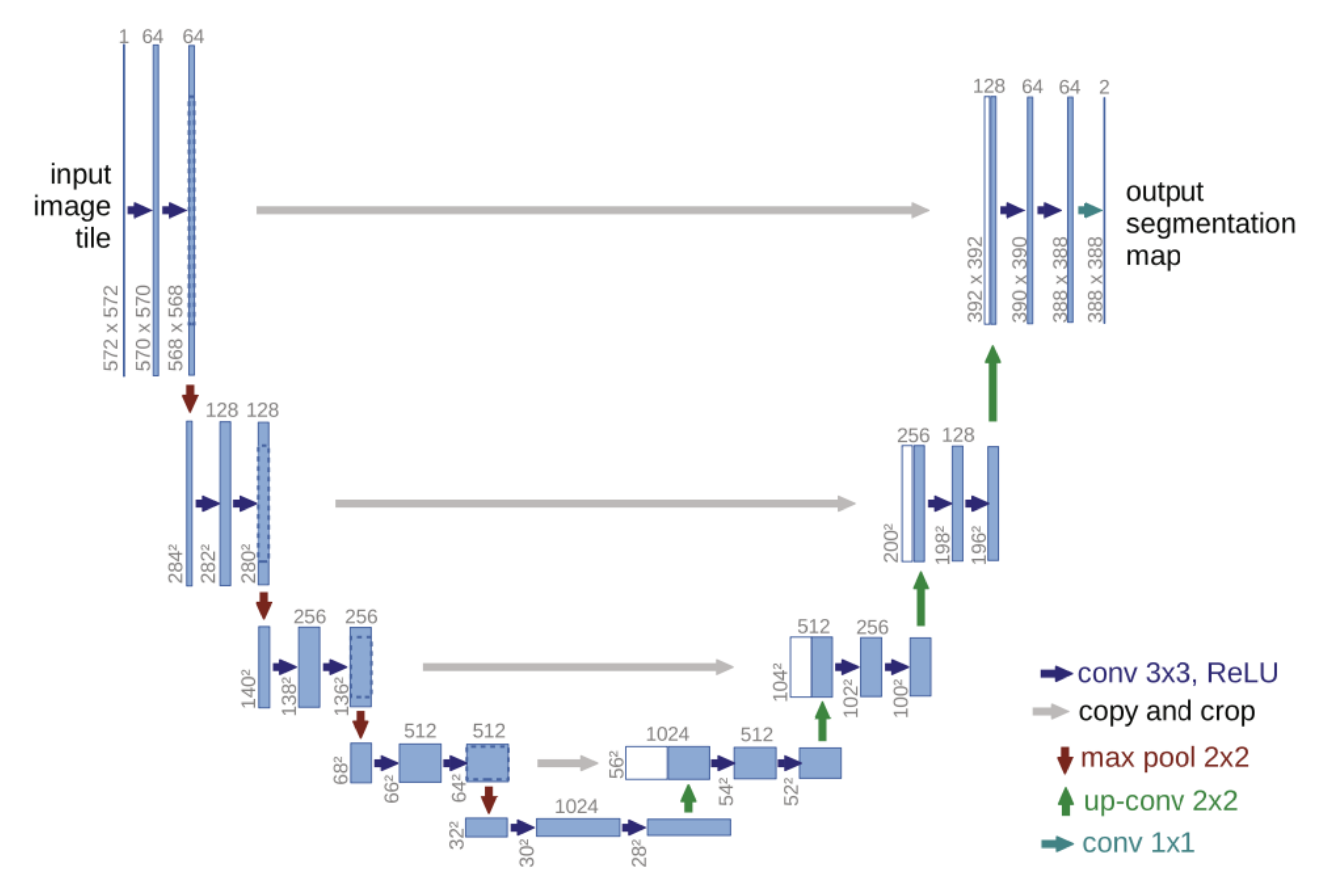
Intensity range of input



Slice number and cancerous tumour pixels

- Max value = 32767
- Min value = 0

U-NET



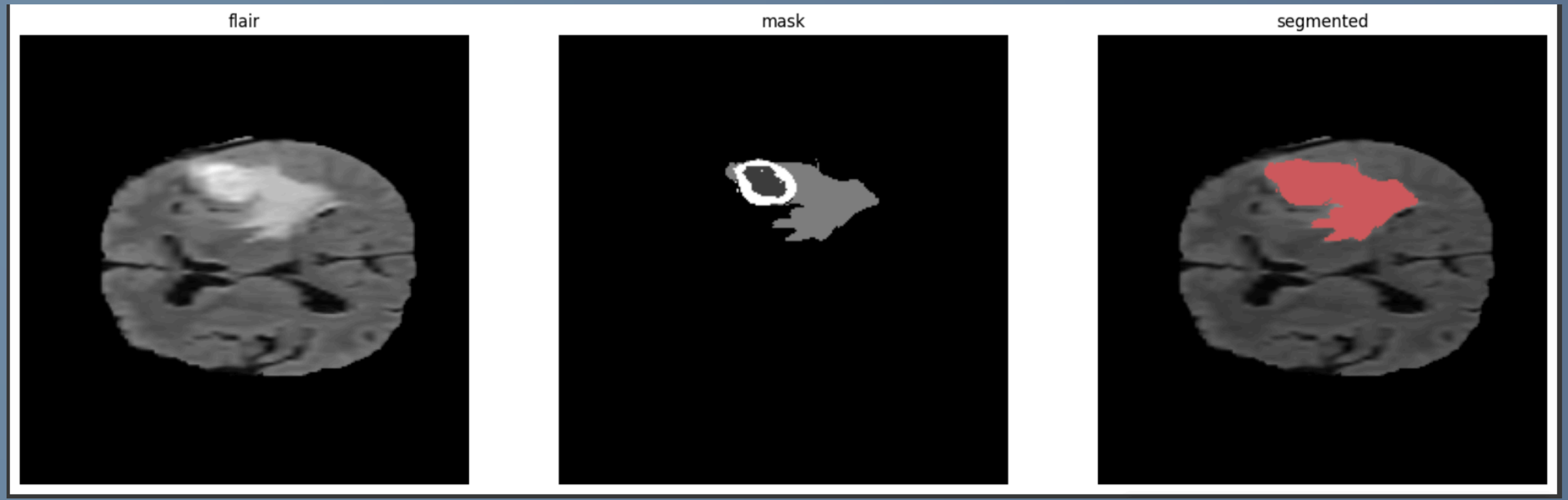
U-Net architecture

METHODOLOGY

- **Data preparation**
  - Reduced dataset- 60 patients data is used
  - 1 modal from each patient at random
  - Resized input to 128x128x146 (cv2.resize function and thresholding with 0.4)
  - Intensity values normalised to 0 to 255
  - Mask is converted to binary mask- one hot encoding
  - Slices without foreground data is removed to avoid overfitting

METHODOLOGY

- **Model training and Evaluation**
  - 3373 slices - Training & Validation (20%)
  - 375 slices - Testing
  - Binary cross entropy loss function
  - Adam Optimizer
  - Learning rate= 0.0001
  - 50 epochs
  - Evaluation metric- BinaryIoU

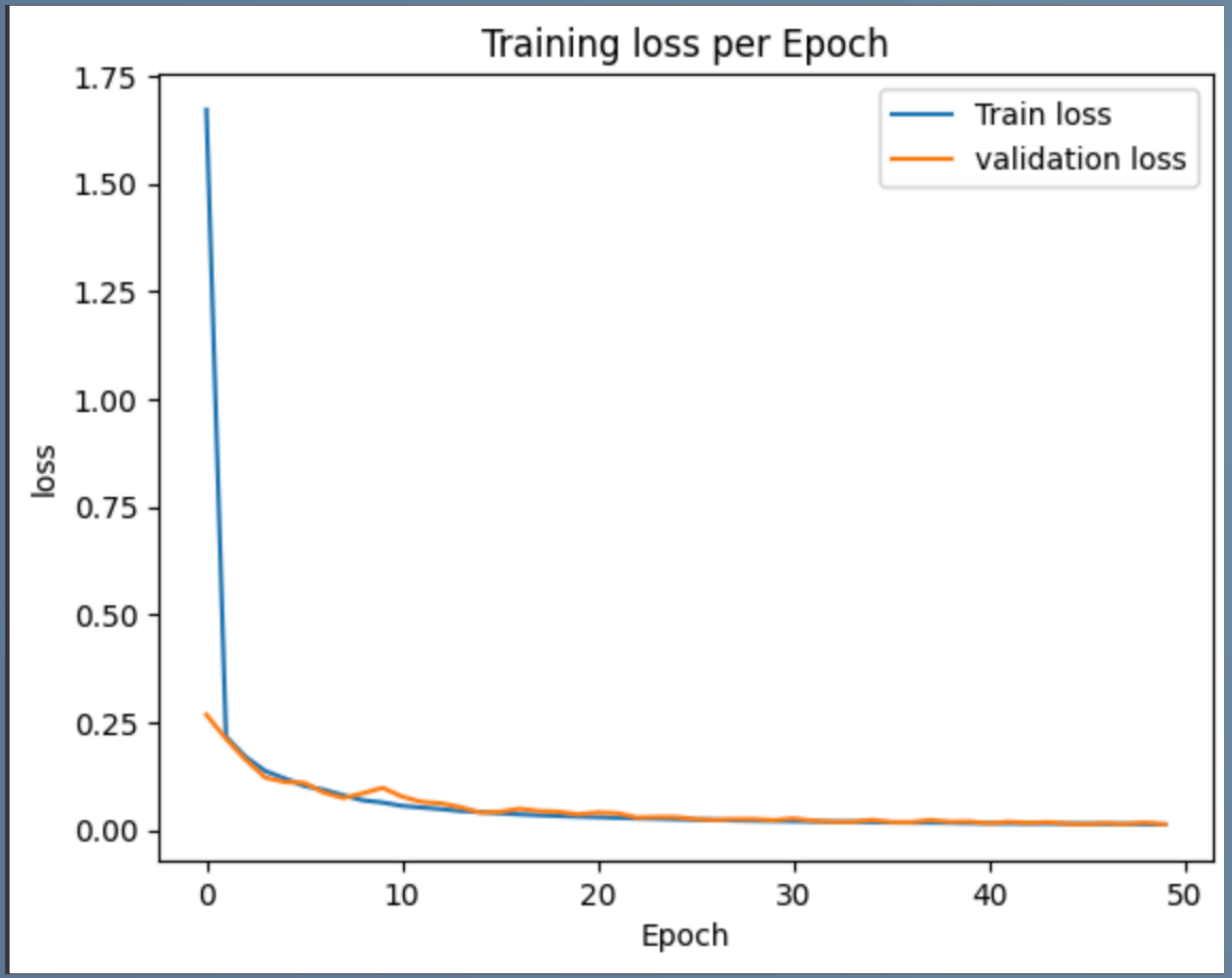


Input, mask and super imposed image after binary segmentation

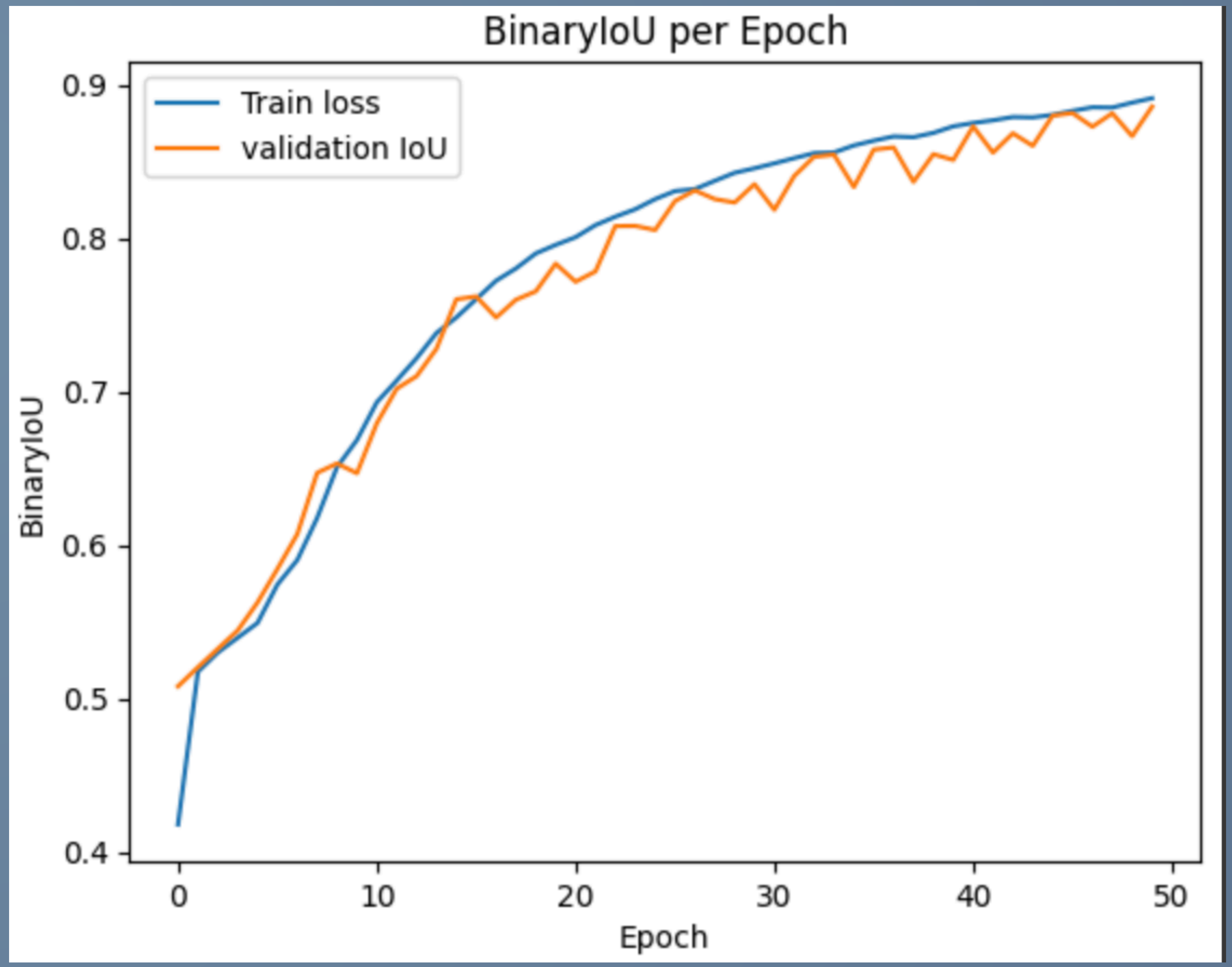
RESULTS

NATIONAL INSTITUTE OF TECHNOLOGY
KARNATAKA, SURATHKAL

- Trained BinaryIoU of 0.8913 and validation IoU of 0.8858
- Testing loss of 0.3669 and BinaryIoU of 0.4886

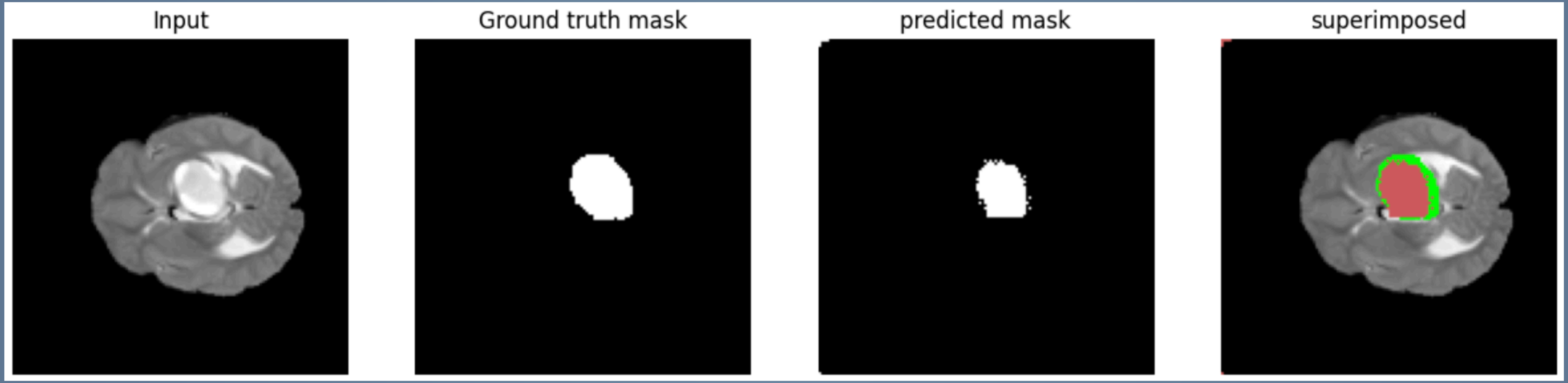


Binary cross entropy in training



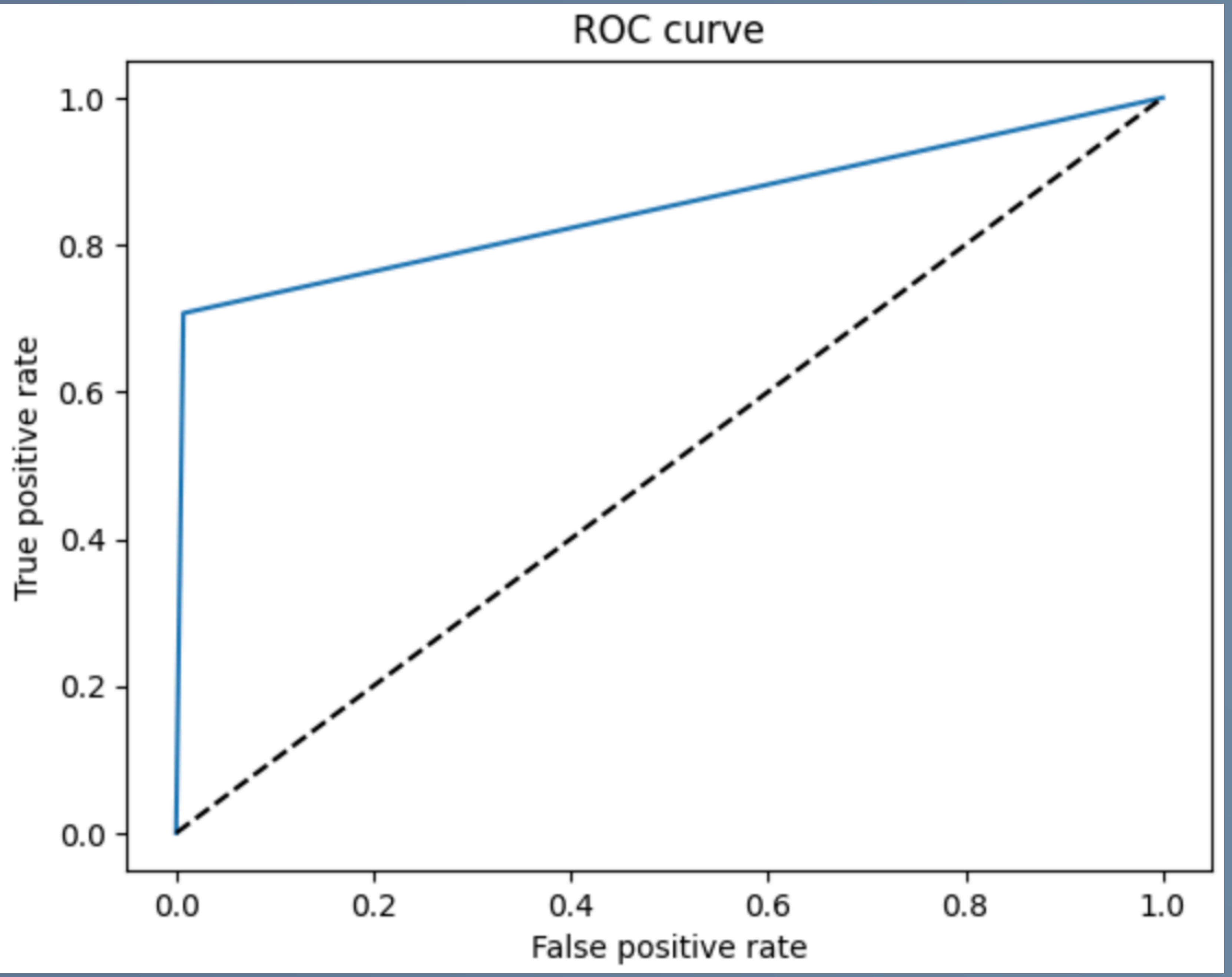
BinaryIoU in training

RESULTS

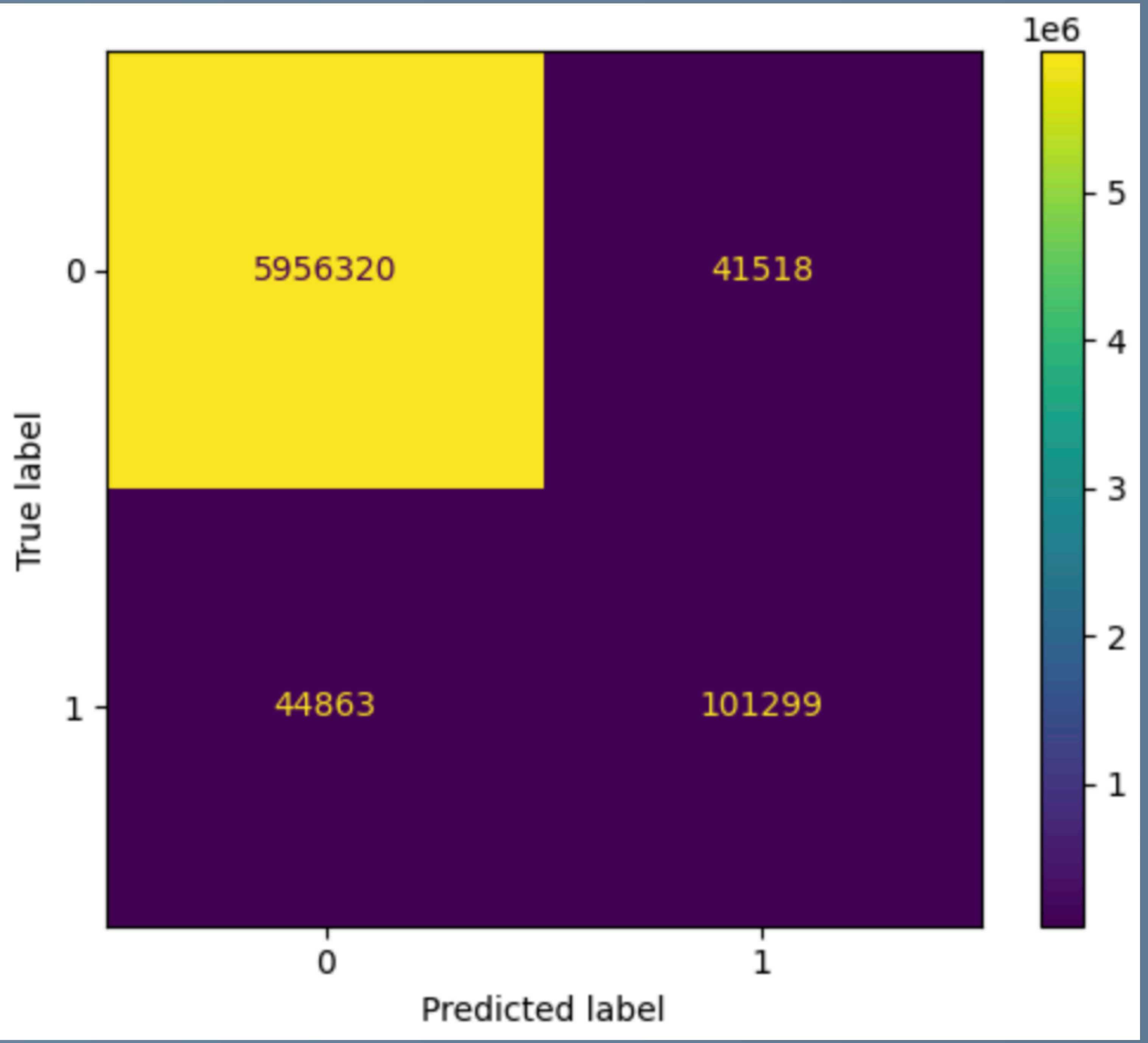


Prediction results

RESULTS



ROC curve



Confusion matrix

RESULTS

METRIC	SCORE
ACCURACY	0.9859
PRECISION	0.7092
RECALL (SENSITIVITY, TPR)	0.693
SPECIFICITY	0.993
F1 SCORE	0.7009

REFERENCES

NATIONAL INSTITUTE OF TECHNOLOGY
KARNATAKA, SURATHKAL

- Wang, S., Pang, X., de Keyzer, F. *et al.* AI-based MRI auto-segmentation of brain tumor in rodents, a multicenter study. *acta neuropathol commun* **11**, 11 (2023). https://doi.org/10.1186/s40478-023-01509-w
- Çiçek, Ö., Abdulkadir, A., Lienkamp, S.S., Brox, T., Ronneberger, O. (2016). 3D U-Net: Learning Dense Volumetric Segmentation from Sparse Annotation. In: Ourselin, S., Joskowicz, L., Sabuncu, M., Unal, G., Wells, W. (eds) *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2016*. MICCAI 2016. Lecture Notes in Computer Science(), vol 9901. Springer, Cham.
- Alom MZ, Yakopcic C, Taha TM, Asari VK (2018) Nuclei segmentation with recurrent residual convolutional neural networks based U-Net (R2U-Net). In: *NAECON 2018–IEEE national aerospace and electronics conference*, City, pp 228–233
- Hsu L-M, Wang S, Walton L, Wang T-WW, Lee S-H, Shih Y-YI (2021) 3D U-Net improves automatic brain extraction for isotropic rat brain magnetic resonance imaging data. *Front Neurosci*. https://doi.org/10.3389/fnins.2021.801008
- Ronneberger, O., Fischer, P., Brox, T. (2015). U-Net: Convolutional Networks for Biomedical Image Segmentation. In: Navab, N., Hornegger, J., Wells, W., Frangi, A. (eds) *Medical Image Computing and Computer-Assisted Intervention – MICCAI 2015*. MICCAI 2015. Lecture Notes in Computer Science(), vol 9351. Springer, Cham. https://doi.org/10.1007/978-3-319-24574-4_28

THANK YOU!