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# Automating The Process of Linear Feature Extraction of Europa Using Machine Learning

## The Project :

To automate the process of detection of Lineaments of Europa, using Machine Learning.

## Motivation :

**'Europa'**, a moon of Jupiter, has recently been a focus of many scientists for its unusual features. It has liquid water and as per theory some essential chemicals, which are the ingredients for **Life**.

In this we tried to build a model that can detect the lineas, which later could be integrated with the available spectral data for analysis.
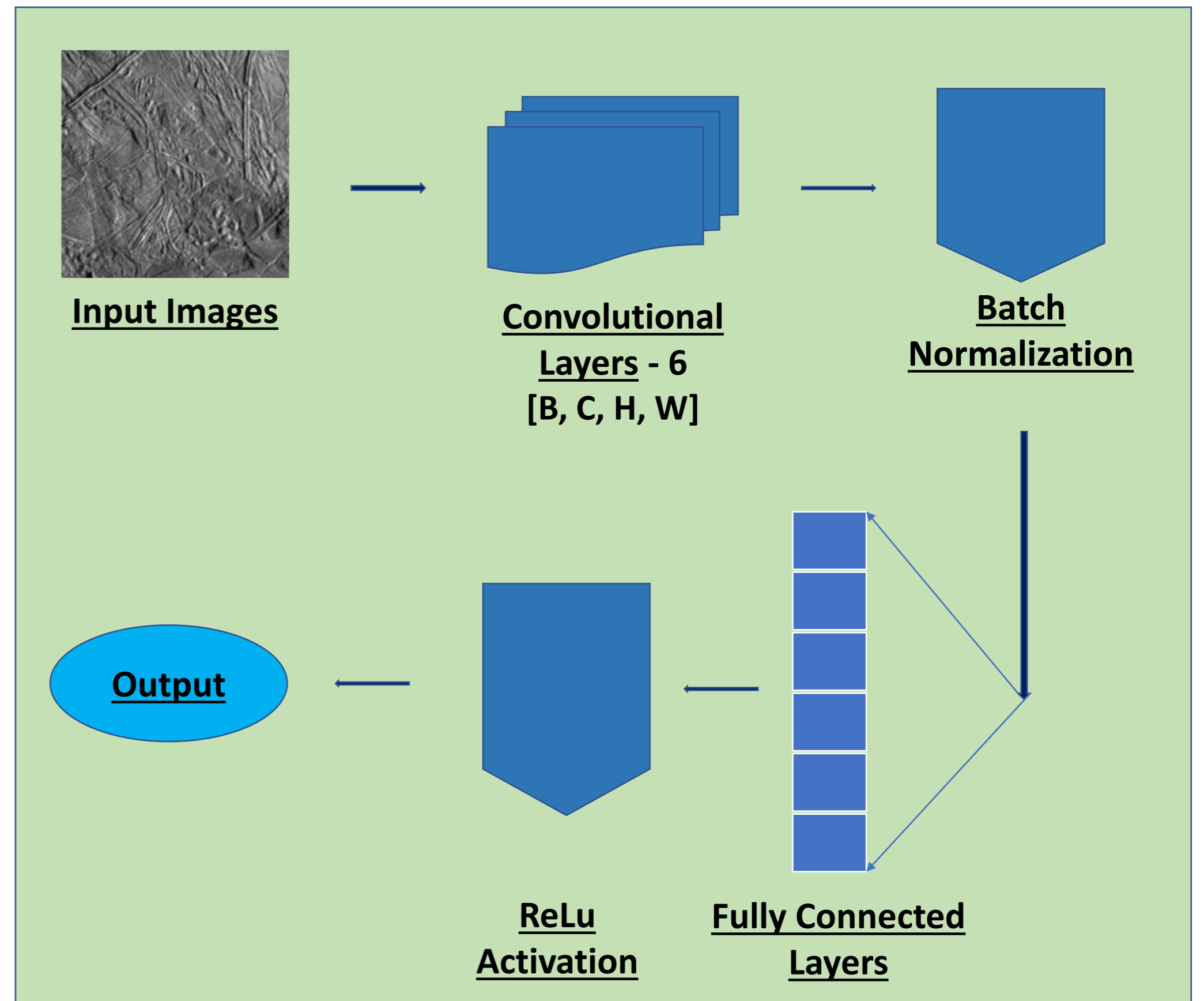
## The Dataset :

The images were collected from **Galileo's Solid State Imaging instrument** (launched in 1989), which have been made public by NASA through PDS-atlas. We have 1,023 (224 × 224) images which were already labeled.



## The Model :

Our goal was to build a model for image segmentation. Here the model was prepared for binary classification [lineas or no linea(surface)].

We have built a CNN based model.



Input Images — Convolutional Layers - 6 [B, C, H, W] — Batch Normalization — ReLu Activation — Fully Connected Layers — Output

The model output is passed through **sigmoid** activation function, which performs the final classification i.e says the presence of linea or no linea.
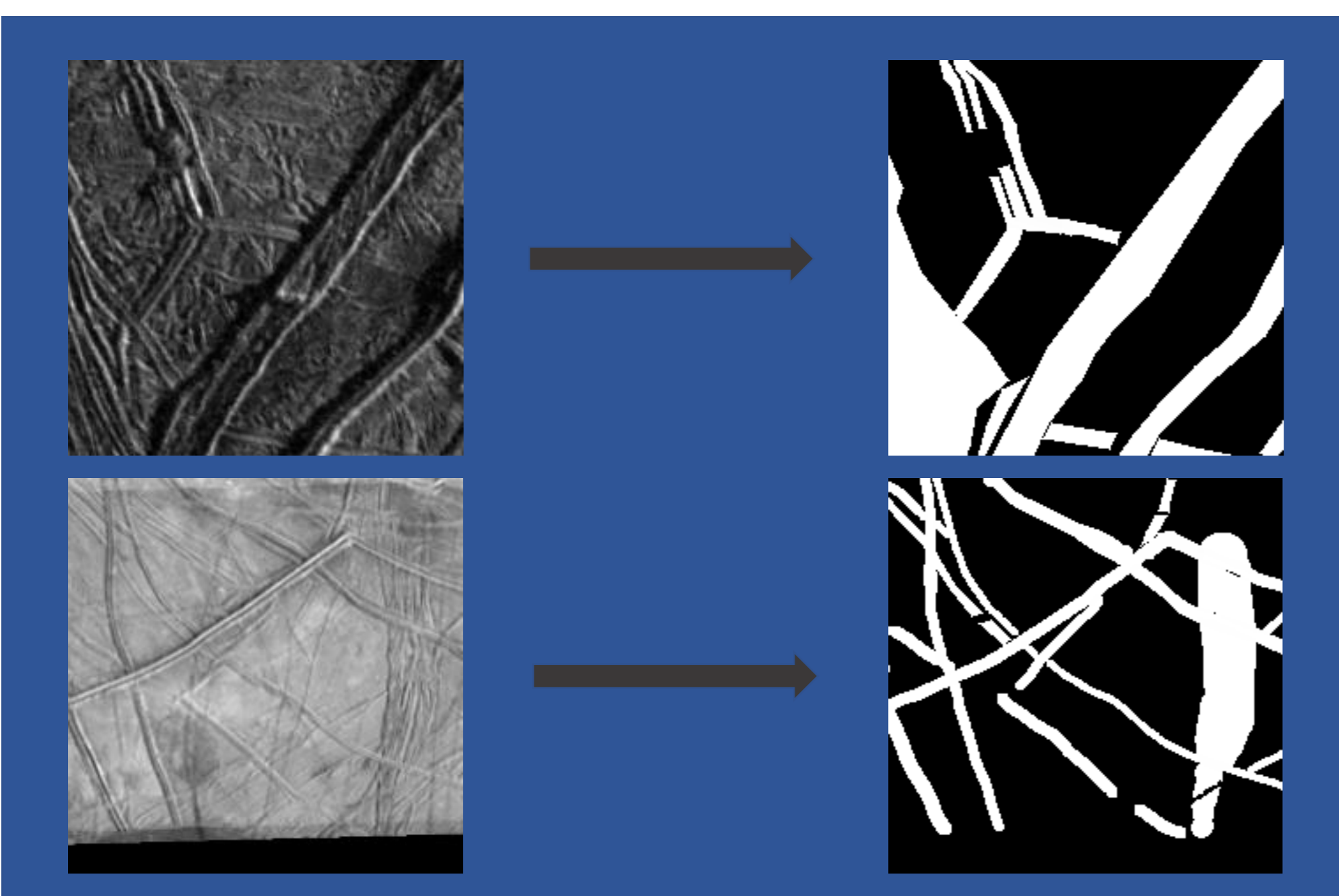
The model was trained over 16 epochs.

## Loss :

$$BCELoss(p,y) = -\frac{1}{N}\sum_{i=1}^{N}[y_i \cdot log(p_i) + (1-y_i) \cdot log(1-p_i)]$$

**$p_i$** = predicted probability that sample belongs to linea class
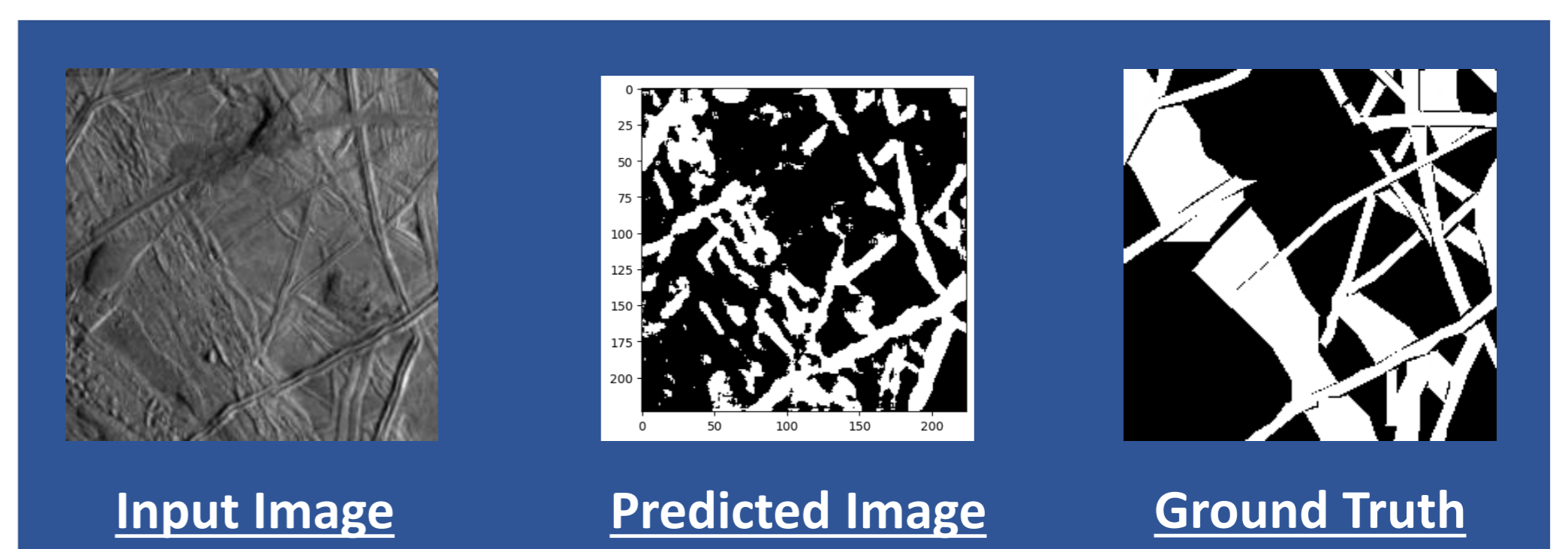**$y_i$** = actual label for the sample

## Evaluation :

[ **Training IoU : 32%** ]      [ **Testing IoU : 29.6%** ]

[ **Precision : 52.63%** ]      [ **Recall : 54.05%** ]

[ **f1 score : 54.05%** ]



**Input Image**      **Predicted Image**      **Ground Truth**

*REFERENCES:*
1. *Caroline Haslebacher, Nicolas Thomas, Valentin T. Bickel, LineaMapper: A deep learning-powered tool for mapping linear surface features on Europa, Icarus, Volume 410, 2024, 115722, ISSN 0019-1035, https://doi.org/10.1016/j.icarus.2023.115722*
2. *Das et al.(2022)]{2022LPICo2678.2709D} Das, N.~P., Nazareth, R.~G., Mishra, S., et al.\ 2022, 53rd Lunar and Planetary Science Conference, 2678, 2709*