Deep learning for 3D fault detection within virtual reality visualization seismic volumes

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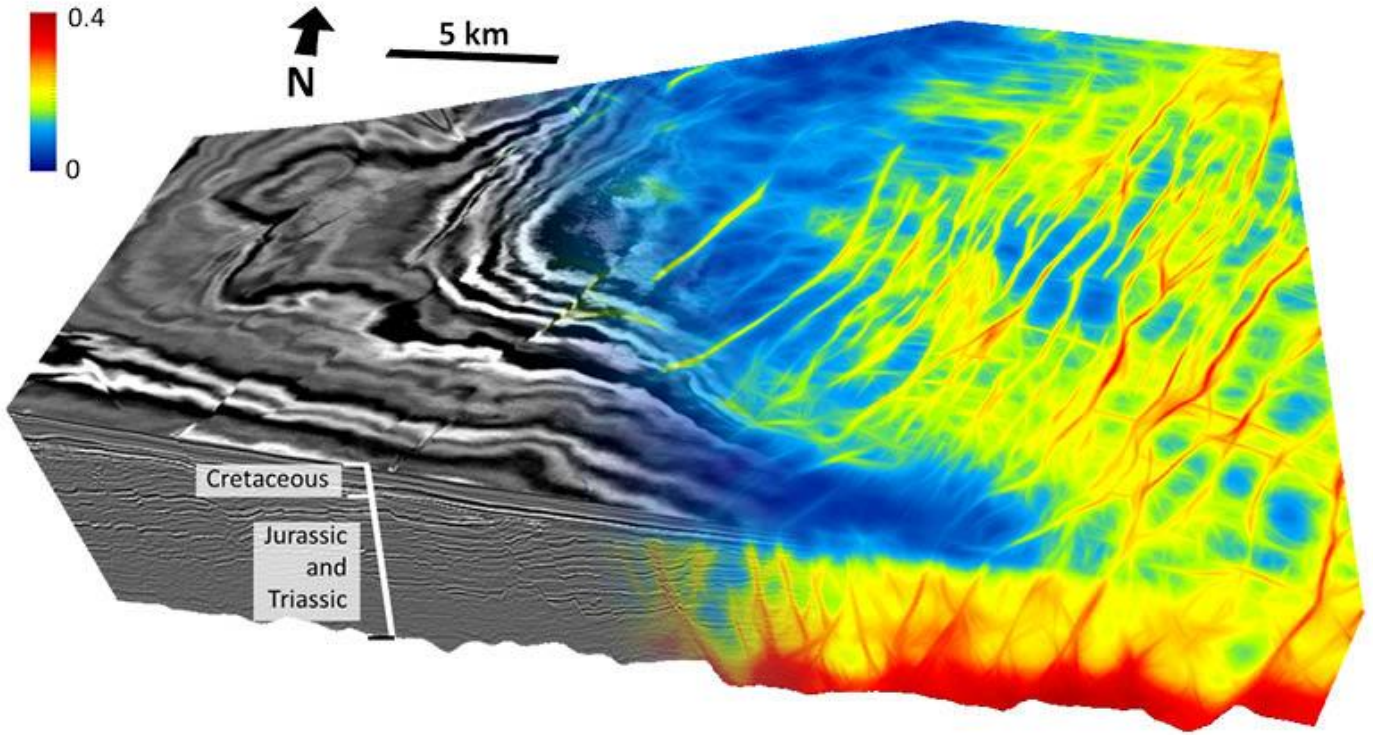
Motivation

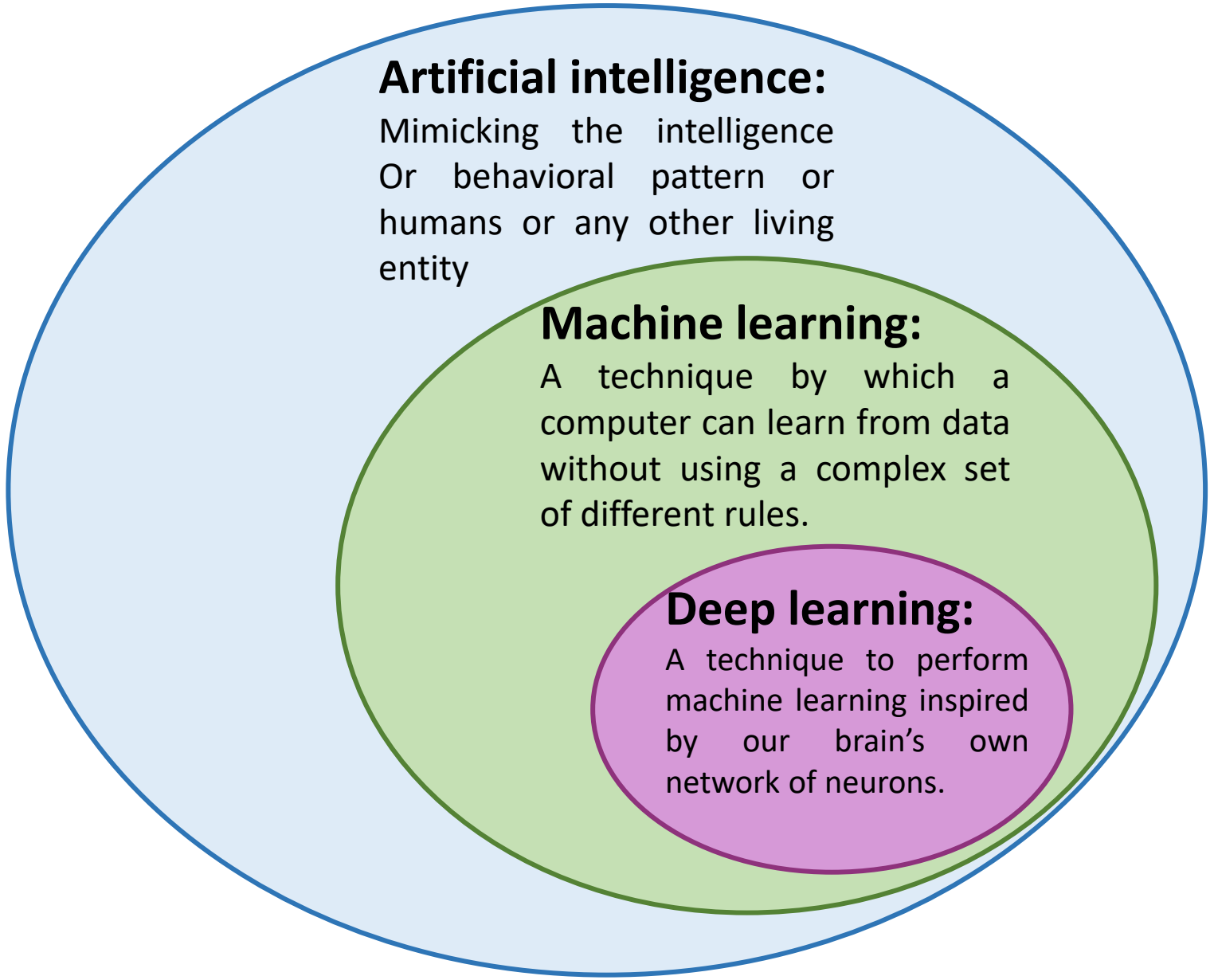


The Exmouth sub-basin, located in the Carnarvon Basin, offshore North West Australia. Source: Eliis.

Seismic fault detection is an important task in seismic interpretation because faults may indicate the locations of petroleum reservoirs.

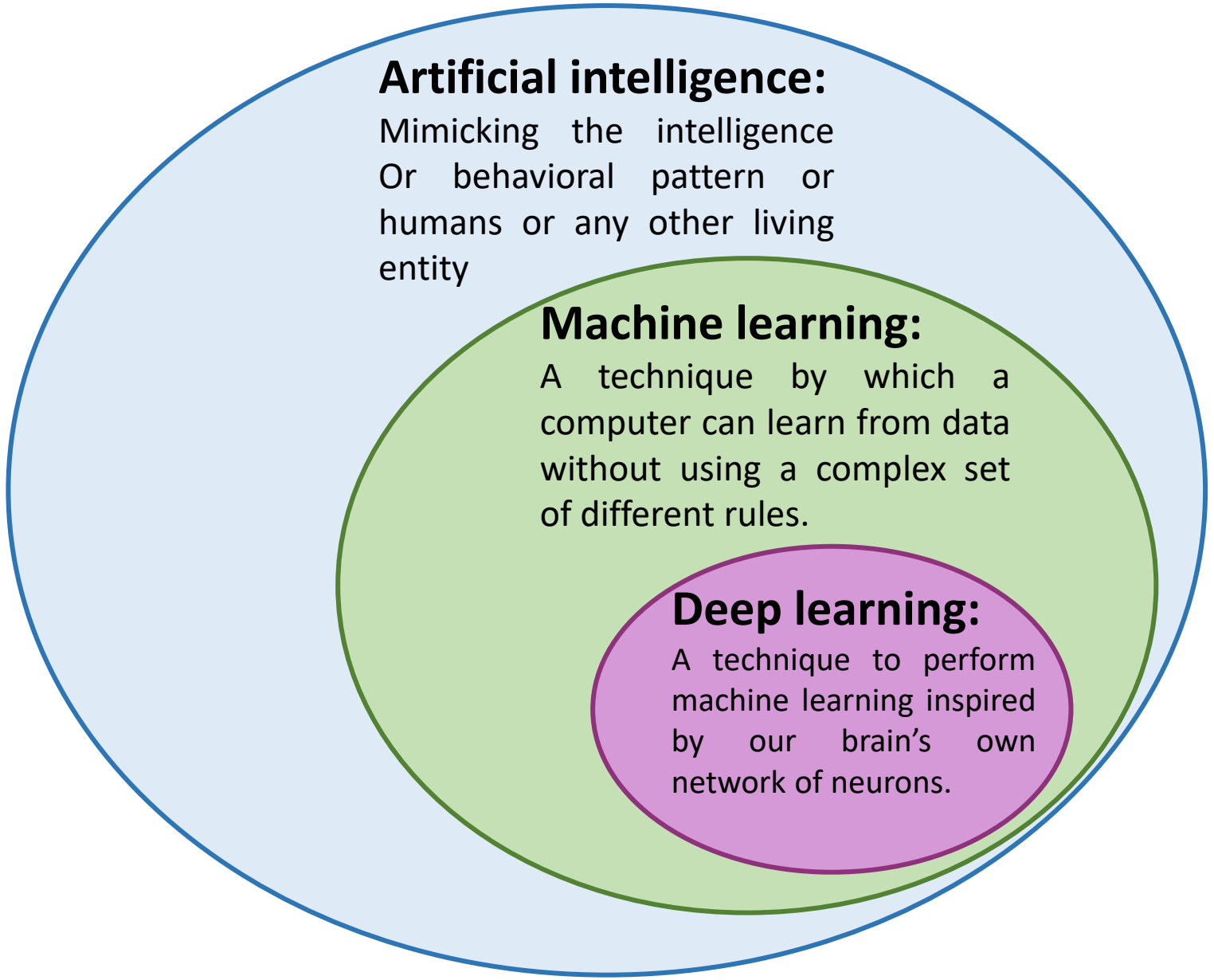
- ✓ Process of big data
- ✓ Interpretation efficiency

Why deep learning?



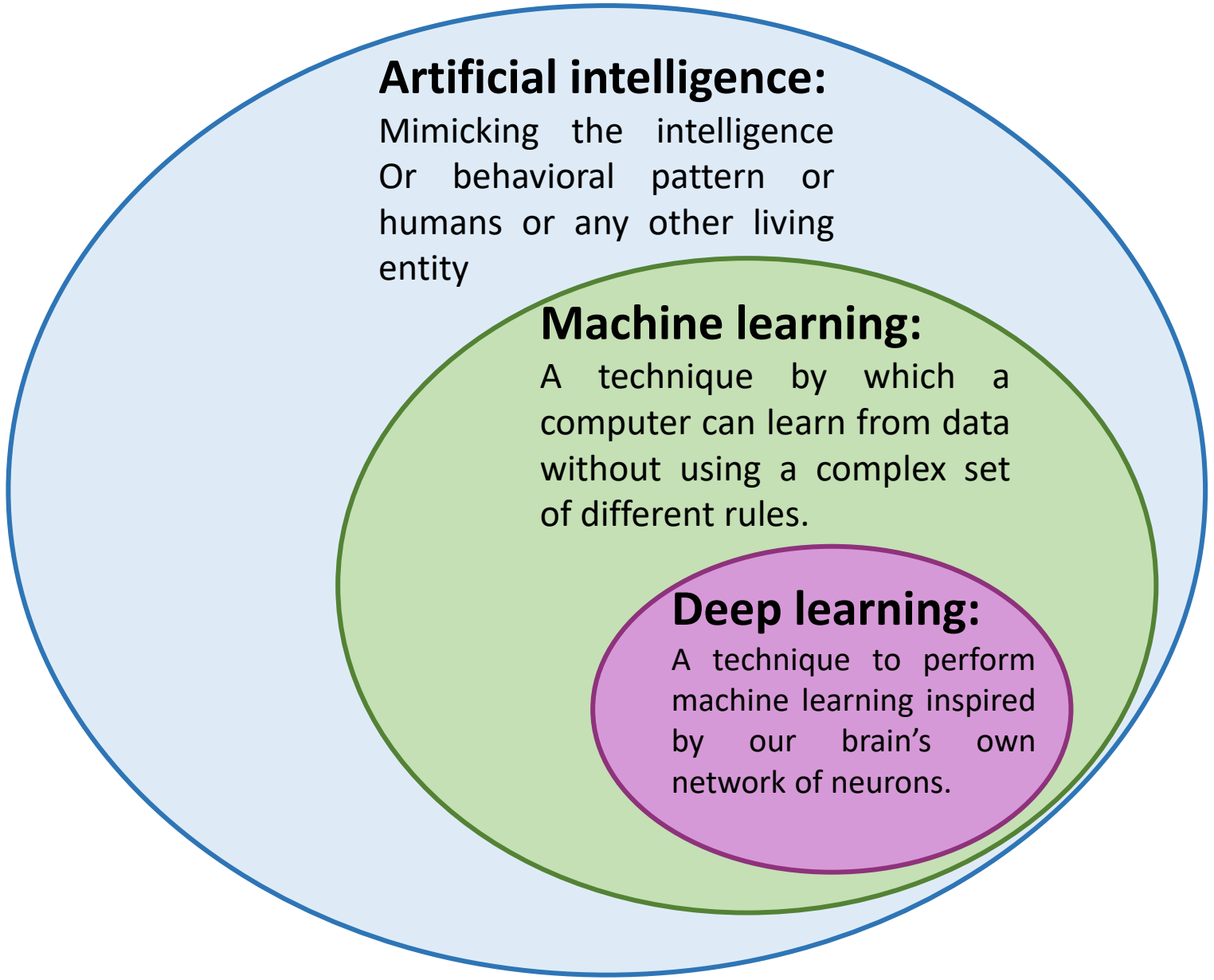
- ✓ Deep learning computer models learn to perform classification tasks directly from images

Why deep learning?



- ✓ Deep learning computer models learn to perform classification tasks directly from images
- ✓ A deep learning model can " learn" to be accurate.

Why deep learning?



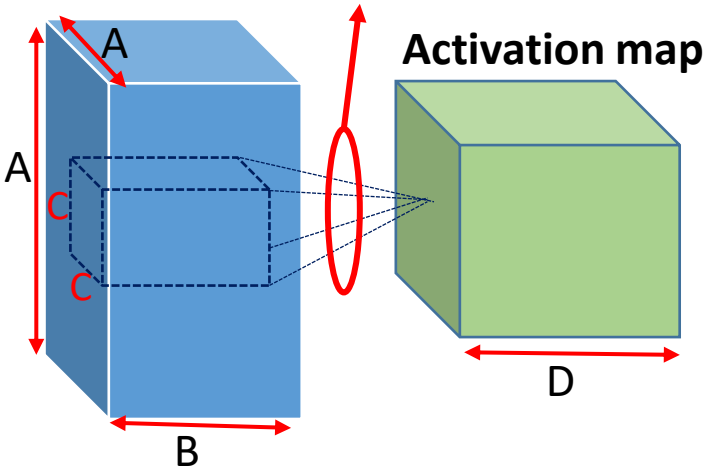
- ✓ Deep learning computer models learn to perform classification tasks directly from images
- ✓ A deep learning model can " learn" to be accurate.
- ✓ These models are "trained" to use large sets of labeled data as well as neural network architectures

Convolutional neural network (U-Net)

U-Net architecture

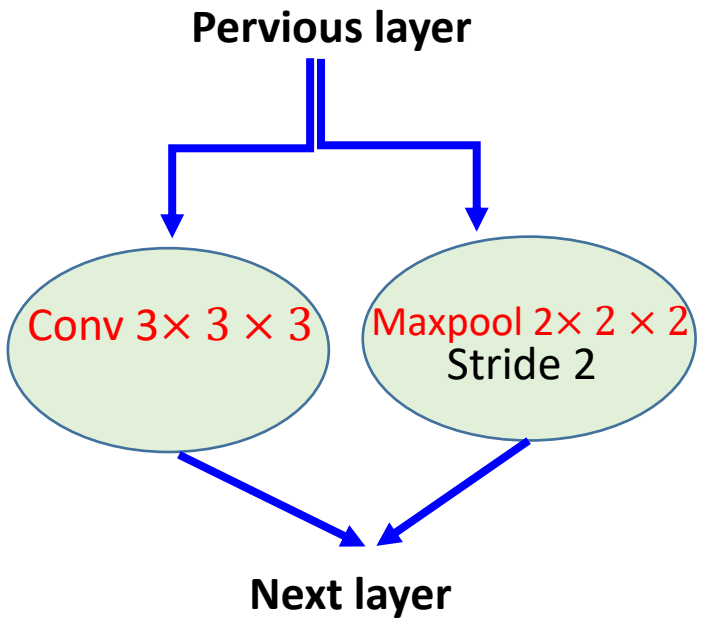
Convolution

Convolution between C x C x B filter and region of input feature map

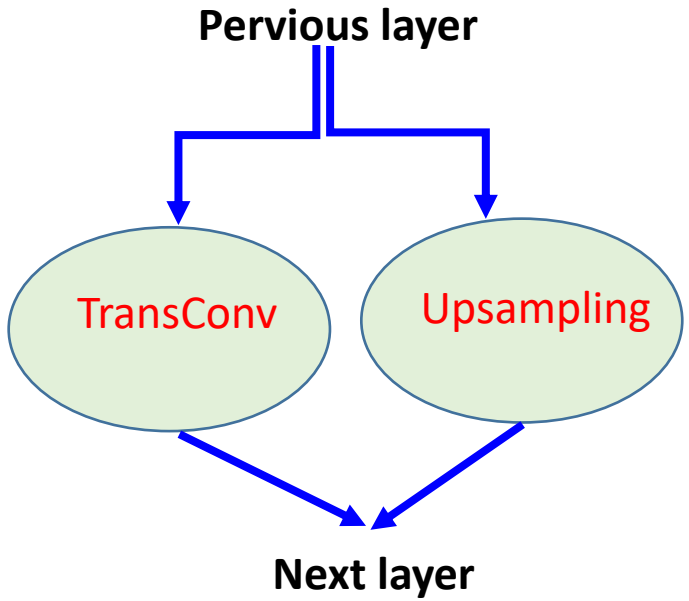


A = Input height and width
C = Kernel height and width
B = Input depth
D= Feature maps

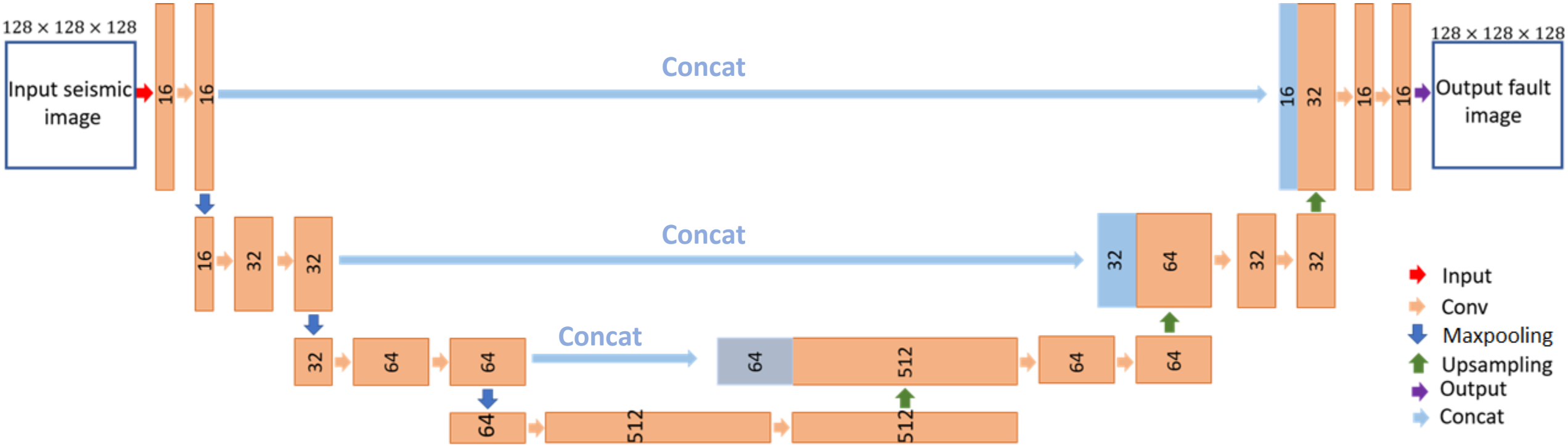
Downsampling



Upsampling



U-Net architecture



Contracting path (left side)

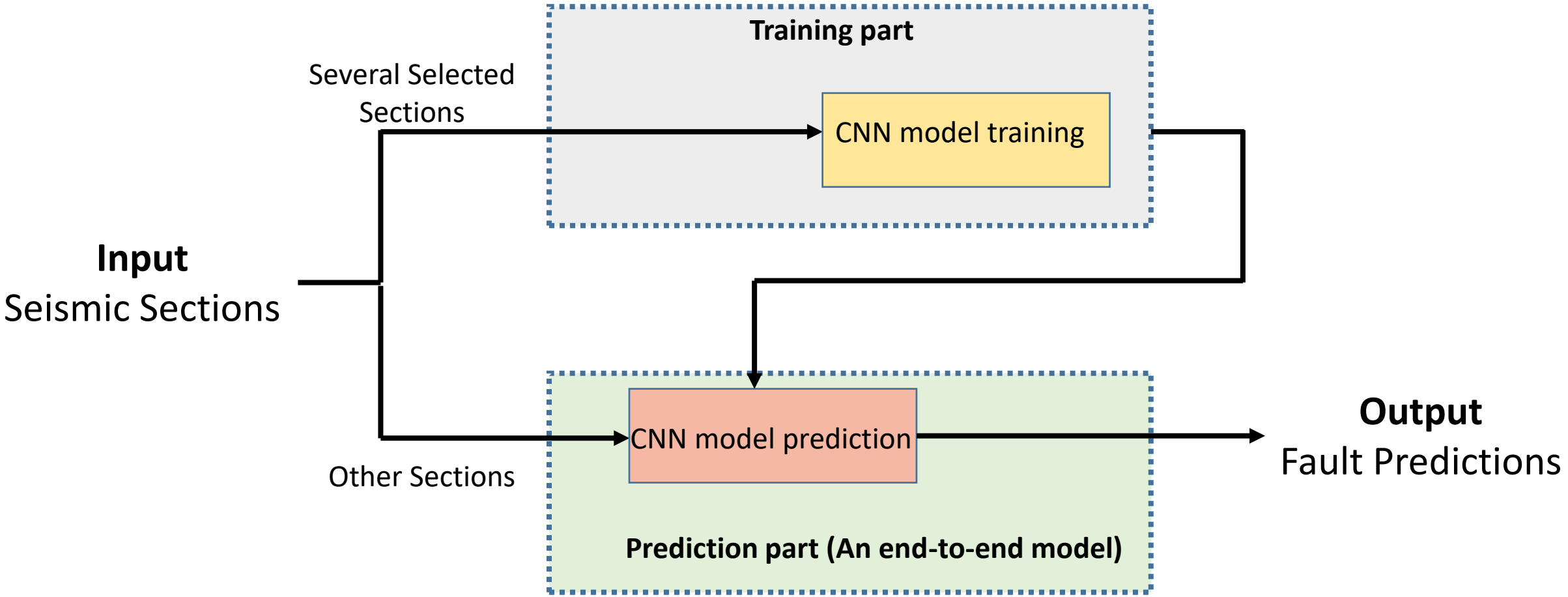
- Two 3 × 3 × 3 convolutional layers followed by a rectified linear unit (ReLU) activation
- A 2 × 2 × 2 max pooling operation with stride 2

expansive path (right side)

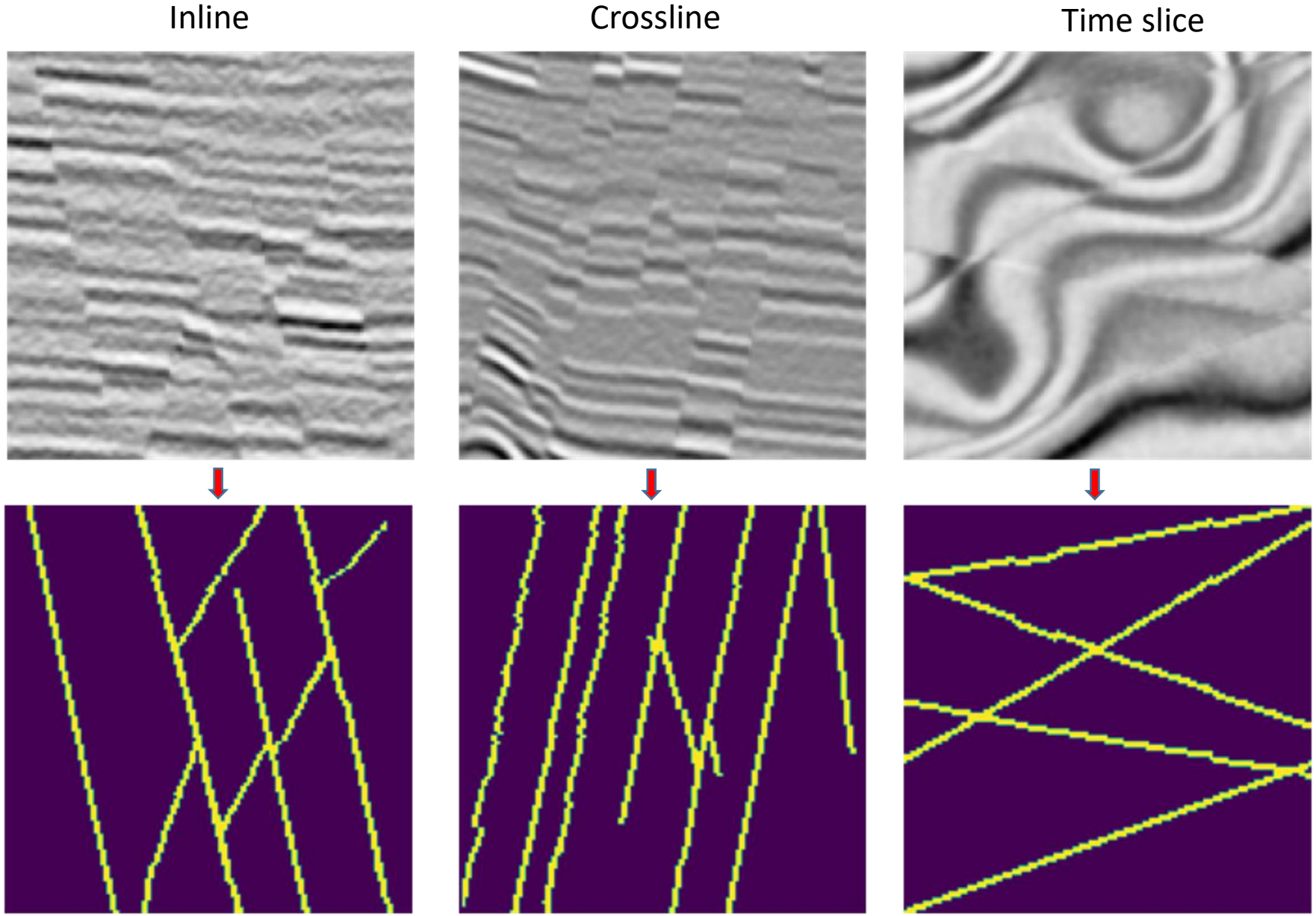
- A 2 × 2 × 2 upsampling operation
- Two 3 × 3 × 3 convolutional layers followed by a ReLU activation

Workflow

The workflow of the proposed method containing two main parts: training and prediction

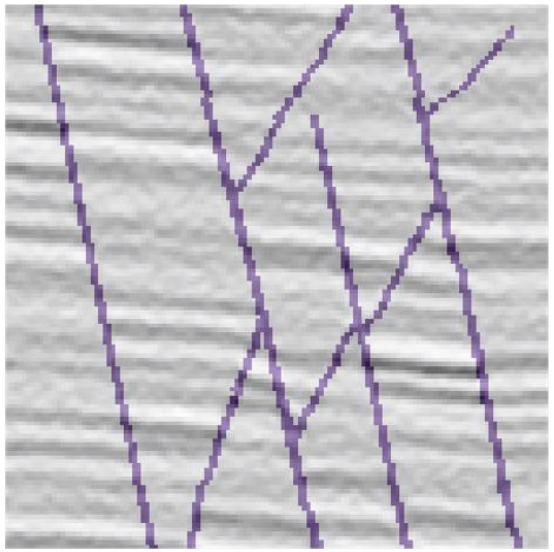
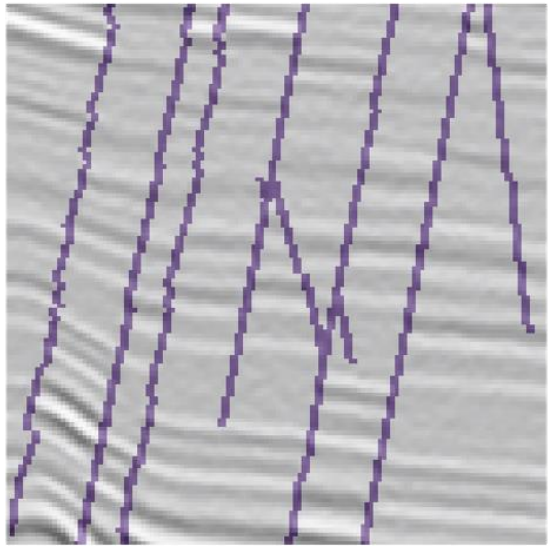
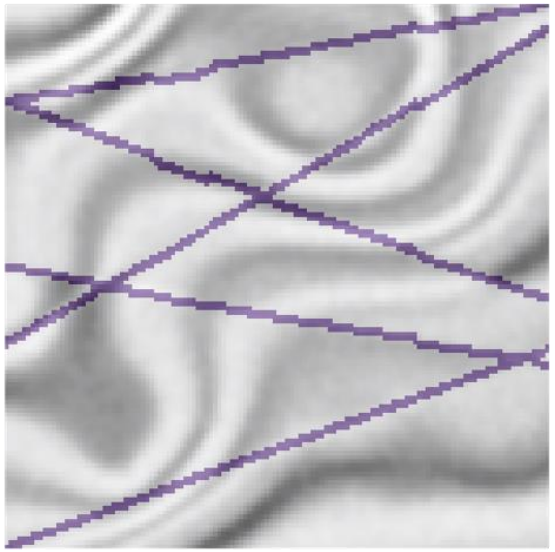
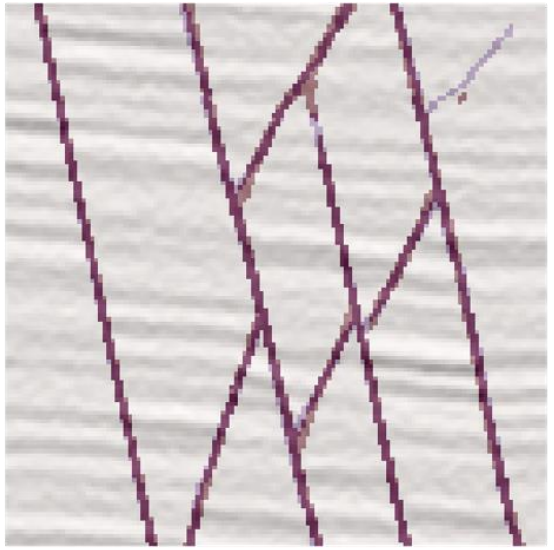
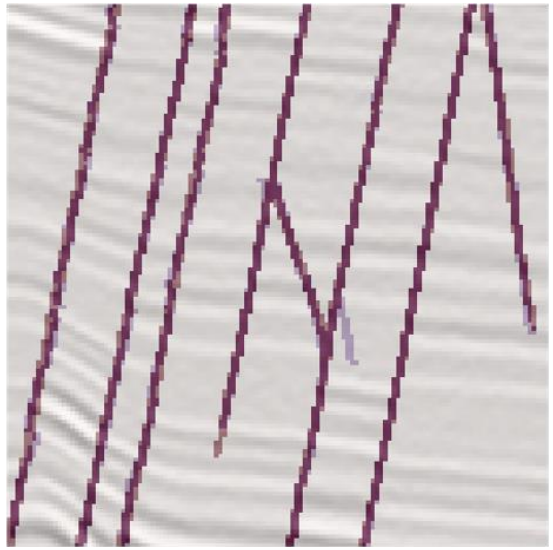
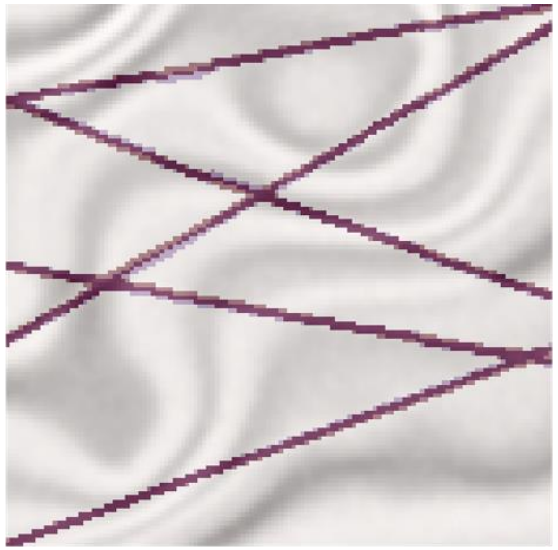


Training (Synthetic data)



Wu et al. (2019)

Predictions (Synthetic data)

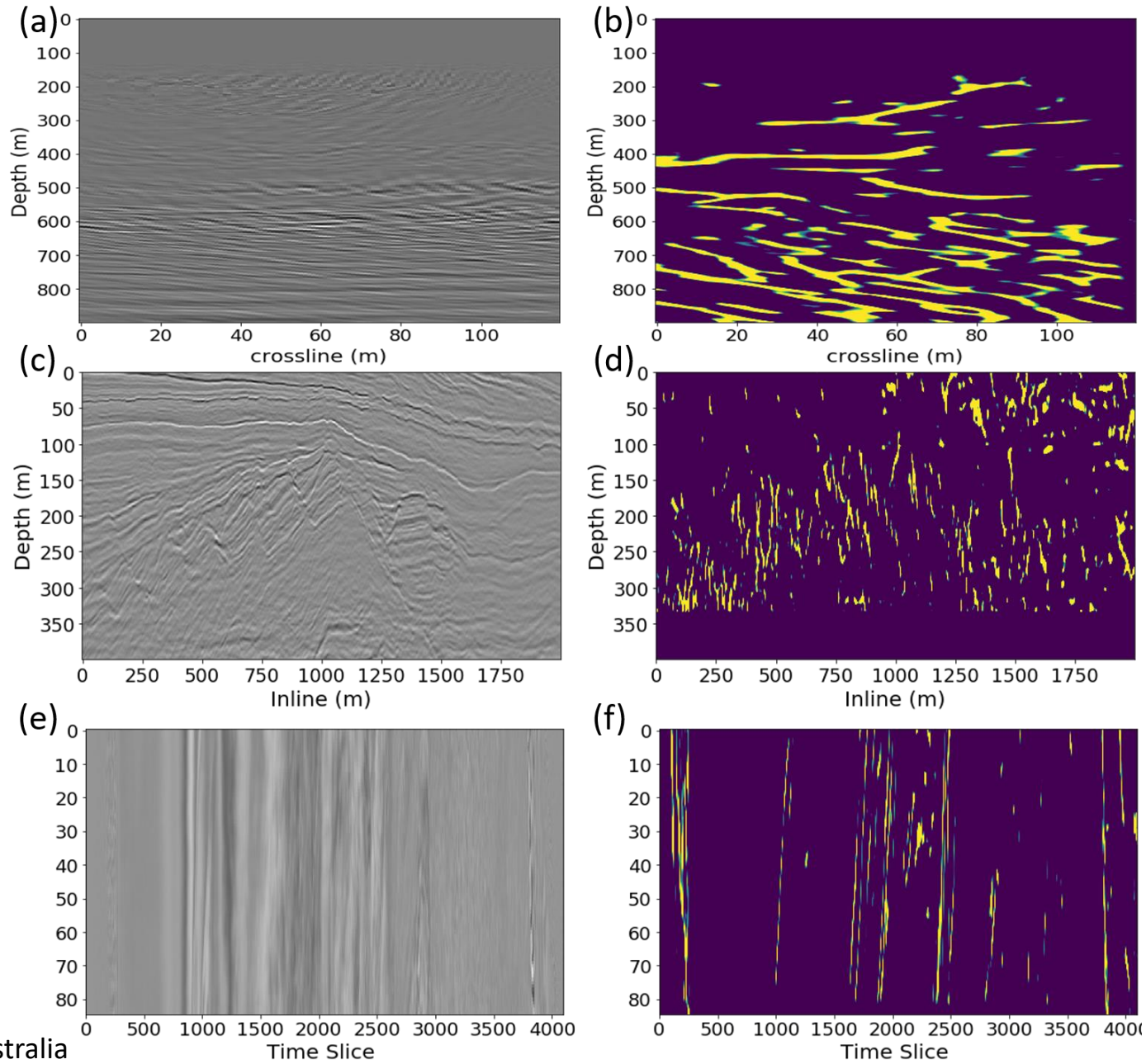
	Inline	Crossline	Time slice
Validation			
Prediction			

Application to the field seismic data (Poseidon 3D-NW Australia)

Crossline →

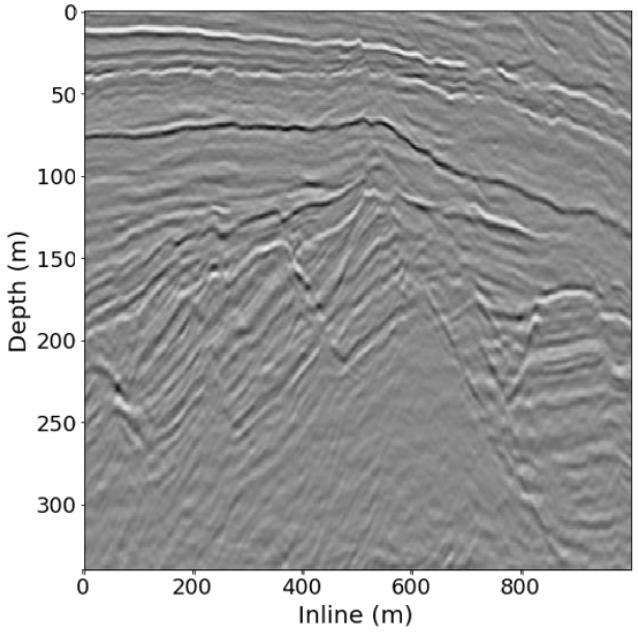
Inline →

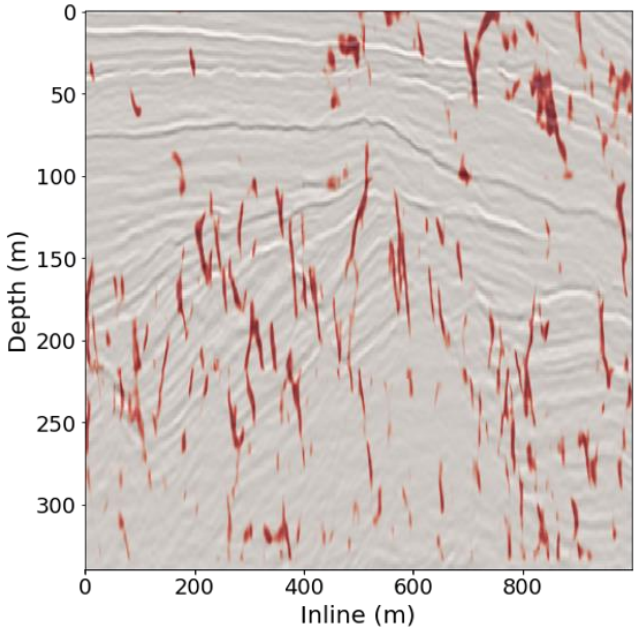
Time Slice →

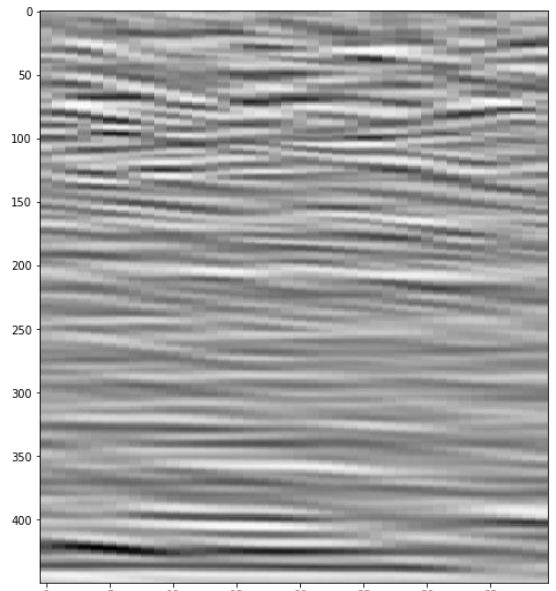


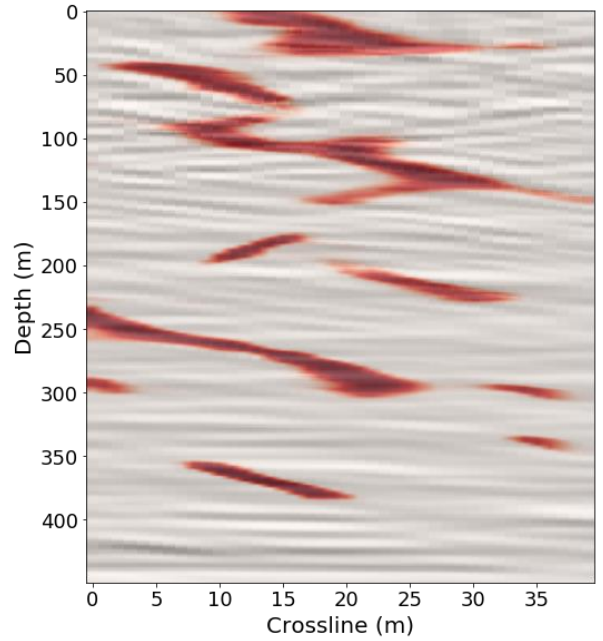
Offshore seismic data, NW Australia, Geoscience Australia

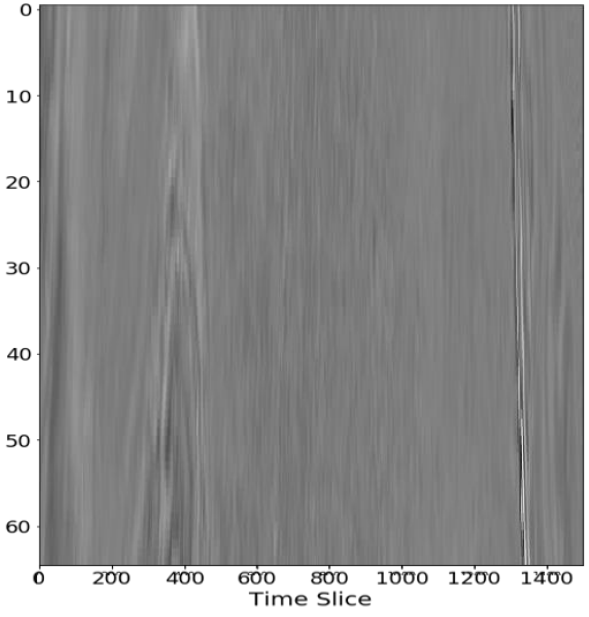
Application to the field seismic data (Poseidon 3D-NW Australia)

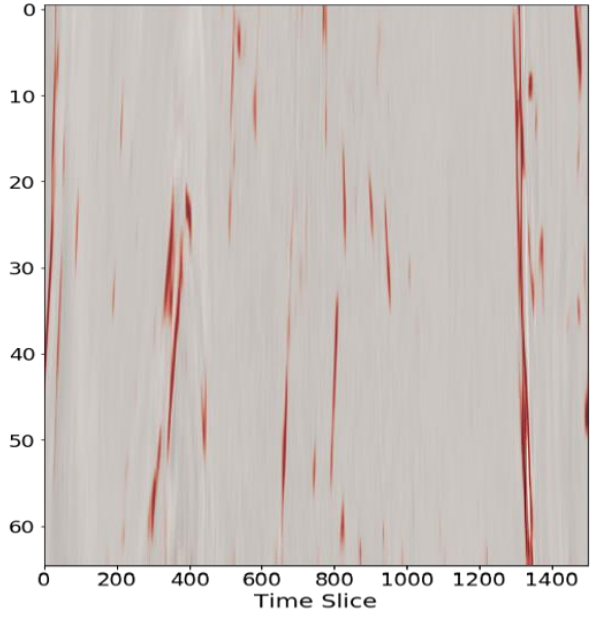








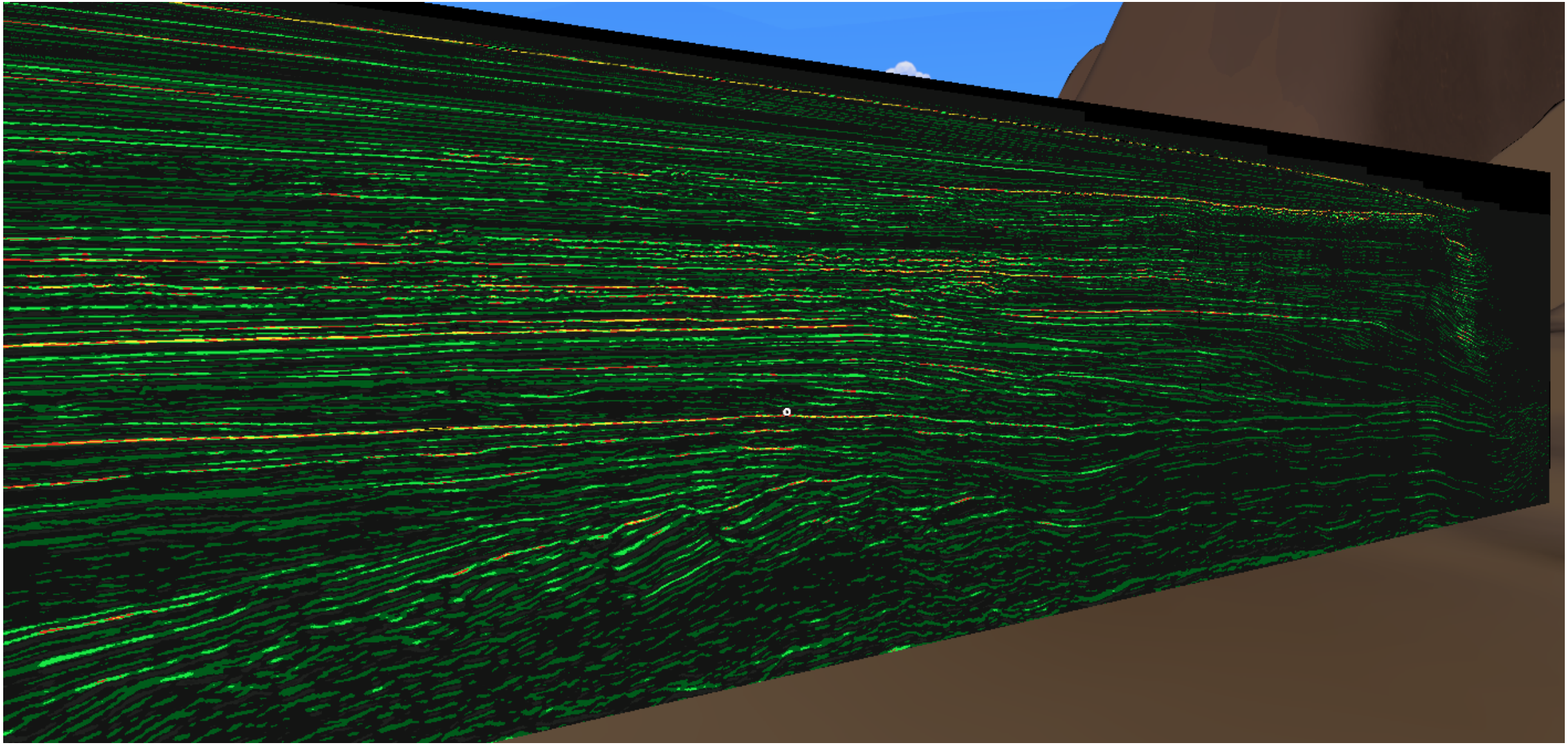




Virtual reality visualization

- ✓ 3D virtual reality (VR) visualization is a useful tool that can benefit seismic data interpretation.
- ✓ We employ the seismic information extended reality analytics (SIERA) tool to present a seismic data visualization in an extended reality environment.
- ✓ This allows for a more immersive and intuitive way to interact with seismic data and machine learning results, providing an improved experience over conventional analytics tools.

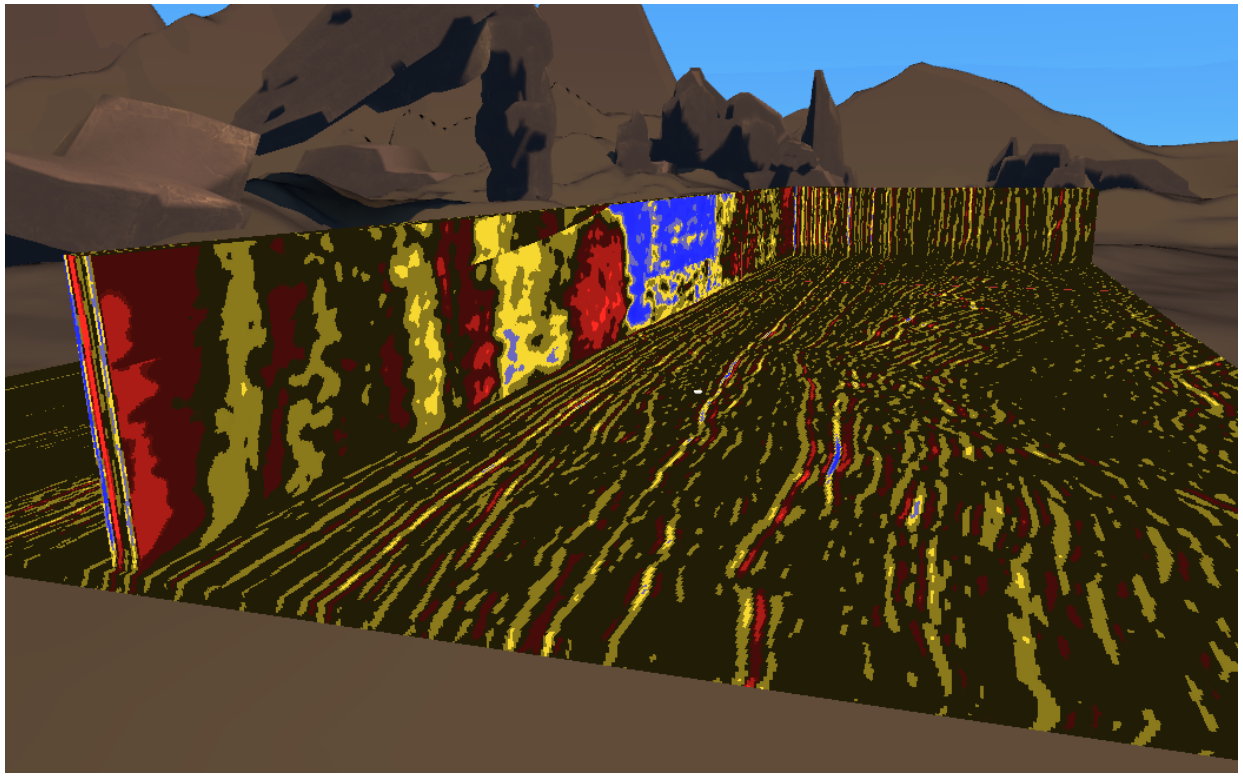
Virtual reality visualization



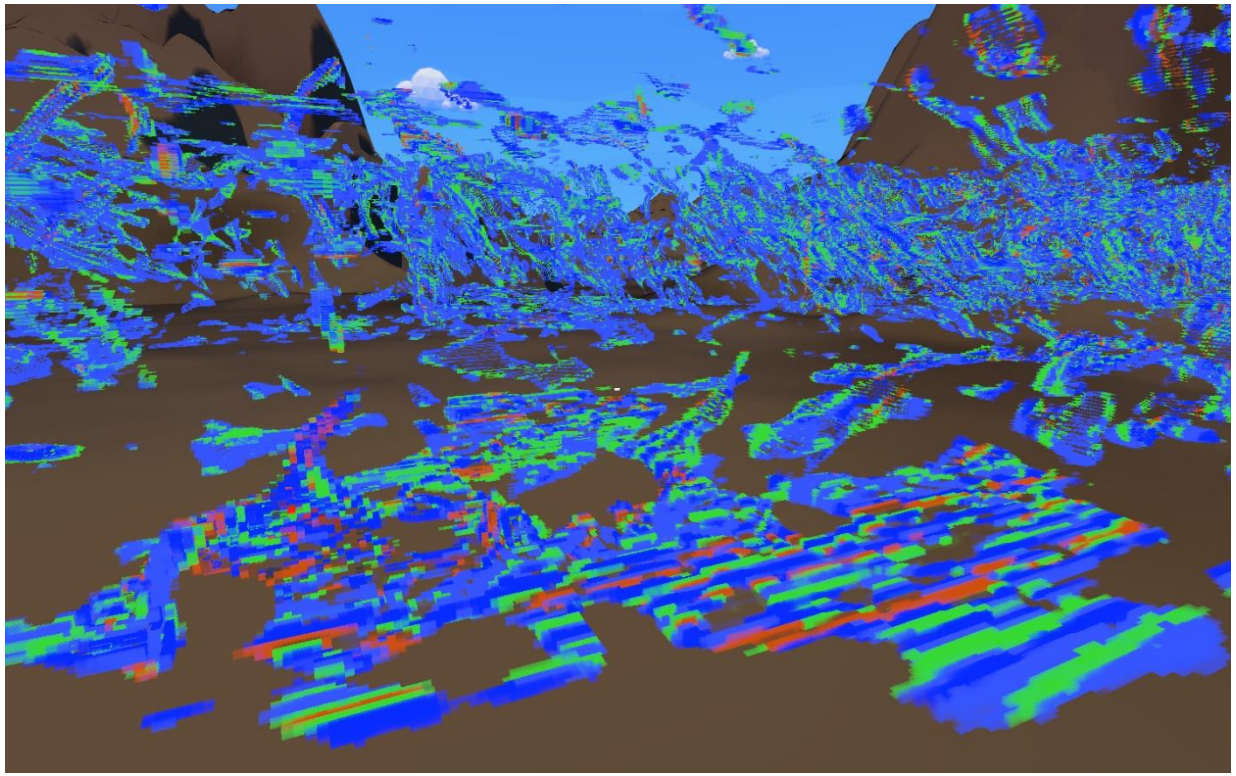
Virtual reality visualization

Data Highlighting & Filtering

(a)



(b)



Conclusions

- We have presented a CNN to detect faults from 3D seismic images, in which the fault detection is considered as a binary segmentation problem.
- After training with only the synthetic data sets, the neural network can accurately detect faults from 3D field seismic volumes.
- We use the SIERA tool to provides a way to more intuitively and immersively interact with the three-dimensional nature of seismic data and ML results.
- This tool allows for analyzing several large data volumes simultaneously and scale them to sizes impractical with traditional techniques for better analysis and the creation of completely customizable and unique data visualizations through the use of voxel color and transparency manipulation.

Acknowledgments

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