interTwin

InterTwin Use Cases - Virgo and CMCC

2024 CERN openlab Technical Workshop, 27.03.2024

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Funded by the European Union

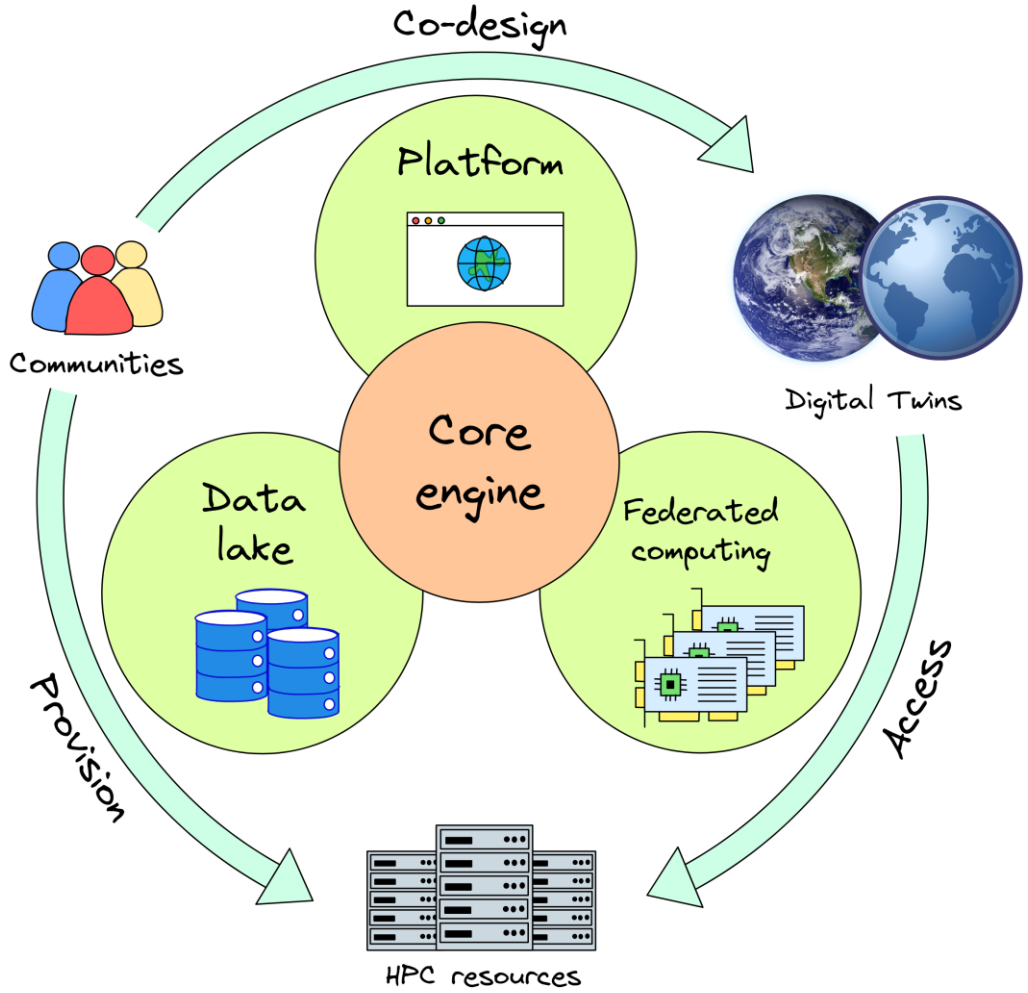
The interTwin project is funded by the European Union - Grant Agreement Number 101058386

Content

- Distributed Training framework of interTwin (itwinai)
- Use-cases of interTwin
- Tropical Cyclone Detection
- Gravitational Wave Denoising

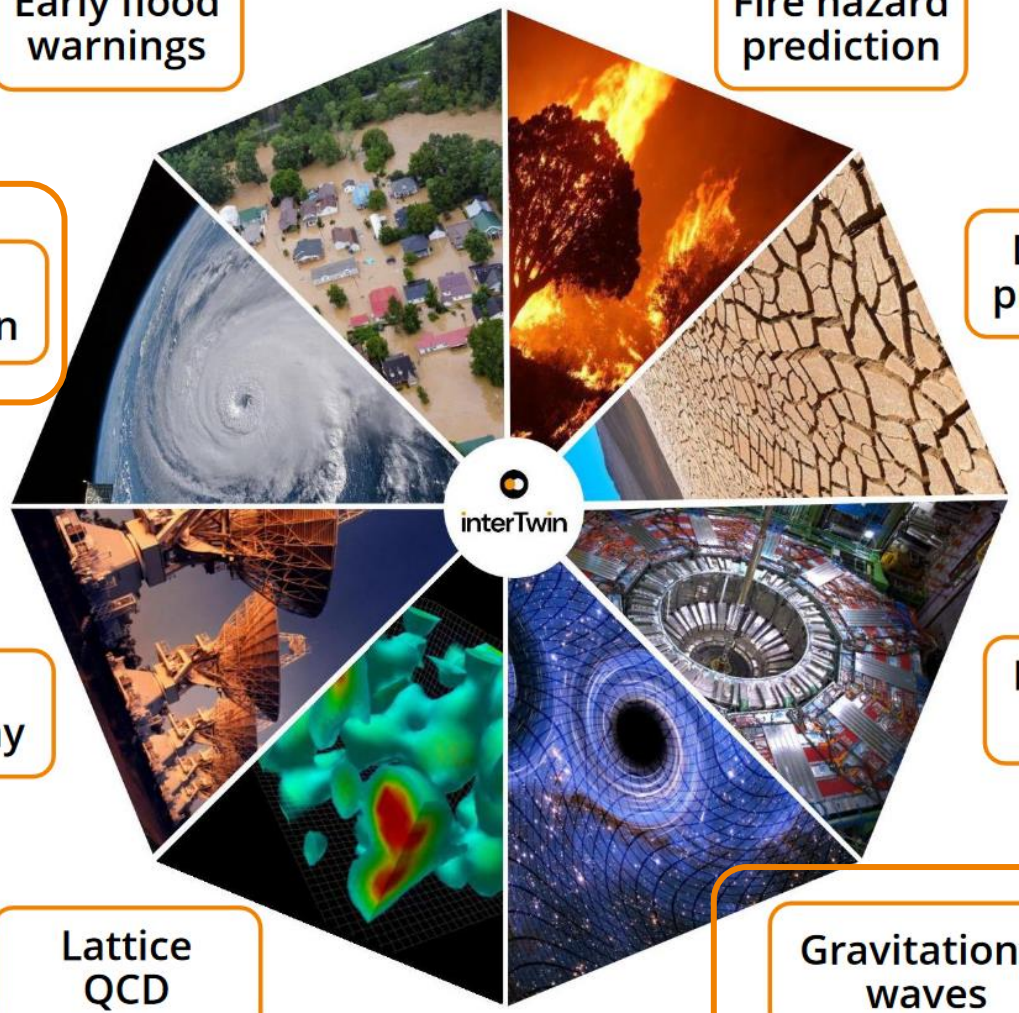
itwinai

- Provides out of the box solutions to automate your AI workflows
- Essential part of the Core Engine for creating Digital Twins
- Further details



interTwin use cases

interTwin use cases



cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

INFN
Istituto Nazionale di Fisica Nucleare

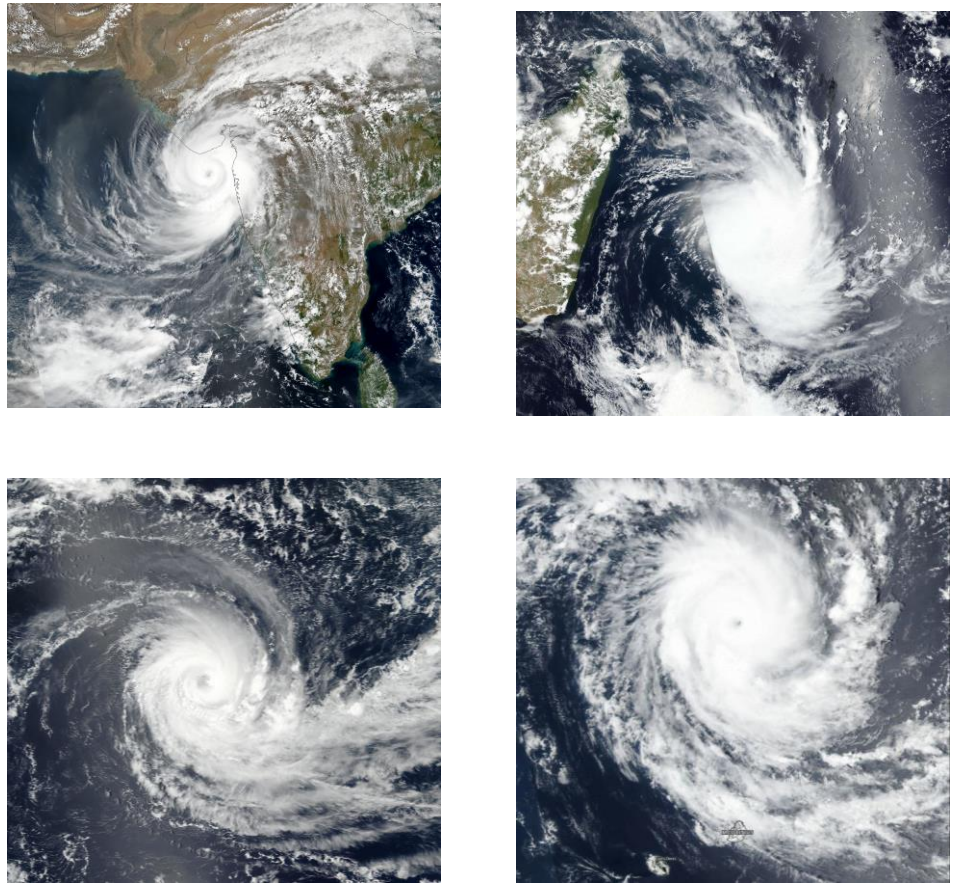
Tropical Cyclone Detection

- Cyclones can have devasting effects on areas they hit
- Tropical cyclone detection traditionally relies on meteorological data and expert analysis

Tropical Cyclone Detection

- Machine learning offers a data-driven approach to enhance detection accuracy and efficiency

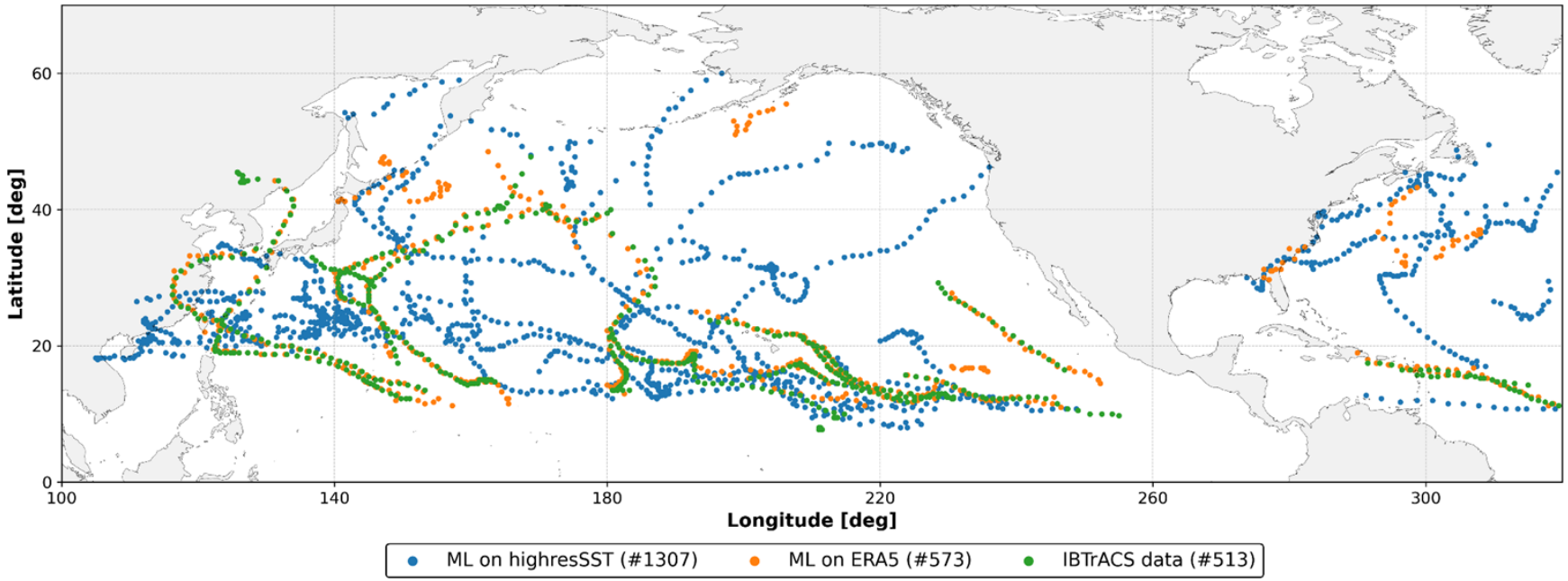
- Key features extracted from satellite imagery, such as cloud patterns, sea surface temperature, and atmospheric pressure gradients, serve as inputs.



Visible Infrared Imaging Radiometer Suite (VIIRS) on the NASA-NOAA Suomi NPP satellite

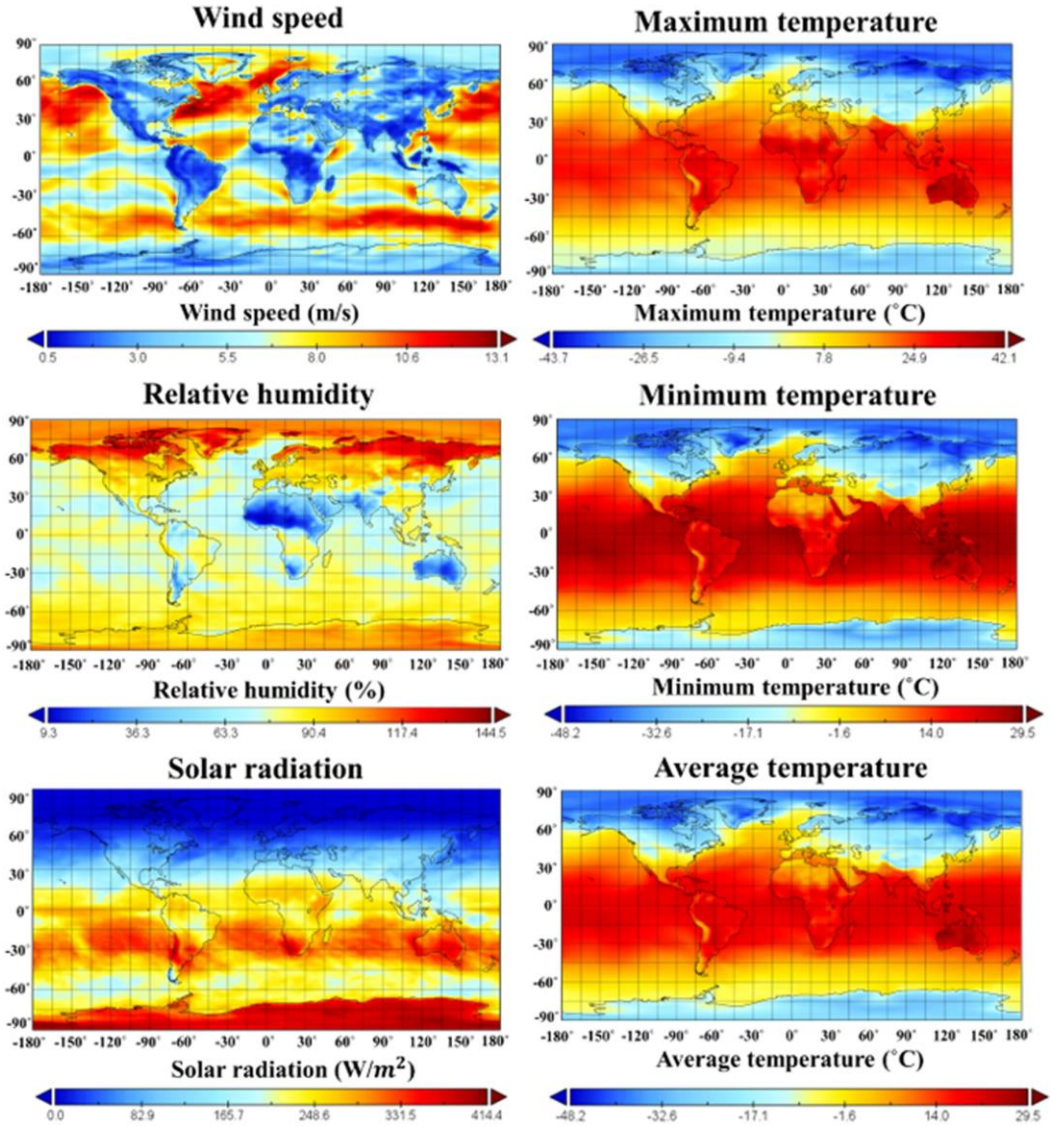
Tropical Cyclone Detection

- Task is to track the center of the cyclone



Dataset

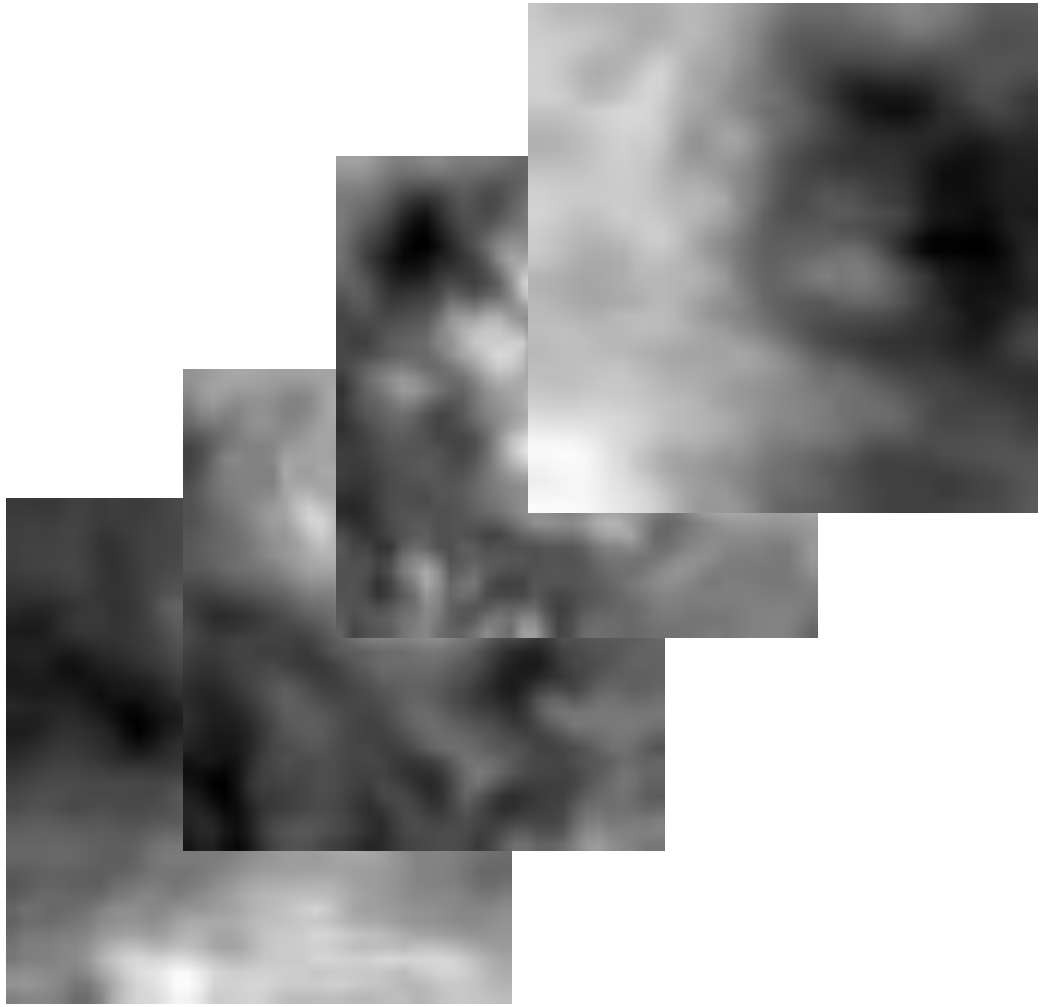
- High-resolution, daily, global dataset from CMIP6
- Several features are available (temperature, pressure, humidity, solar radiation, wind)
- ~30PB in size



Song, Y.H., Chung, ES., Shahid, S. *et al.* Development of global monthly dataset of CMIP6 climate variables for estimating evapotranspiration. *Sci Data* **10**, 568 (2023). https://doi.org/10.1038/s41597-023-02475-7

Dataset

- High-resolution, daily, global dataset from CMIP6
- Only part of the whole dataset is used due to the large size
- Training on patches



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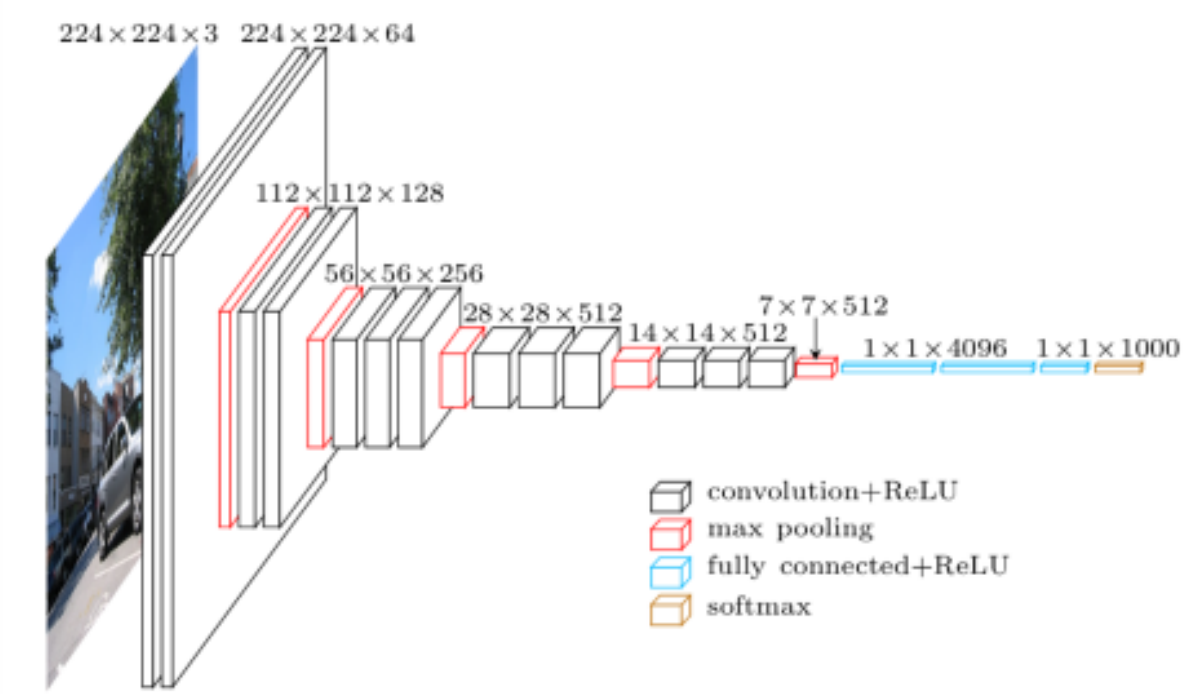
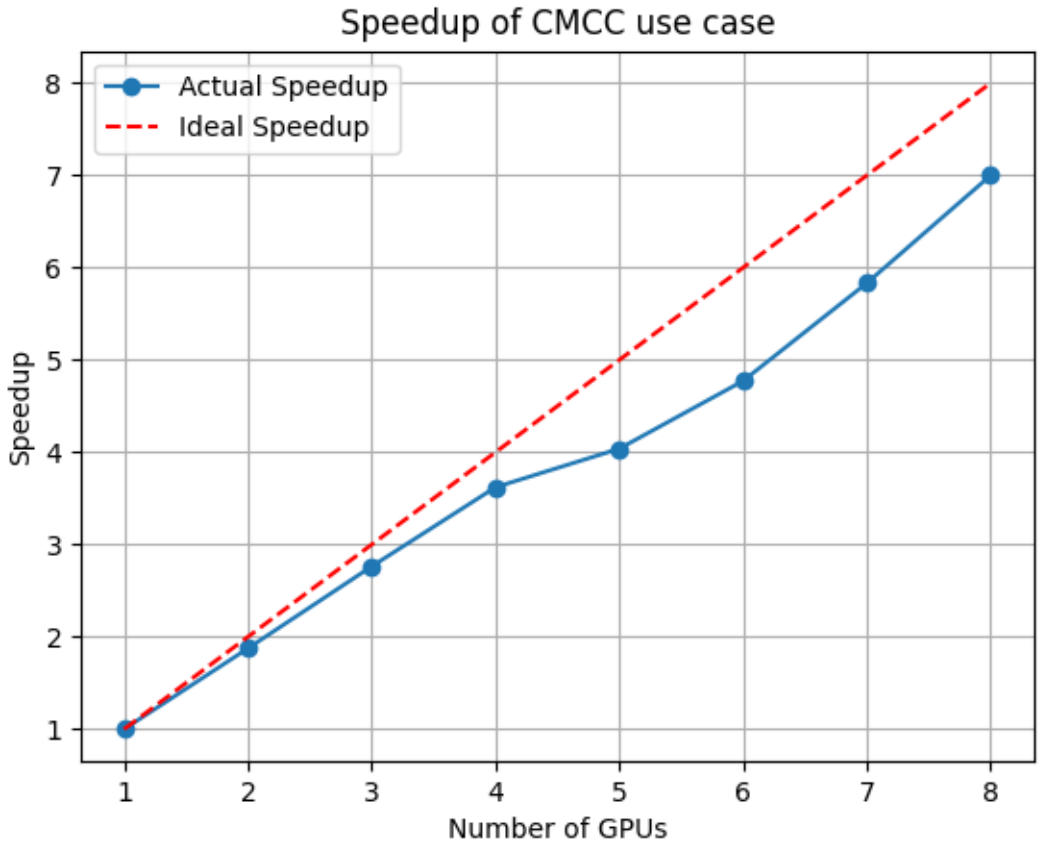
Neural Network

- Modified VGG-like architecture (CNN)
- Parameters 3.75M (14.30 MB)
- Based on Tensorflow
- Trained on Tesla V100-SXM2-32GB



Distributed Training using itwinai

- Tested scaling with 1-8 GPUs
- Good scaling, for lower number of GPUs
- Performance loss for higher number of GPUs



Gravitational Wave Detection

- Ripples of curvature in the fabric of spacetime travelling at the speed of light
- Completely different modality from EM telescopes
- Detected via Laser interferometry
- The effect is extremely small: Strain = ΔL / L ~ 10^-21

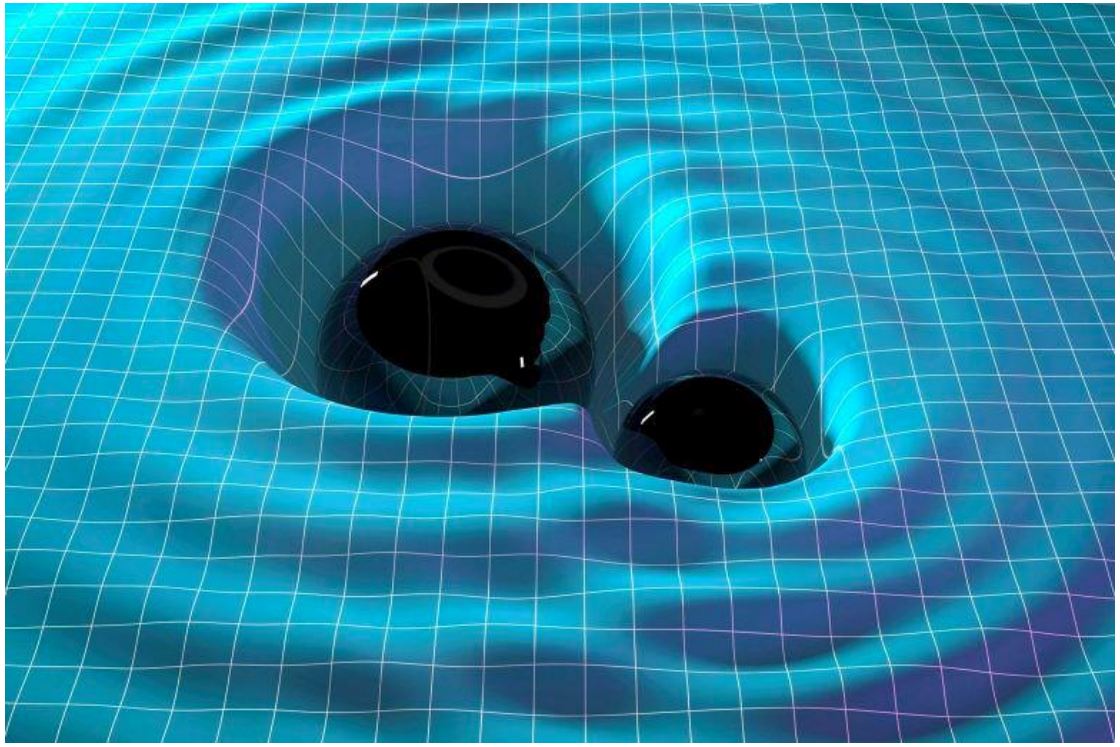
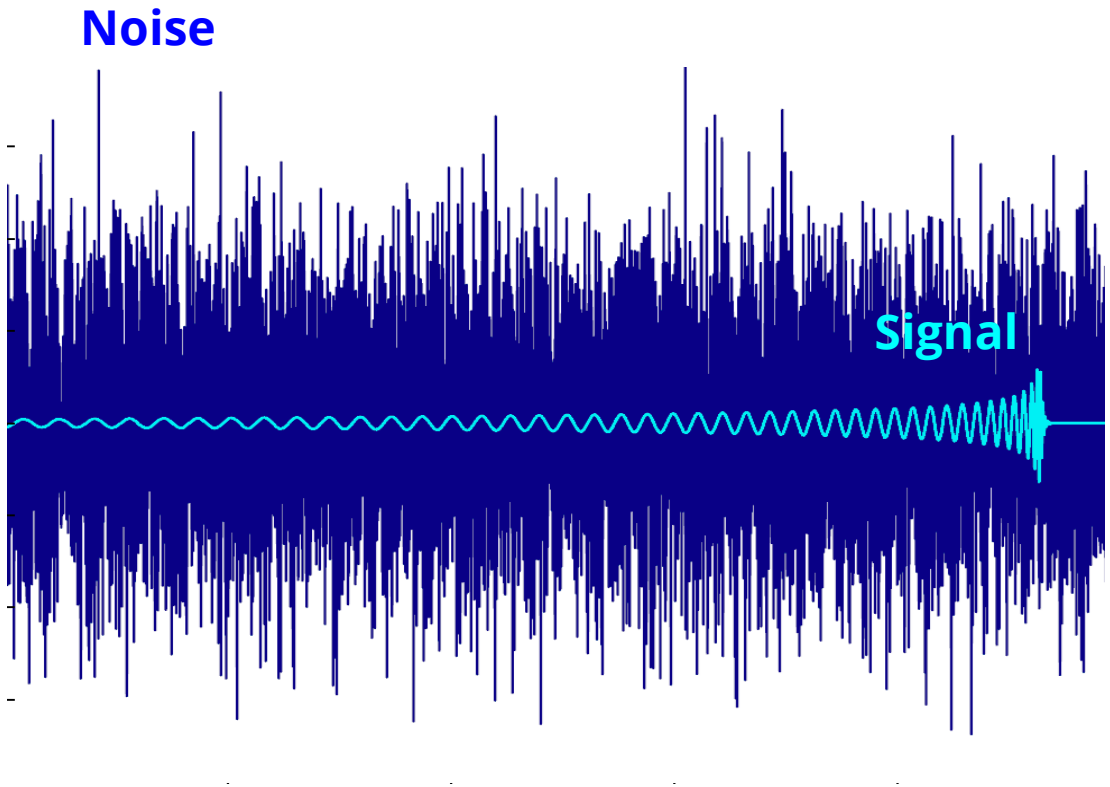


Illustration of two orbiting black holes warping spacetime and generating gravitational waves.

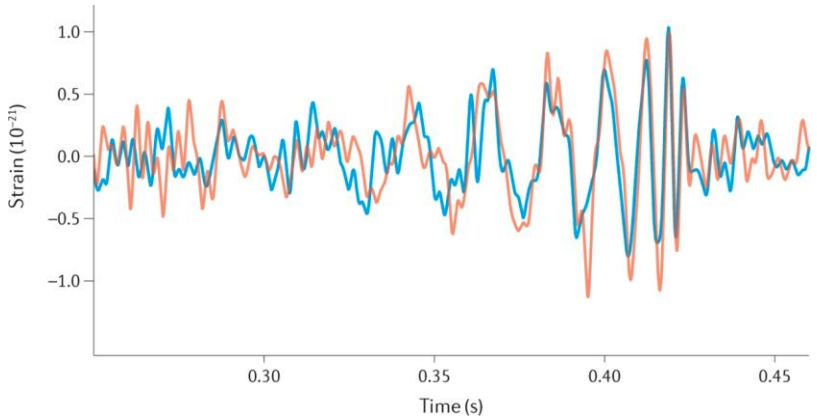
Gravitational Wave Denoising

- Due to the nature of gravitational wave measurement (weak signal, transient nature) very difficult to distinguish from noise

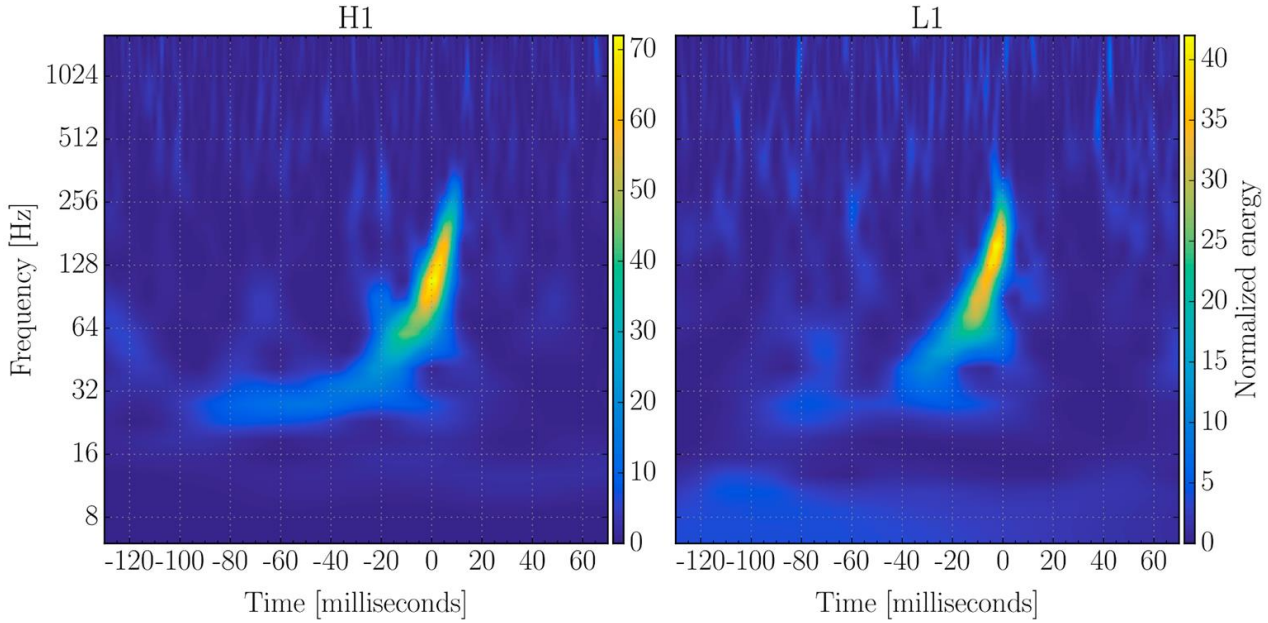
- Noise is often non-gaussian Noise, making it harder for traditional denoising techniques



Dataset

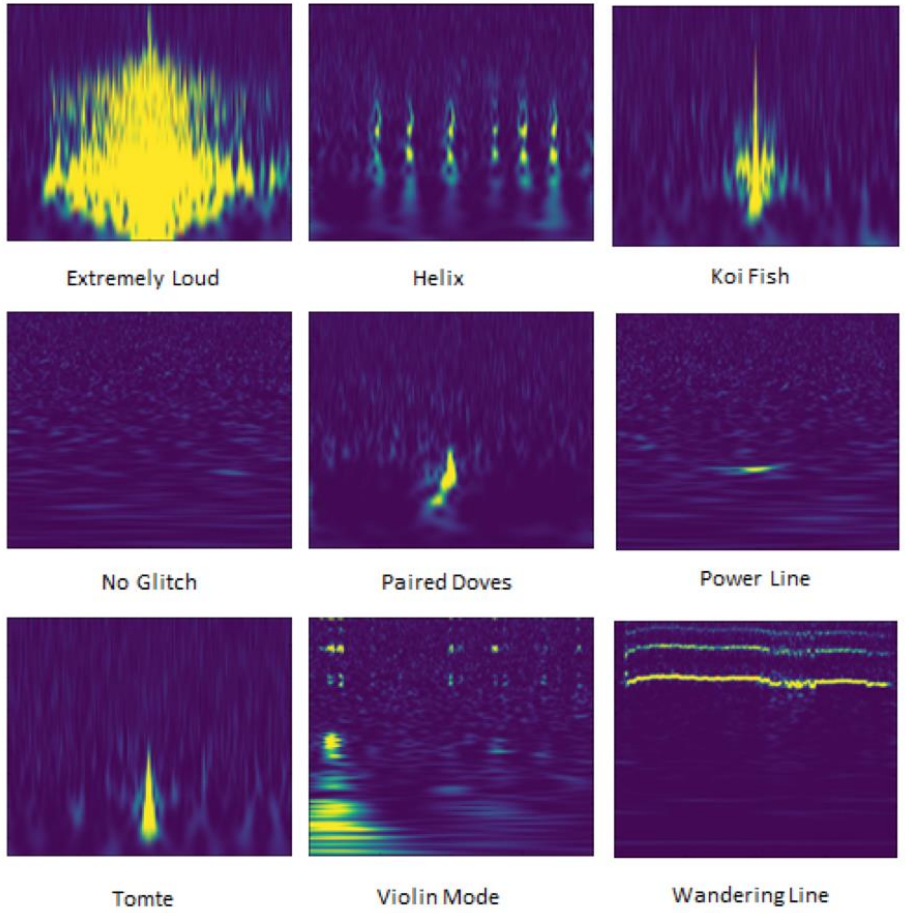


Q-TRANSFORM



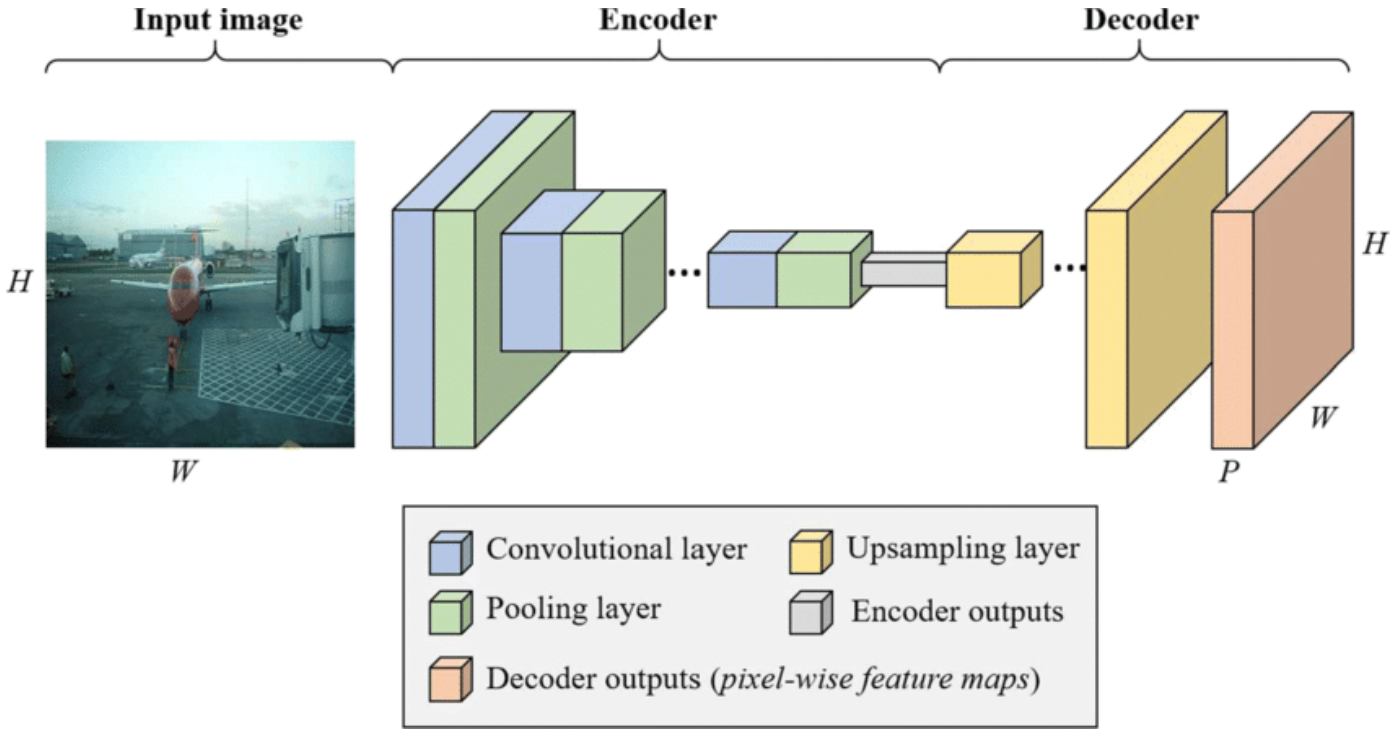
Noise Examples

- Very sensitive detector setup leads to many noise sources
- Different kind of noise due to anthropogenic sources, weather, equipment malfunctions, unknown sources



Neural Network

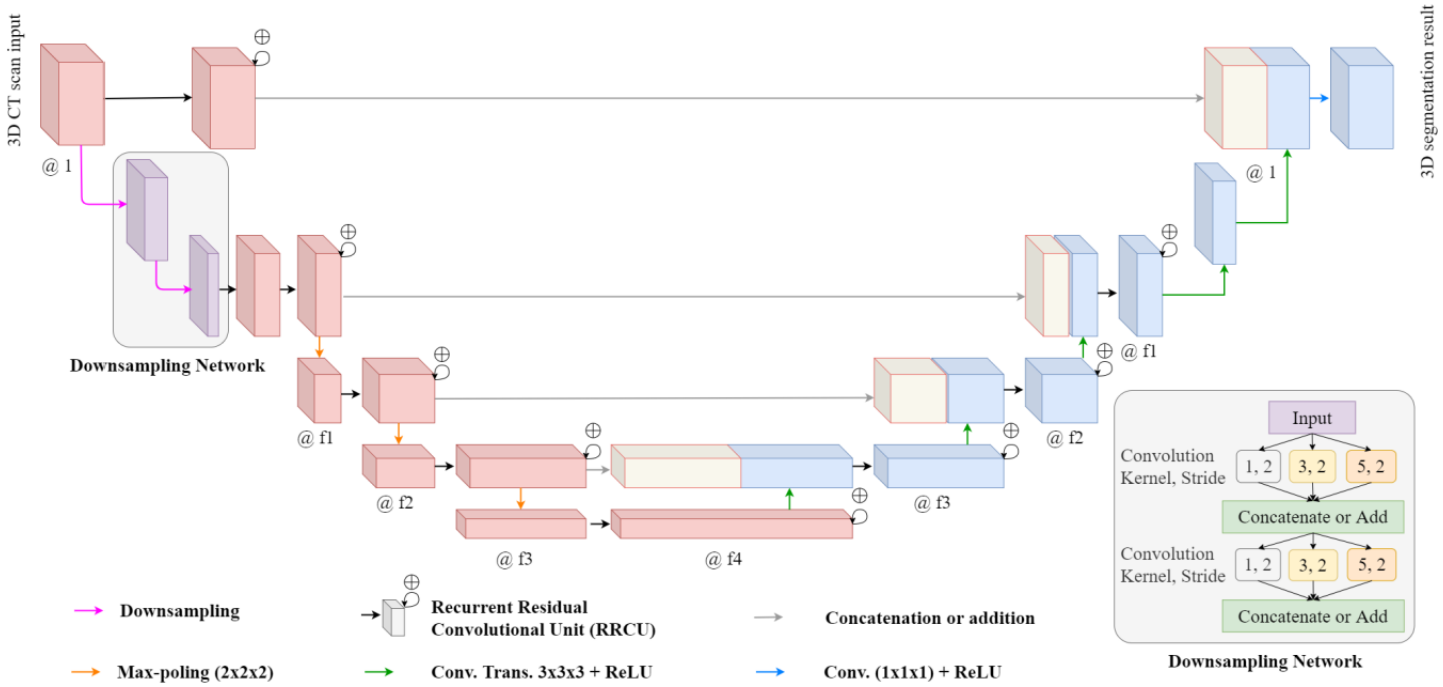
- Decoder Network
- Parameters 2.1M
- Based on PyTorch
- Trained on Tesla V100-SXM2-32GB



Tong, Zheng & Xu, Philippe & Denœux, Thierry. (2021). Evidential fully convolutional network for semantic segmentation. Applied Intelligence. 51. 10.1007/s10489-021-02327-0.

Neural Network

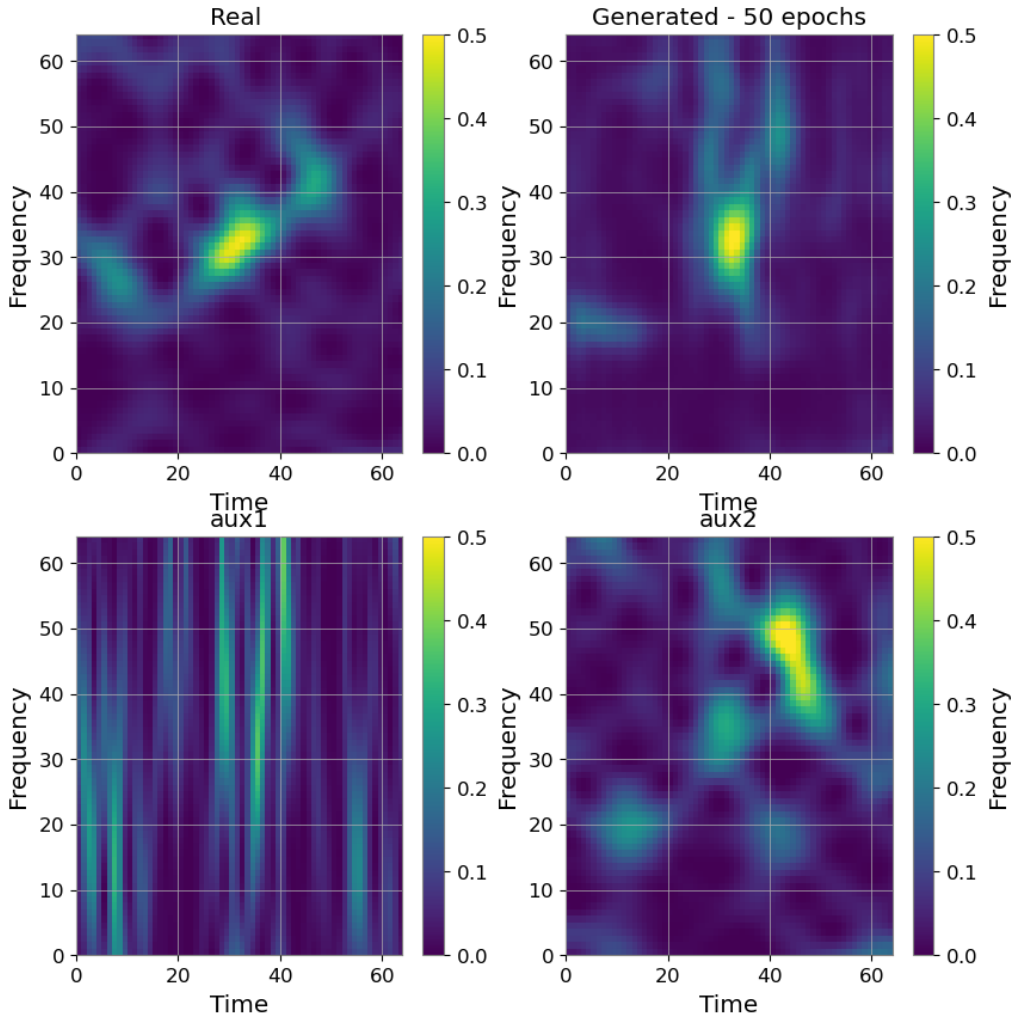
- U-Net architecture
- Parameters 2.5M
- Based on PyTorch
- Trained on Tesla V100-SXM2-32GB



Kadia, Dhaval, Md. Zahangir Alom, Ranga Burada, Tam V. Nguyen and Vijayan K. Asari. "R2U3D: Recurrent Residual 3D U-Net for Lung Segmentation." IEEE Access 9 (2021): 88835-88843.

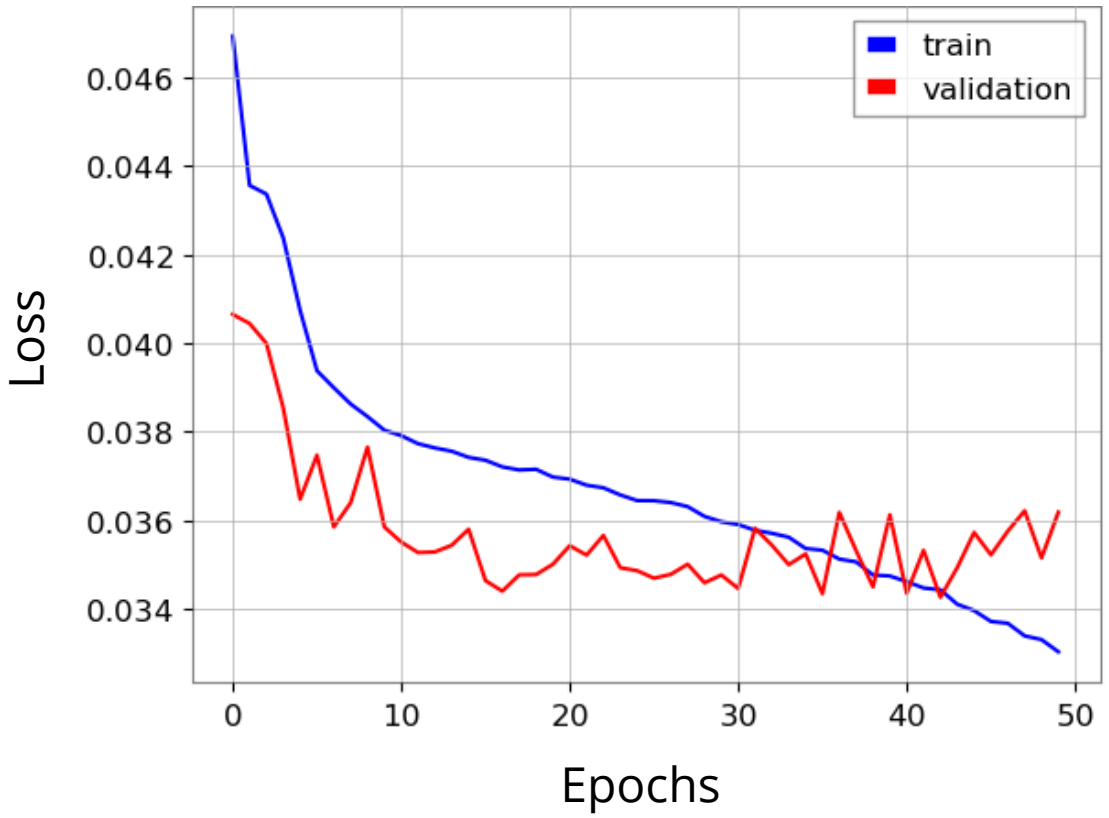
Single-device Training using itwinai

- Trained on 1 GPU



Single-device Training using itwinai

- Trained on 1 GPU
- Training Loss steadily declines
- Validation Loss plateaus at around 30 epochs



Thank you! Questions?

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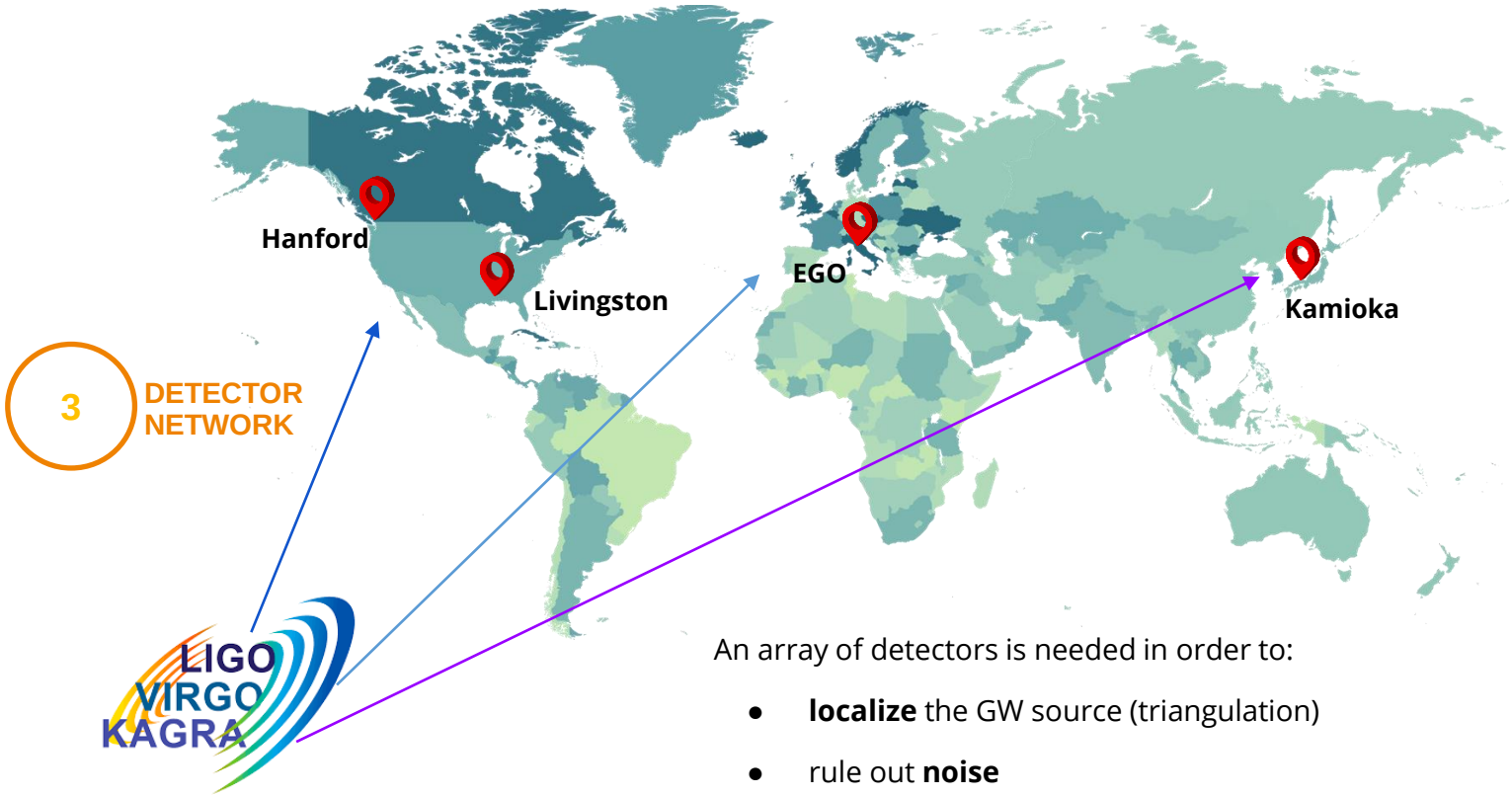
Gravitational Wave Detection



An array of detectors is needed in order to:

- **localize** the GW source (triangulation)
- rule out **noise**