Autoencoders for VIRGO GW signal analysis

Second ML-INFN Hackathon

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15/12/2021

Gravitational Waves

Gravitational Waves

GW detectors

Detector noise

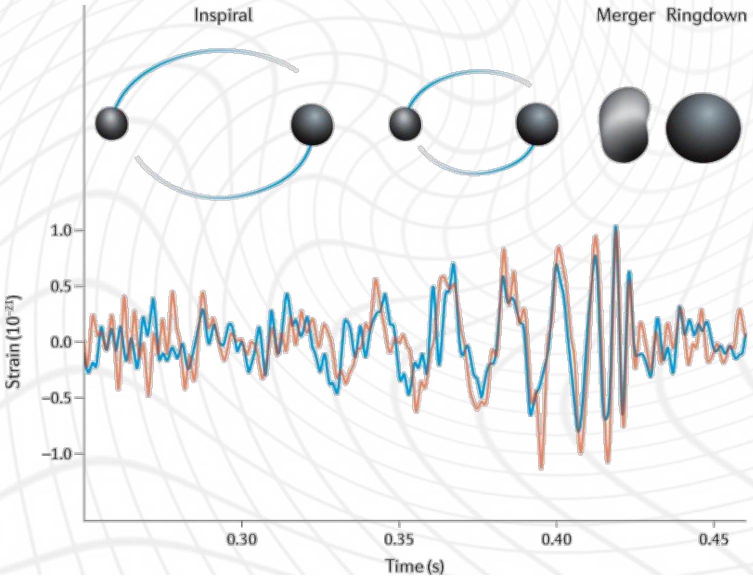
Autoencoders

Open access to GW public data

Hackathon Workflow

More about ML in GW research

...are propagating ripples in the fabric of spacetime, originated from **accelerating masses**, such as the inspiral of a binary black hole system.



Phys. Rev. Lett. **116** (6): 061102

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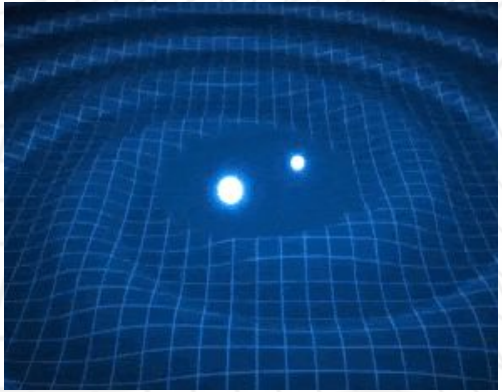
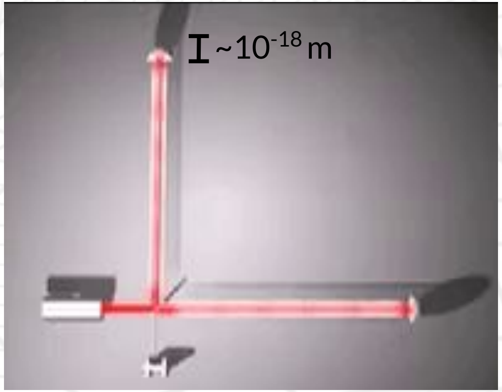
- GWs propagates through space at the speed of light;
- Their effect is an alternate *stretch* and *squeeze* of the distances between the masses;
- We can user Michelson interferometers to detect them.





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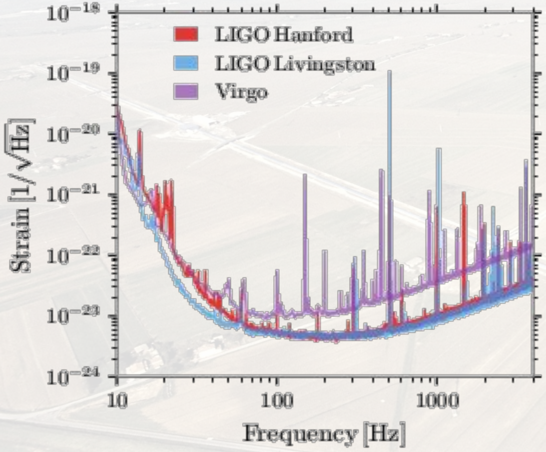
Detector noise

Many instrumental or environmental sources produce a *strain equivalent noise*.

Detection problem: our ability to extract the information about the astrophysical signal depends on how good we know the (statistical) properties of the noise.



If the data is **stationary** and **Gaussian**, we can fully characterize the noise from its Power Spectral Density, whos square root provides a measure of the *strain sensitivity*.

But this is true only in first approximation: ***we need better modeling!***

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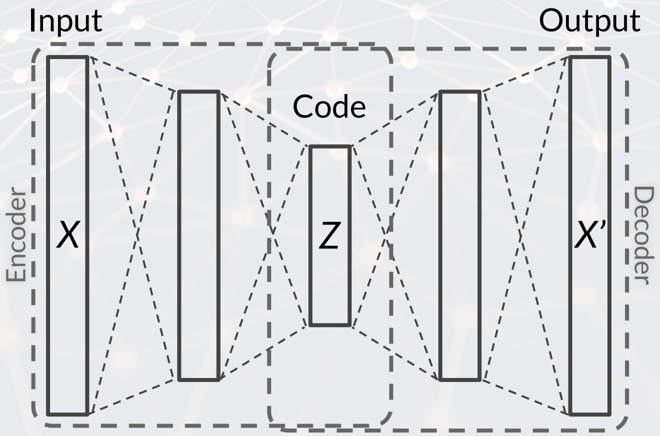
Autoencoders

...are an unsupervised learning technique in which we leverage neural networks for the task of **representation learning**.

We force a compressed representation of the original input; if some sort of structure exists in the data, this can be learned and used for “de-noising”.



- *Dim(X’) = Dim(X)*
- *Dim(Z) < Dim(X)*
- $X' \rightarrow X$

AIChE Journal. 37 (2): 233–243

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GW data is made available by the International Gravitational Wave Observatory Network (IGWN) and the GW Open Science Center (GWOSC).

- Strain data of GW events and observing runs;
- Tutorials to learn more about GW science;
- Software for signal analysis.

Hackathon workflow

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- Download and explore GW data;
- Learn the basics of GW data processing and visualization;
- Create your autoencoder model;
- Experiment with hyperparameters: batch size, epochs, layers and regularization;
- Test it with random Gaussian data;
- Apply it to real GW data.

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GWitchHunters citizen science project:

https://www.zooniverse.org/projects/reinforce/gwitchhunters, or just