HACK DAY – LIGO CLASSIFICATION USING KERAS

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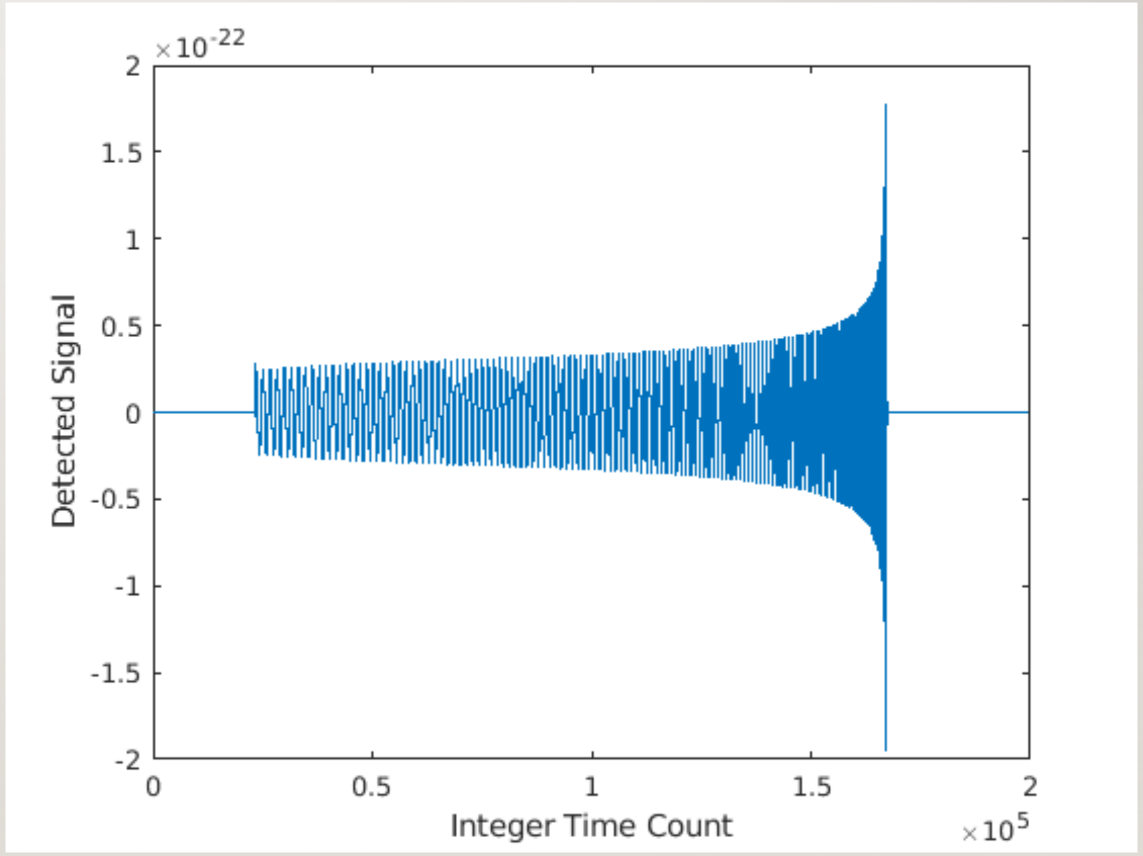
PROBLEM DEFINITION

- Welcome to the last part of this ML workshop.
- Today, your mission is simple: create a tool which, when fed a LIGO data sequence, can let the user know if there is a gravity wave present or not. Hence, this is a binary classification problem involving sequences.
- You will need to:
  - Train a database

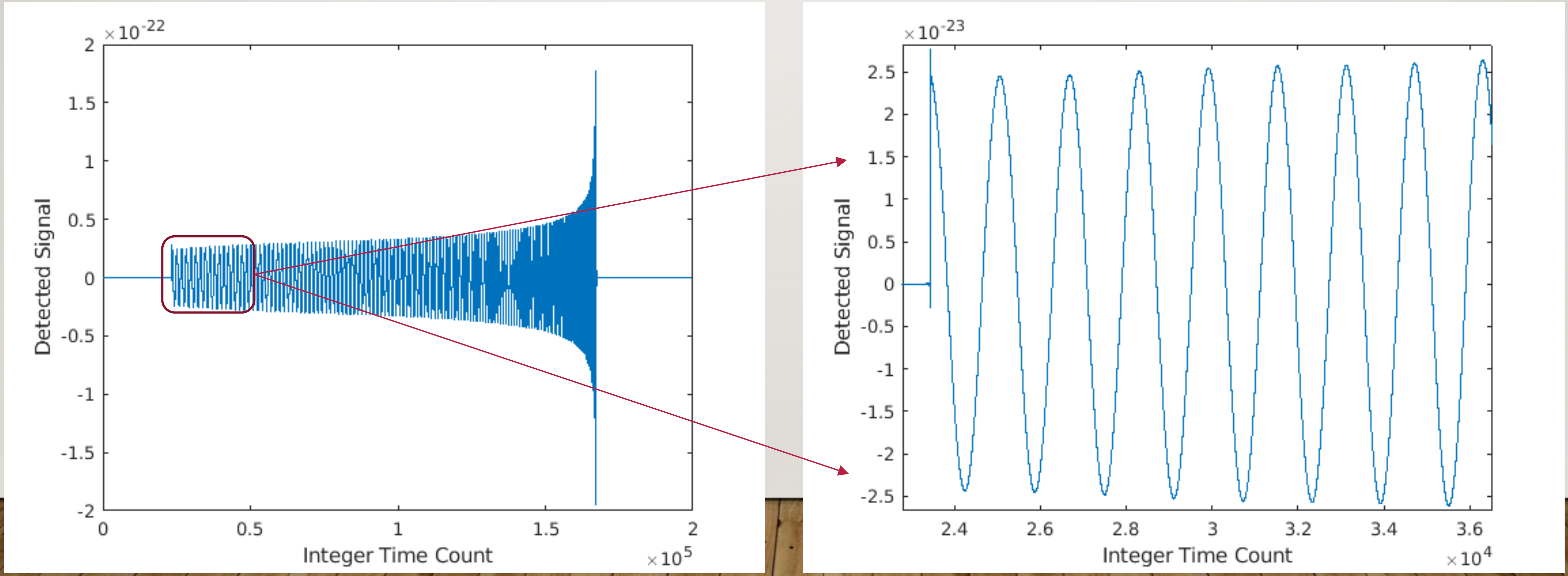
LIGO SIGNALS

- Let's introduce you to your target – this is what a simulated gravity wave, as might be observed by LIGO, looks like without the noise.
- Let's draw some attention to some features of this signal:
  - Average magnitude is around 0.5e-22, and
  - Each signal contains 200,000 pieces of data.
- This data is double precision, and saved to file in binary format.



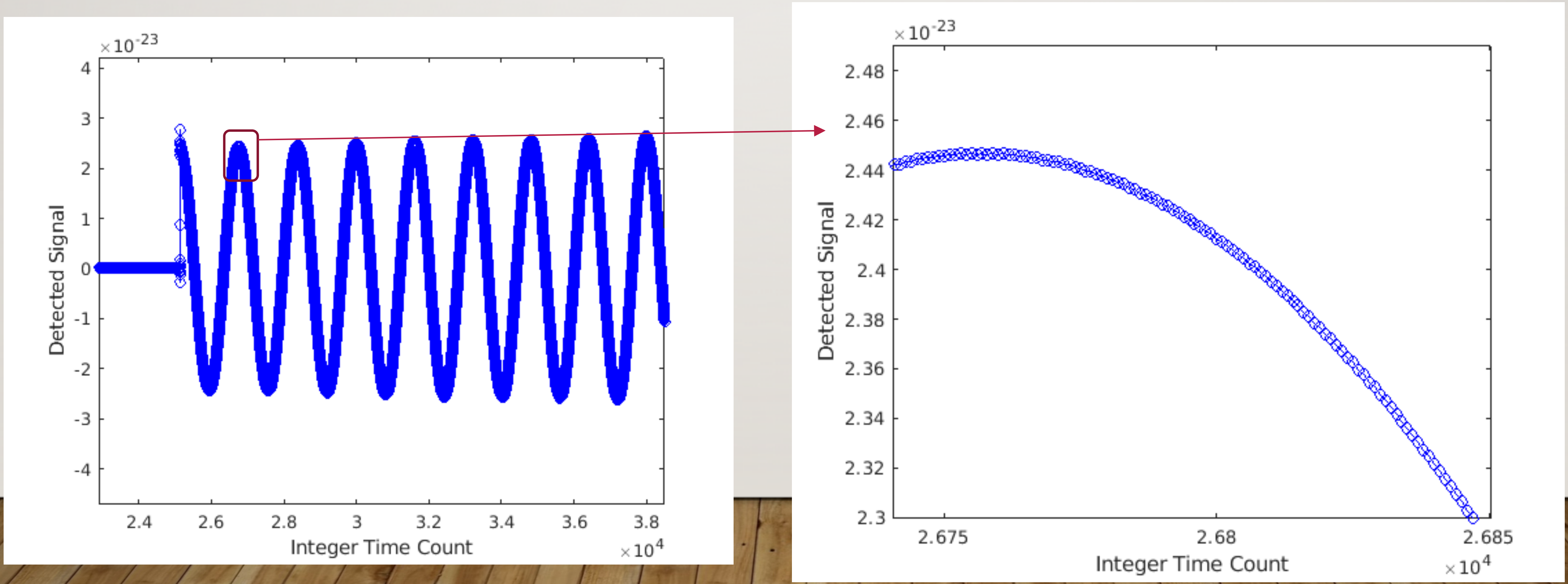
LIGO SIGNALS

- Let's have a closer look at the data – it is oscillatory with increasing frequency and magnitude.



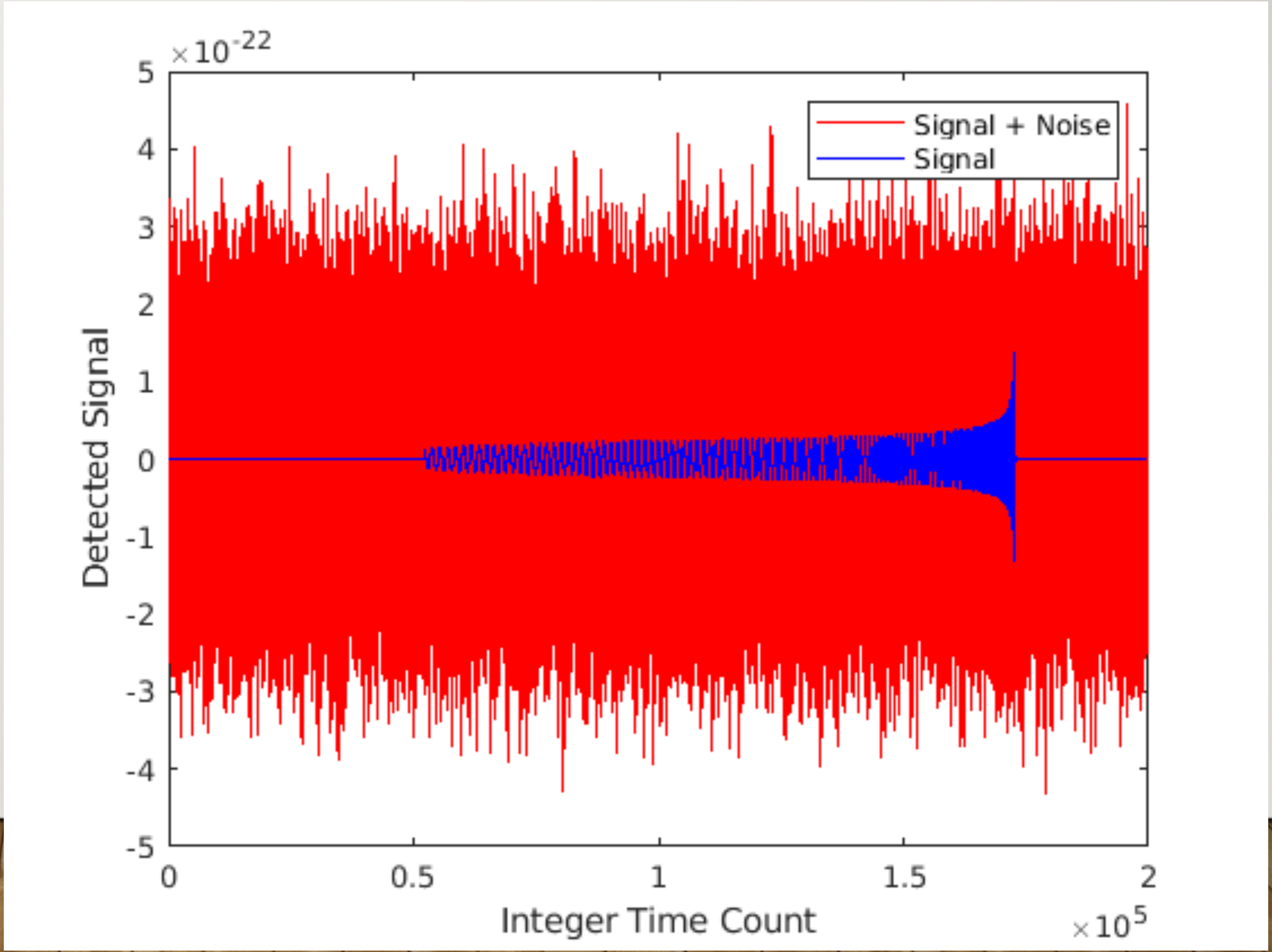
LIGO SIGNALS

- If you check the frequency of reported data against the wave frequency, we can see this data is excellently resolved.



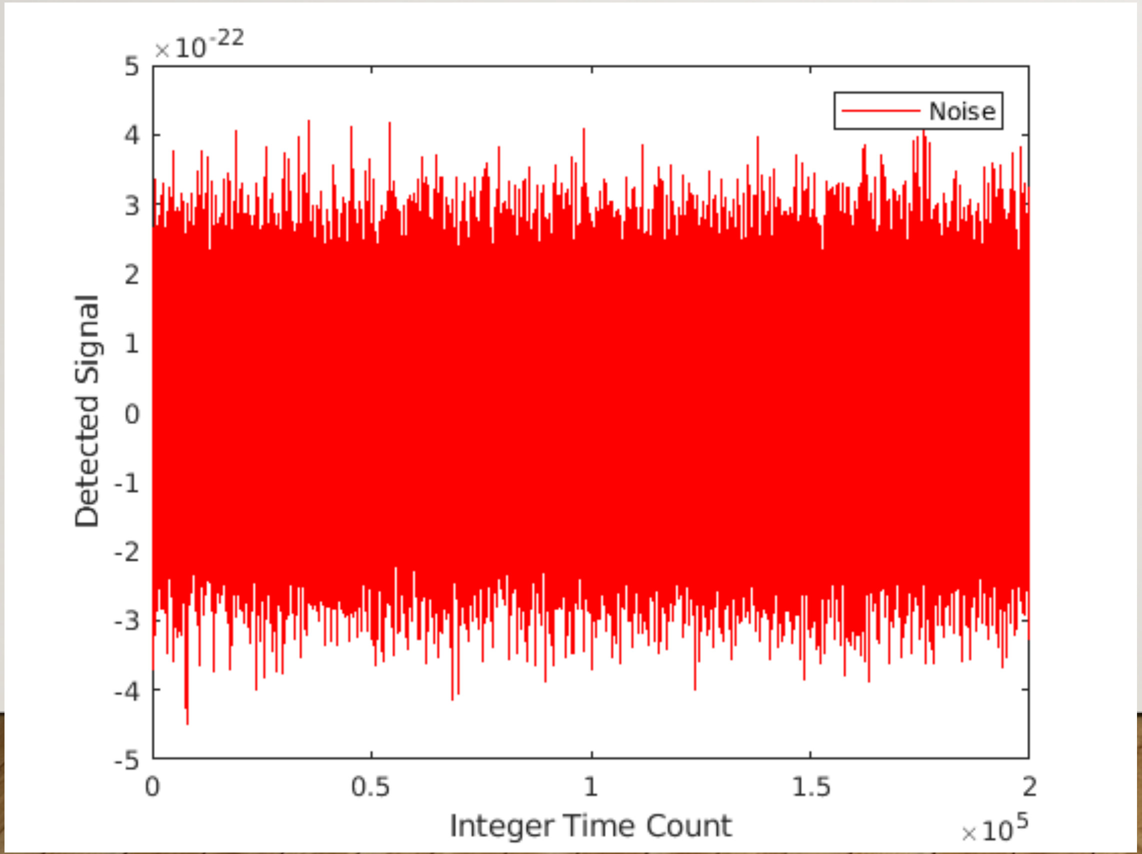
LIGO SIGNALS

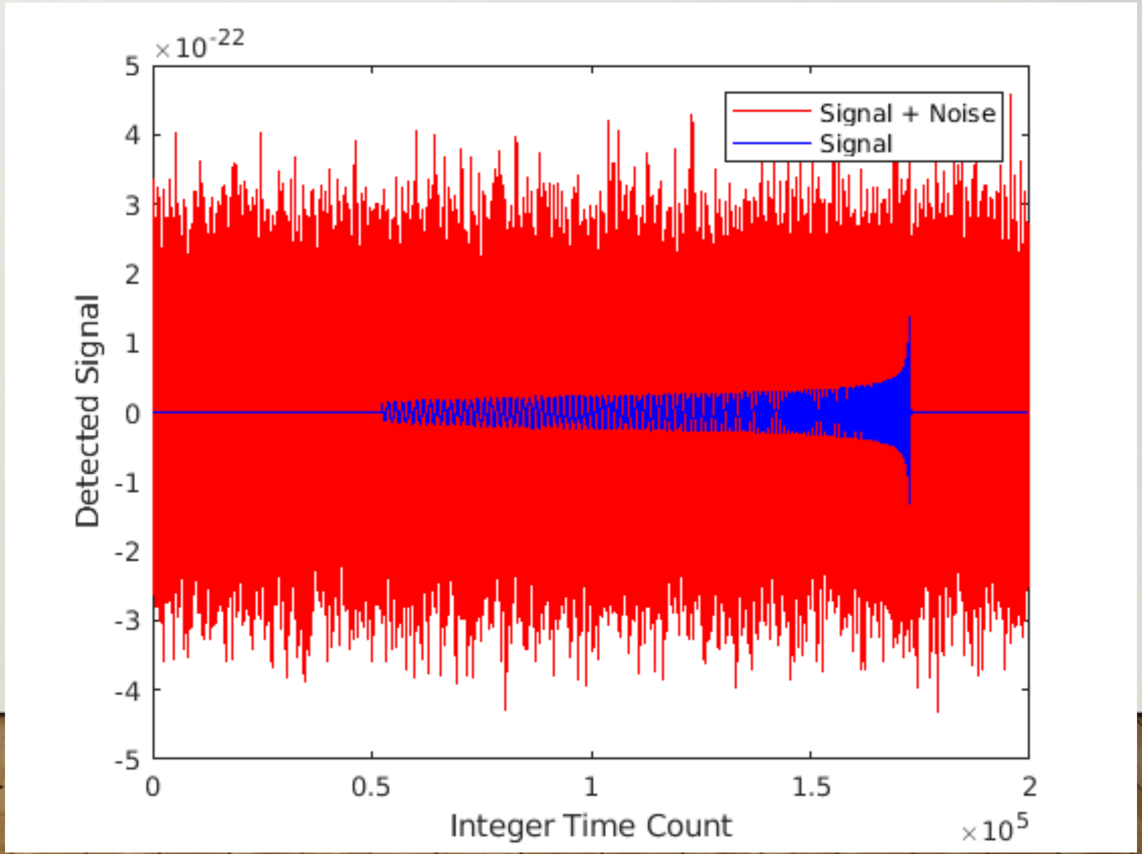
- Many experimental observations contain noise - this one is no exception.
- Thus, on top of this signal, we have added noise – which is taken from a normally distributed random number generator.
- As a matter of fact, the noise present here is much smaller than the actual noise present in real LIGO signals – but we want today to be at least a little fun.



LIGO SIGNALS

- So your mission – create an AI which examines a data packet of 200,000 doubles and classifies it as either (0) not having a gravity wave, or (1) containing a gravity wave.





WHERE TO START..

- Start with the codes provided in ADACS_ML_A and ADACS_ML_B.
- These will need to be modified to:
  - Load a data stream containing 200,000 doubles from file.
  - Filter the data in an attempt to remove the noise and reveal the gravity wave present,
  - Reducing the problem size – perhaps use 200 to 2000 data points instead of the full 200,000
  - Employ dropout in an attempt to prevent overfitting on the noise present.

- You should then save your keras model, and create an inference script (infer.py) which loads the JSON data and model weights and is used for categorising a new LIGO signal.

WHERE TO START..

- When you git cloned this material (ADACS_ML_C), you copied the LIGO signal data you require in the Test_Easy and Train_Easy directories.
- The naming format of these files is: X_LIGO_ZZ.dat where ZZ is an integer from 1 to 400 for the training data and 1 to 100 for the test data. The file containing the classification is Y_LIGO_ZZ.dat (same ID).
- You'll also find the filtering and dropout PDF included with this data; don't be afraid to scp it to your local computer for your reference.

ADVICE?

- Refer to the previous PDF's containing information on filtering and dropout.
- Experiment with filter frequency cutoff values.
- Experiment with the number of neurons in each layer, and the number of layers.
- Experiment with dropout values – don't use 1.0 (which would be silly) but using 0.0 is OK (this is essentially no dropout)
- Write a new view.py script which allows you to view the filtered signal – if you can't see the gravity wave, then there is a good chance your AI won't be able to see it. Use this script to test filter frequency cutoff values.

ADVICE?

- Rewrite your codes to run multiple training sessions – these are known as ensembles - to get a better idea of the average influence of your filter cutoff and dropout values.
- Fix the random seed – by setting the seed, the random numbers used as part of the ML algorithms will be consistent, and your experiments will be repeatable.
- NORMALIZE YOUR DATA. The data contained in the /Test and /Train folders is small (1e-22, 1e-23) – you should divide this by some characteristic small number (perhaps 1e-23) in order to avoid numerical precision problems.
- Work in groups – cooperate with one or two other people. Don't be afraid to communicate.

WHAT CAN YOU EXPECT?

- Without dropout, you might get up to 70% accuracy, depending on how many neurons you use, your filter and the complexity of your network. Simple is better.
- With dropout and a good filter, an average accuracy of 95% should be obtainable. I'd say this is a good target for this workshop.
- You should be able to train your AI in a couple of seconds – if you need more than 2 minutes to train your AI, you are trying to hard. Change your filter, use fewer data points, check precision – if you are still stuck and your AI isn't learning, consult with other groups.

GOOD LUCK

- Any questions? Put your hand up, or email me: msmith@astro.swin.edu.au