Pulsar Detection with Deep Learning

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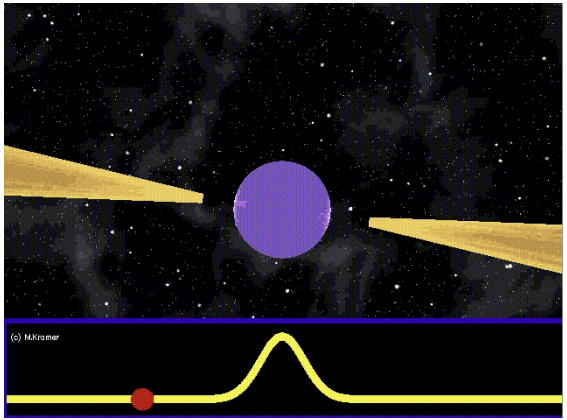
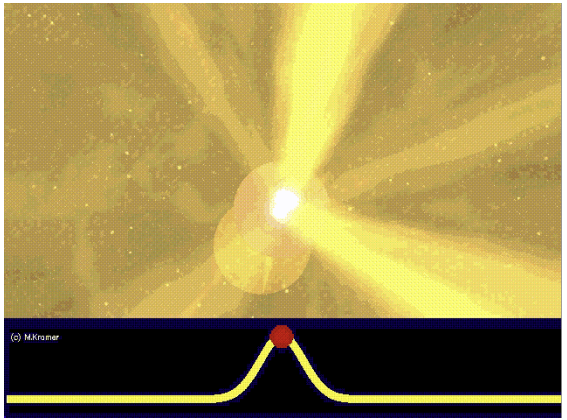
Pulsars

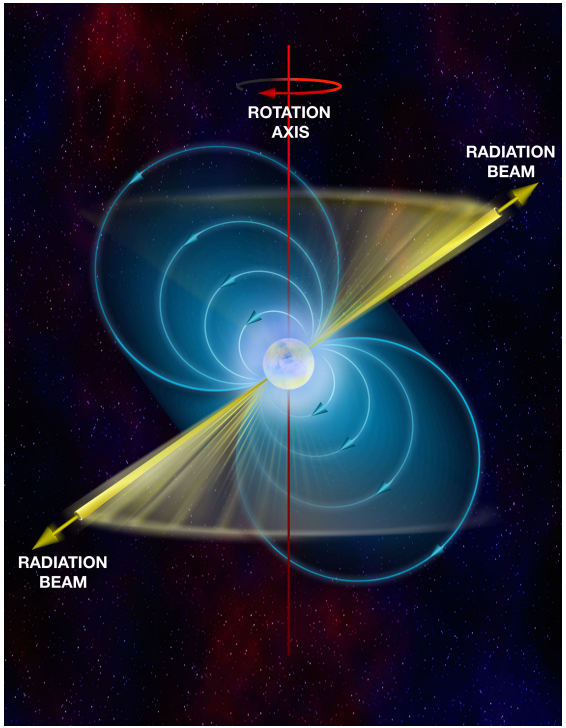
Pulsars are rapidly rotating neutron stars with intense magnetic fields that emit electromagnetic radiation.

Pulsar beam pointed away from the observer



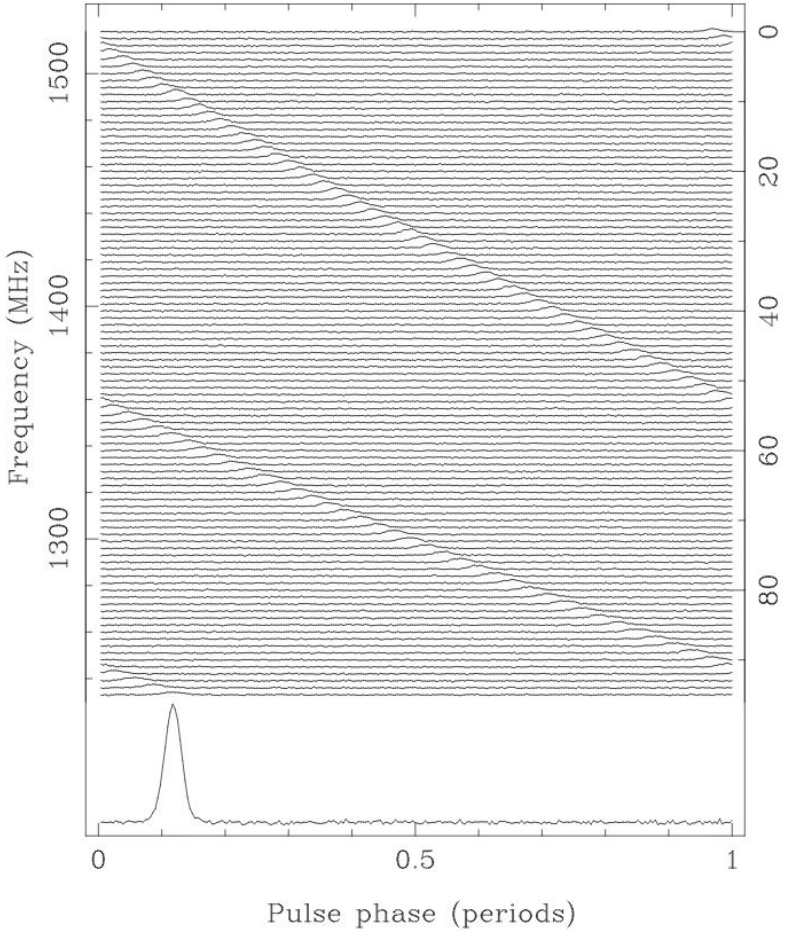


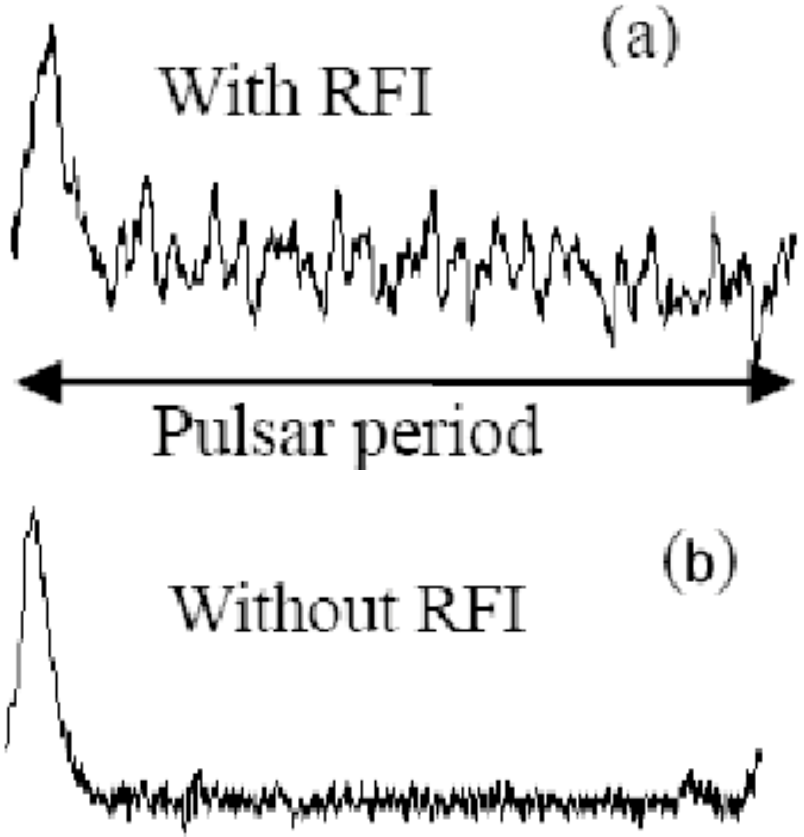
Pulsar beam pointed towards the observer



A model showing radius to frequency mapping in radio pulsars

Dispersion & RFI



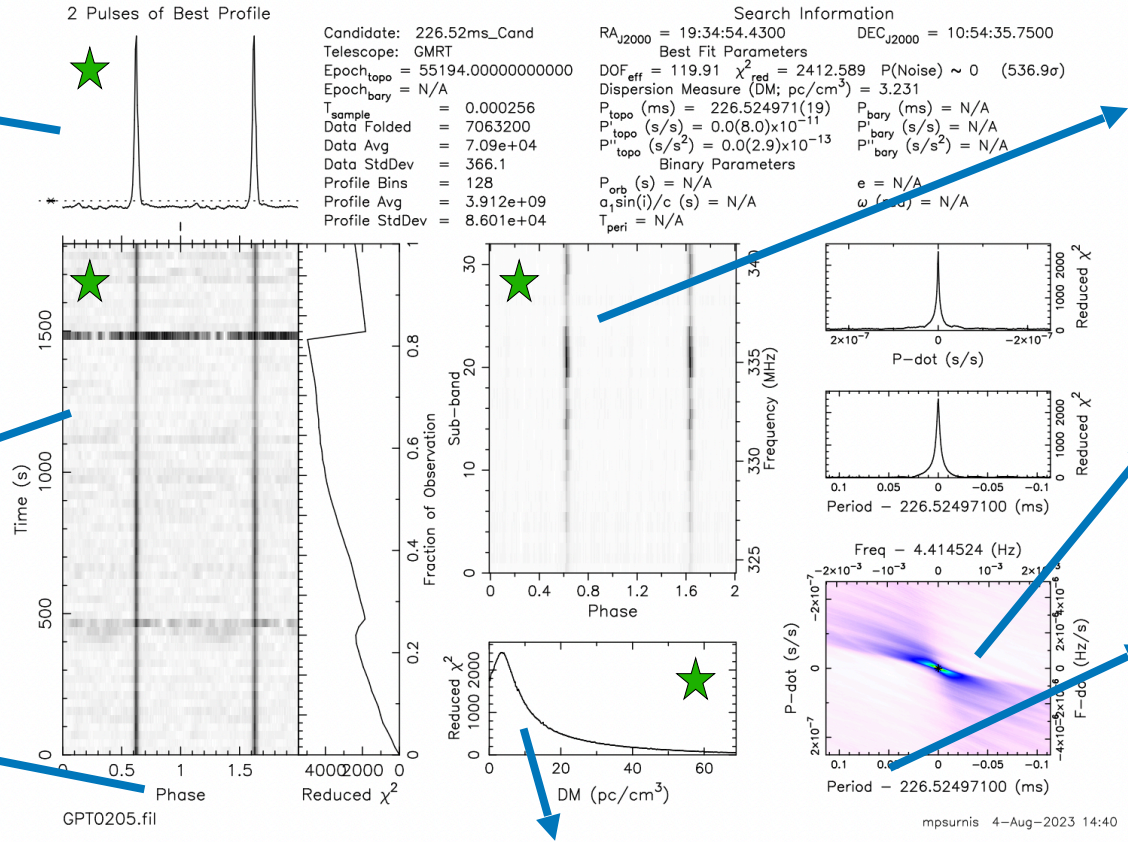


Pulsar Diagnostic Plot

Summed Pulse Profile: The total sum of the entire data folded at the best period.

We can see pulsar is constant approximately over all the time and you can also see other data in here that corresponds to RFI which has not yet been removed from the data.

Pulse phase means one rotation of pulsars going from 0 to 1. Here, it goes to 2 because we are showing two pulses.



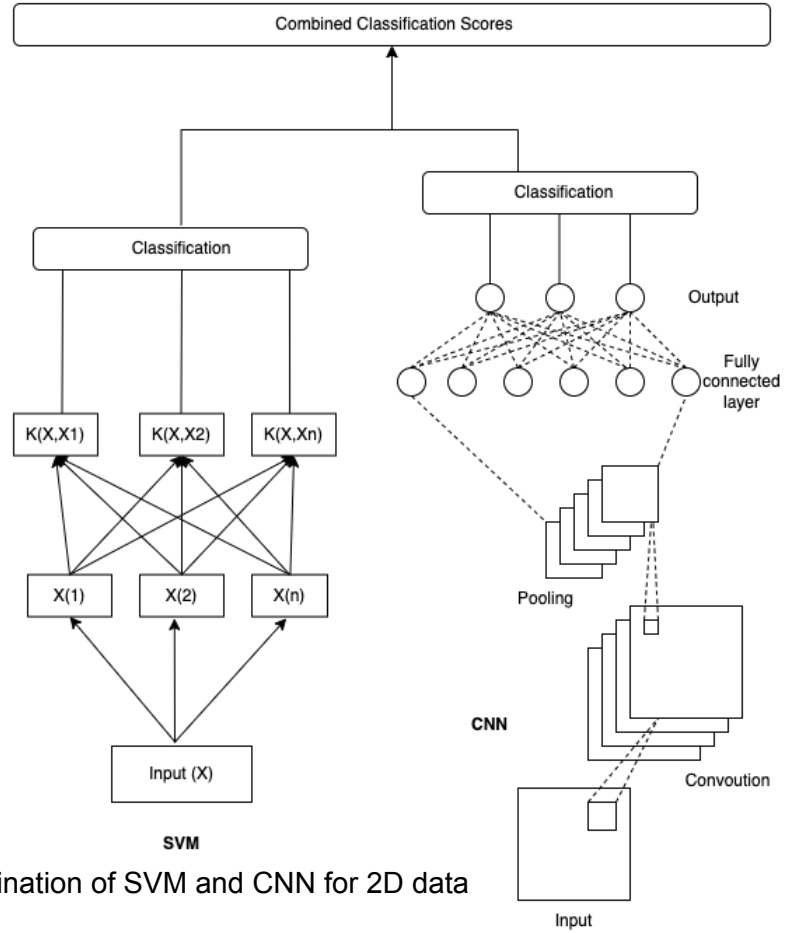
Still pulse phase but as a function of frequency. We've broken the data into multiple frequency bands and we show if we use correct DM the pulsar signal is straight.

Best change of period

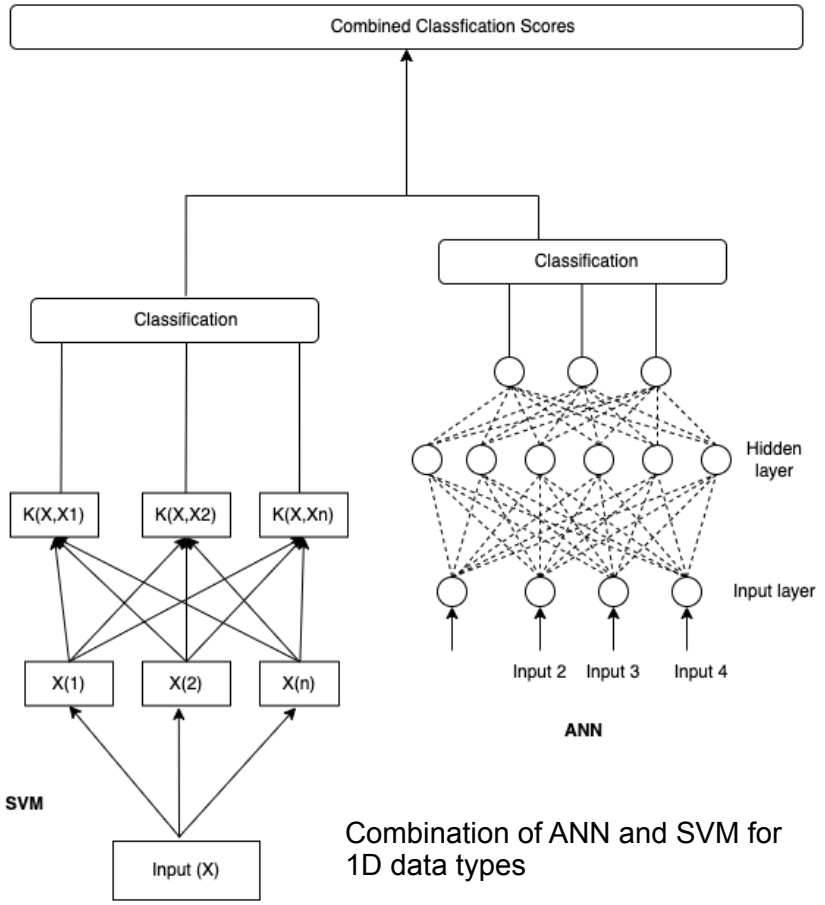
Best period. It may be that we don't get exactly the right period from our Fourier analysis. So, we search around that period to see if we can further improve the value or it may be that the period is slightly changing as a function of time especially if the system is in a binary.

You can think of Chi^2 is like signal to noise. It sharply peaks at best value for the DM and that's the DM we used for all the other analysis

Deep Learning Model



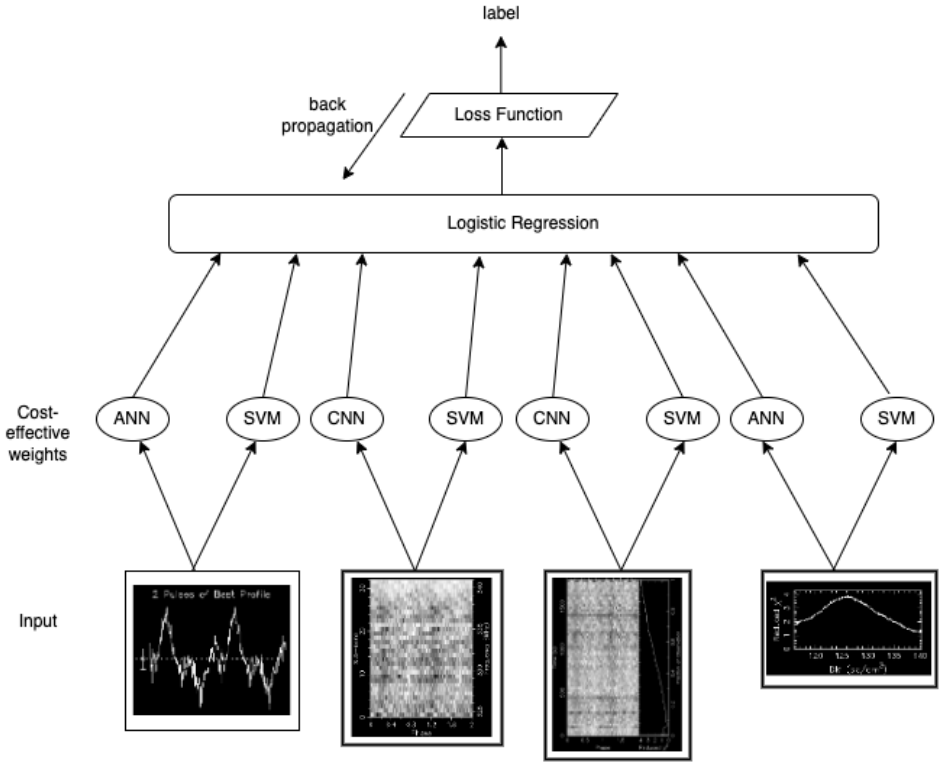
Combination of SVM and CNN for 2D data types



Combination of ANN and SVM for 1D data types

Further Work / Future Directions

- Addressing class imbalance problem
- Optimizing model for better performance.
- Using Advanced Model variants
- Exploring data augmentation for noisy data handling.
- Validating our model with different data.



Base Model (from bottom left to right : Summed pulse profile, phase vs frequency, phase vs time, DM vs SNR)