Business Understanding

The data set comes from pulsar candidates collected during the High Time Resolution Universe Survey (South) (HTRU2).

A neutron star is a large mass star that is at the end of its stellar evolution. At this time, the star has run out of fuel and collapsed post supernova (the mass of the original start is what determines if the star will end as a white dwarf, neutron star or black hole – in order of mass smallest to largest). These stars begin as 1 to 3 solar masses but end as a neutron star as ~12.5 miles across. Neutron stars do not generally emit enough electromagnetic radiation to be detected, which is why we search for pulsars. Pulsars are neutron stars that are spinning fast enough to produce enough electromagnetic radiation for our telescopes to measure (nasa.gov).

There are about 2600 pulsars currently known and almost all of them lie within our galaxy. There are two kinds of pulsars – normal pulsars (having pulse speed 0.3 – 3 seconds) and millisecond pulsars (MSP, having a pulse period between 1mSec – 10 mSec). The pulse period is very stable and predictable, but not constant << kumar: what’s the ref for this paragraph>>.

In order to detect pulsars, we look for the electromagnetic radiation that has cyclical pulses. The best analogy is that a pulsar is like a lighthouse – the light is emitted at regular intervals that can be measured from a distance. The HTRU2 study used radio telescopes to scan for wavelengths in that part of the electromagnetic spectrum to detect pulsars.

Why detect pulsars? Pulsars are used as tools in many areas in physics and astrophysics. The areas range from theories of gravity, cosmology, extrasolar planets, stellar evolution and galactic structure.

Theories of Gravity

One reason the scientific community is trying to detect neutron stars is in order to study its gravitation forces. Gravity is at the center of the theory of General Relativity. If we prove or have prove conflicting theories to General Relativity, we gain better understanding of our solar system’s behavior (nrao.edu).

Cosmology

Pulsars timing is used to understand cosmology. Cosmology is the part of astronomy focused on studying the origin and birth of the universe. Gravitational background wave, left from big bang, systematically affects the pulsar timing of a millisecond pulsar. Currently pulsar is the only tool to understand cosmology.

Extrasolar Planets

The first planets outside the solar system were discovered using pulsar timing.

Stellar Evolution

Stellar evolution describes the lifecycle of a star. Supernova explosions are not spherically symmetric, but evidence is mounting, including the possibility of jetted gamma-ray bursts and hypernovae, that they are in fact asymmetric. Apart from evidence obtained from optical observations of very young supernovae, the strongest evidence comes from the observed pulsar velocities.

Galactic Structure

The free electron component of the galactic interstellar medium is interacting with pulsar signals as it disperses the radio waves. The amount of dispersion is characterized by the dispersion measure DM. DM is used to understand the galactic structure.

(source : University of Manchester – Jodrell Bank Observatory)

The candidates for pulsar consideration are described the simple statistics (mean, standard deviation, skewness and kurtosis) of the probability distributions from the integrated profile and the DM-SNR curve.

Integrated profile: Most candidates also include a copy of the integrated pulse profile (Lorimer and Kramer, 2005; Ghosh, 2007; Lorimer, 2008), which visually depicts a version of the signal averaged across all observed frequencies and time (see (C) in Figure 2.15)

DM-SNR curve: the single curve used to describe the relationship between the DM and the SNR. A candidate which achieves a peak SNR at a DM of zero, is therefore likely caused by local interference. A legitimate pulsar signal on the other hand will be dispersed, therefore its SNR should peak at a DM greater than zero (<http://www.scienceguyrob.com/wp-content/uploads/2016/12/WhyArePulsarsHardToFind_Lyon_2016.pdf>)

To further help understand the data or the measurements:

Kurotsis: measure of whether the data are heavy-tailed or light-tailed relative to a normal distribution. High kurtosis tend to have outliers, heavy tails, and low kurtosis tend to lack outliers, light tails (nist.gov).

Dispersion Measure (DM): the measure of the delay (or propagation effects) in the pulse that was caused as the signal passed through the interstellar medium (jb.man.ac.uk). DM is different for each frequency since they are dependent.

Signal-to-noise ratio (SNR): the signal compared to the random noise in the environment. Larger SNR implies a stronger signal that cannot be blocked out by noise.

The effectiveness of a good algorithm will be measured by << xxxx >>. This method was chosen because << xxxx >>.