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A Real time Automated Glitch Detection Pipeline at Ooty Radio Telescope (ORT)

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Pulsars being a massive and extremely dense object they have very stable rotation rate. They are rival to some of the most precise terrestrial clocks. The beamed pulsed emission from pulsars originates few hundreds of kilometres above the magnetic pole of the star and co-rotates with the stellar surface, hence the time of arrival (ToA) of the pulsed radio emission on earth carries the rotational information about the star. Pulsars are sometimes categorized by their age, a large fraction of the younger pulsars exhibit two types of rotational instabilities, one is called as pulsar glitches and the other is the timing noise, which is observed as deviations in ToAs of pulses from the expected. Pulsar glitches are sudden spin-up of the star, whereas the timing noise is due to the jittery rotation of the pulsars. The pulsars are cold system resulting in the formation of superfluid of neutrons which are responsible for glitches. The post glitch evolution of the rotation rate is observed with exponential decay, in some cases, more than a single exponential recovery has been observed, the timescales of recovery is closely connected to the in-homogeneous matter inside the neutron star crust and the properties of the superfluids.

Currently, a high cadence observation on a set of 18 glitching pulsars is being done at Ooty Radio Telescope (ORT) and Upgraded Giant Meterwave Radio Telescope (uGMRT). The main aim of the project is to increase the database of post glitch recovery timescales. These kinds of observations require the prompt detection of glitches. Automated Glitch Detection Pipeline (AGDP) connected to the ORT pulsar backend PONDER is one such pipeline developed for prompt detection and notification of glitches. AGDP computes the median absolute deviation (MAD) on each of the post-fit residuals obtained from `TEMPO2`[1]. The timing irregularities like timing noise are taken care by choosing a moving window of a certain size over which median in computed and MAD is computed on all the points. The residuals which deviate more than the acceptable threshold are detected as glitches. On detection of the glitch, a notification is sent to the observers over the email. The favourable combination of window and threshold is dependent on the uncertainties on the ToAs, the amplitude of the timing noise and lowest frequency sinusoid fitted to the timing noise. The best combination of the window and threshold is obtained by looking at the minima of the $l1-norm$ of the probability of non-detection $P(\bar{D})$ and the probability of false alarm $P(f)$. The quantity $P(\bar{D})$ and $P(f)$ is obtained from extensive simulations of glitched ToAs, the simulated residuals were constructed using `TEMPO2` and by our own algorithm. In this paper, we will present our algorithm on which AGDP works for detection of pulsar glitches.

[1] http://www.atnf.csiro.au/research/pulsar/tempo2/