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A web-based tool listing discovery database with transient alert generation for the SPOTLIGHT

Santaji N. Katore[(1)], Shilkumar Meshram[(1)], Ujjwal Panda[(1)], SPOTLIGHT team members

(1) NCRA-TIFR, Pune 411007, India; e-mail: snk@gmrt.ncra.tifr.res.in

Abstract

The extremely bright millisecond-duration events from Fast Radio Bursts (FRBs) are examples of one of the most extreme coherent radio emissions in the Universe providing a unique opportunity to probe the ionisation, densities, and magnetic properties of plasma on a cosmological scale. The uGMRT is currently the only interferometric array capable of providing simultaneous detection and the arc-sec localisation of such fast transient sources over the full 300−1460 MHz radio spectrum. The commensal transient survey instrument the SPOTLIGHT promises to discover hundreds of FRBs with the uGRMT. The majority of these bursts are usually non-repeating in nature, typically emitting for only a few milliseconds. In this paper, we present a real-time web-based monitoring tool that visualises detections from the SPOTLIGHT system and allows us to track the proper run-time functionality of this fully automated system. It is important to create an online discovery database that generates prompt transient alerts via the Virtual Observatory Event (VOEvent) Service. This ensures rapid follow-up with various telescopes, maximising scientific returns.

1. Introduction

The SPOTLIGHT system, a commensal time-domain survey instrument at the GMRT, is expected to discover more than a few hundred of FRBs with host galaxy association as well as several hundreds of pulsars over the next few years of scientific operation by piggy-backing to the ongoing observations [1]. The time-domain event detection system searches for millisecond bursts and periodic signals up to a dispersion measure (DM) limit of 2000 pc cm^{-3} over a frequency range of 300-1460 MHz [4]. The Deep Learning based AI (artificial intelligence)-powered system optimises triggers for baseband voltage capturing to probe spectro-temporal-polarimetric properties of the bursts disentangling the intrinsic emission features from the propagation imprints [7]. Visibilities and raw data for all candidates will be saved to disk for real-time imaging localisation [5] and quasi-real-time confirmation at full GMRT sensitivity.

2. Web-based Tools

We have developed a web-based tool for maintaining the SPOTLIGHT discovery database, generating transient alerts, and monitoring the health of the system in real-time. The output results from the multi-beam SPOTLIGHT detection systems, powered by HPC and AI, are stored on disk along with the data products from the correlator and beamformer [2,3]. The real-time monitoring tools include the display of the GMRT antenna's current position (Azimuth-Elevation), the self-power spectrum and the phase spectrum. This tool helps track the target field and ensure the proper functionality of the correlator and beamformer during the ongoing observation. This system can highlight the presence of intriguing individual known time-domain sources within the field of view. The real-time monitoring tool also displays the results from the transient detection system with plots of the genuine classified candidates along with the respective parameters (metadata) like dispersion measure (DM), signal-to-noise-ratio (SNR), target position, observing frequency, etc. The output from the real-time imager, which localises genuine events, is also linked here.

The other online tool is the Discovery database. This is an important tool that will maintain a long-term

archive of all the results produced by SPOTLIGHT, including all FRB detections with their metadata, plots, and respective images. This editable discovery database records confirmations of real discoveries following manual inspections. Following the confirmation prompt transient alerts via the Virtual Observatory Event (VOEvent) Service will be generated. This ensures rapid follow-up with many telescopes across various wavebands, revealing progenitor models, their emission physics, and enabling cosmological studies. This also prepares the output database to either trigger post-processing of the baseband voltage data for confirmed candidates or clear the buffered visibility, beam, and baseband data for false detections. This discovery database will be physically hosted at the GMRT observatory. The main SPOTLIGHT web page (https://spotlight.ncra.tifr.res.in/) is physically hosted at the NCRA facility to ensure its uninterrupted access by the astronomers. Both databases will be synchronised on a quasi-real-time basis. Figures 1,2,3 and 4 show the real-time plots posted on the monitoring web-page of the SPOTLIGHT system. These tools are locally developed at NCRA-GMRT by using the open source utilities to ensure rapid response by SPOTLIGHT users and astronomers for their study.

3. Figures

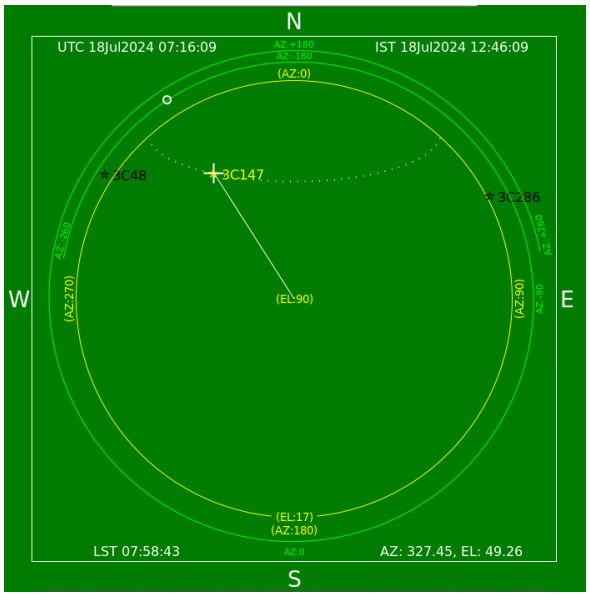

Figure 1. GMRT antenna tracking status

Source name	Test Spotlight
Right ascension, RA (J2000)	16:17:2.40625
Declination, DEC (J2000)	-22:-58:-33.90625
t_{cand}	150.00 s
DM	100.00 pc cm^{-3}
SNR	541.38
W_{bin}	3 bins
N_t	256
N_ν	256
δt	1310.72 µs
$\delta\nu$	781.02 kHz
ν_{first}	499.98 MHz
ν_{last}	300.03 MHz
N_{DM}	256
δDM	0.54 pc cm^{-3}
DM_{low}	31.73 pc cm^{-3}
DM_{high}	168.27 pc cm^{-3}

Figure 2. FRB detection metadata information

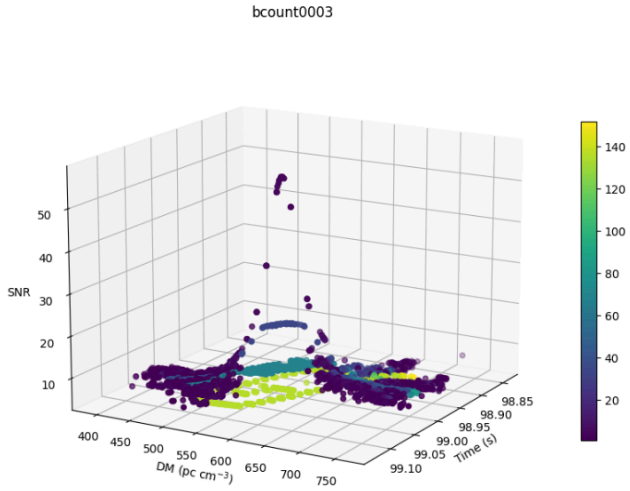

Figure 3. Multi-dimensional transient detection plot

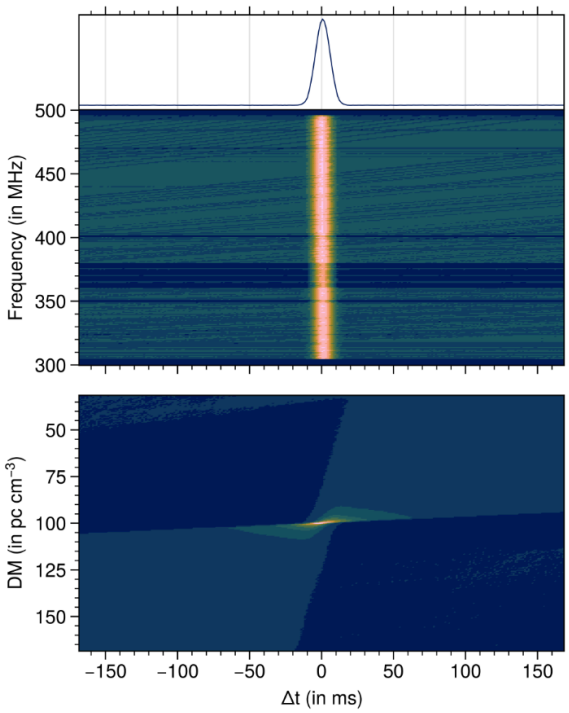

Figure 4. AI-classifier output confirming the genuinity of the event

4. References

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