A Proposed RFI Intelligent Monitoring and Positioning System of FAST

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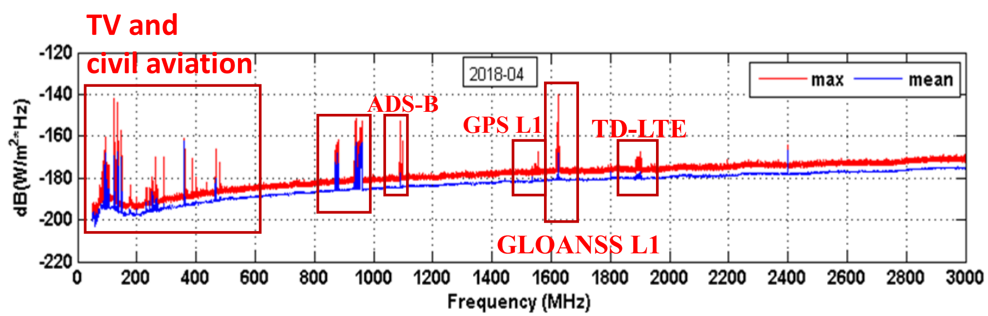
RFI in FAST

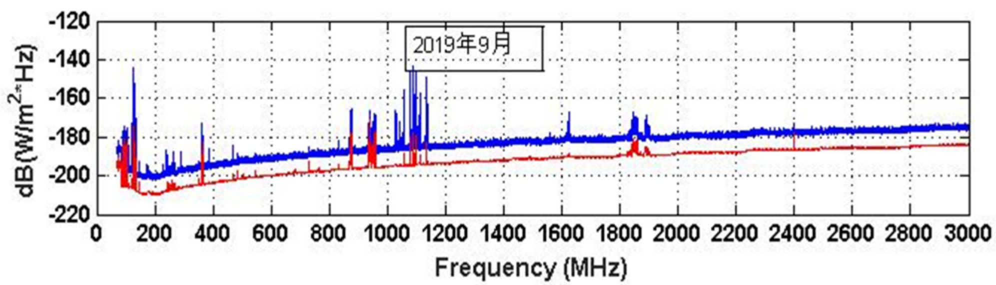
- Located in Guizhou, China
- 500-meter aperture (300-meter observing aperture)
- Operates between 70MHz-3GHz
- In the FAST Radio Quiet Zone

RFI in FAST

RFI Categories:
Mobile communication,
Satellite signals, FM radio,
TV and civil aviation signals…



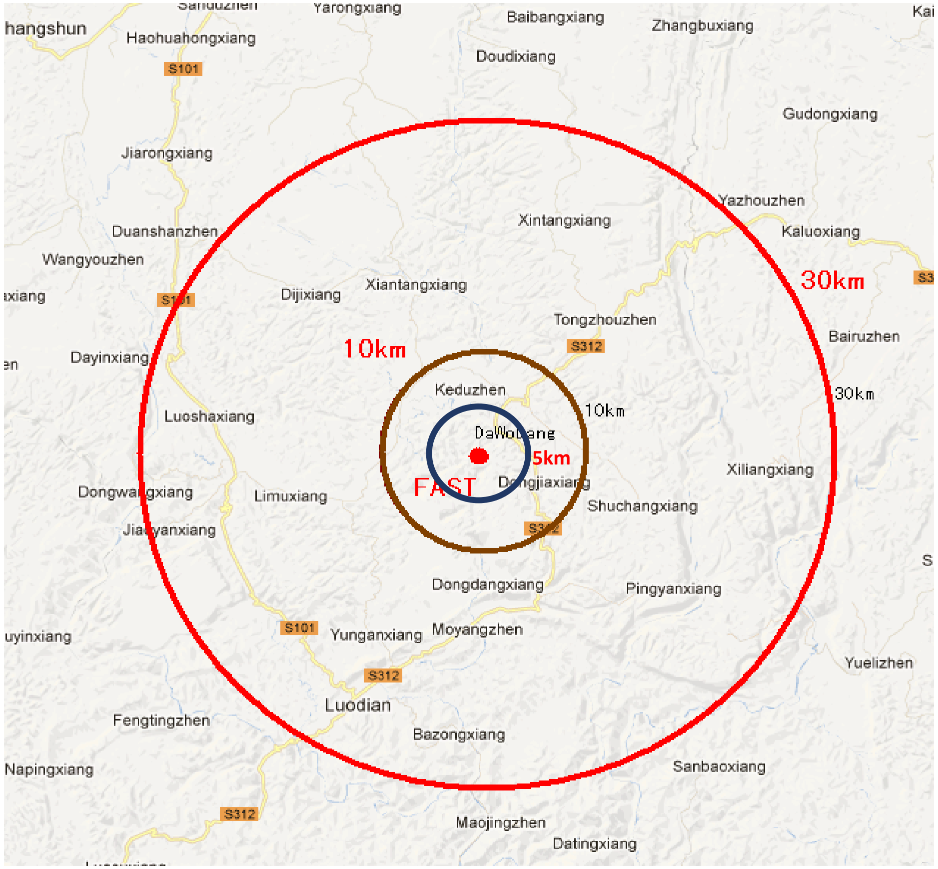
RFI monitoring antenna in FAST site



FAST RFI monitoring results in 2018 and 2019

Radio Quiet Zone of FAST

- Core Zone: r ≤ 5km; strictly forbidden to set up or use radio stations, or construct facilities
- Middle Zone: 5km ≤ r ≤ 10km
- Remote Zone: 10km≤ r ≤ 30km



RFI Intelligent Monitoring and Positioning System

Function:

- ✓ To monitoring, positioning and identifying the RFI sources in the core zone;
- ✓ To establish a RFI database for FAST;
- ✓ To strengthen the operation and management of the FAST RQZ.

Key Techniques:

- ✓ RFI intelligent recognition
- ✓ RFI source location

Preliminary Design

Including:

- 1 center station with a data center located in FAST site;
- 3 remote stations at least distributed in the core zone of FAST RQZ;
- Stations are connected with optical fibers.

Design parameters of each station:

Frequency band	70MHz-3GHz
Receiver sensitivity	<-90 dBm
Monitoring angle range	360°

RFI Intelligent Identification

Purpose: detect and recognize the RFI in real-time

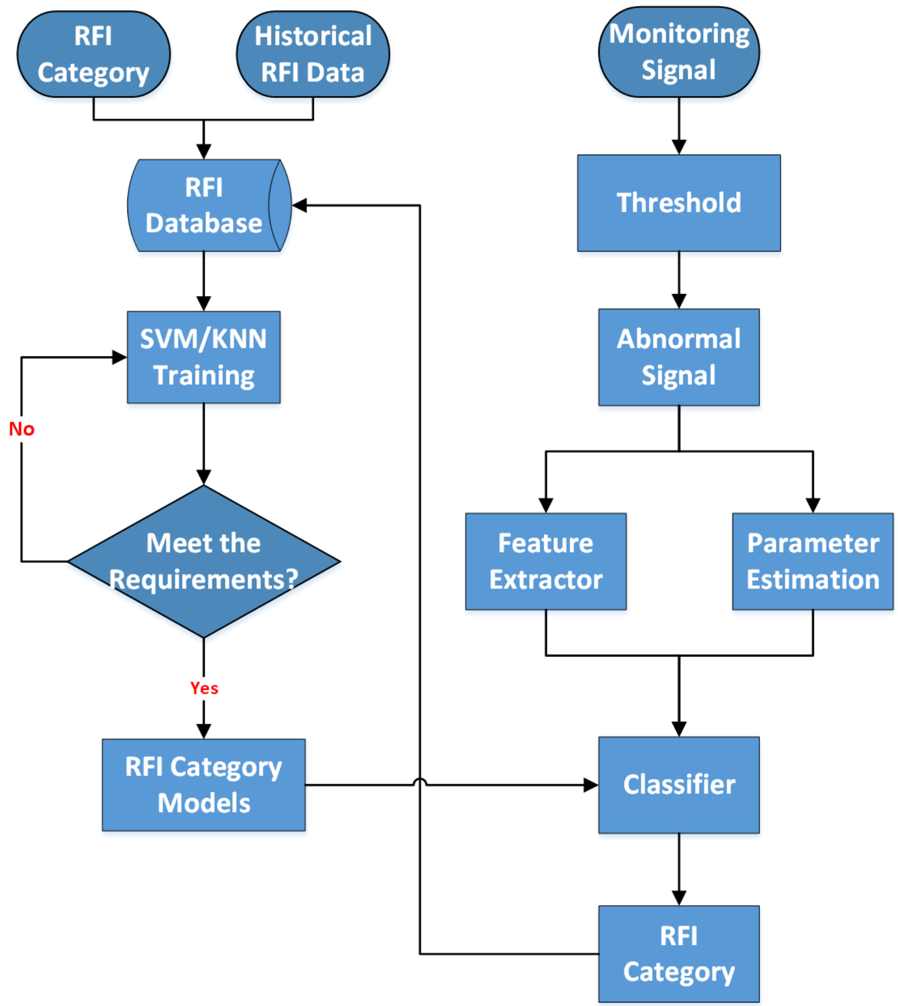
The RFI database:

- Including RFI signals and their characteristics, categories
- Continue to collect signals from monitoring stations
- Providing samples for training models

The RFI model:

- Train the model with machine learning algorithms (SVM, KNN)
- Check the model based on the practical measurement

RFI Intelligent Identification



Flow chart of the RFI intelligent identification system

RFI Source Localization

The Time Difference of Arrival(TDOA) positioning:

- The remote stations transmit the same RFI signal measured at the same time to the central station;
- Then, the time difference of arrival between remote stations can be derived by cross-correlation algorithm;
- After that, the time difference can be converted into the distance difference, and the hyperbolic curve of RFI source distribution can be obtained;
- Finally, the position of the RFI source can be derived from the intersection point between multiple curves.

RFI Source Localization

The same signal measured at the same time by different stations:

$$x_1(t) = s(t) + n_1(t)$$

$$x_2(t) = A * s(t - \tau) + n_2(t)$$

$s(t), A * s(t - \tau)$: the same RFI signal received by different stations

$n_1(t), n_2(t)$: the noise of different stations

$$R_{x_1x_2}(\Delta t) = A * R_{ss}(\Delta t - \tau) + A * R_{sn_1}(\Delta t - \tau) + R_{sn_2}(\Delta t) + R_{n_1n_2}(\Delta t)$$

$R_{x_1x_2}$: the cross-correlation between $x_1(t)$ and $x_2(t)$

R_{ss}: the autocorrelation of the $s(t)$

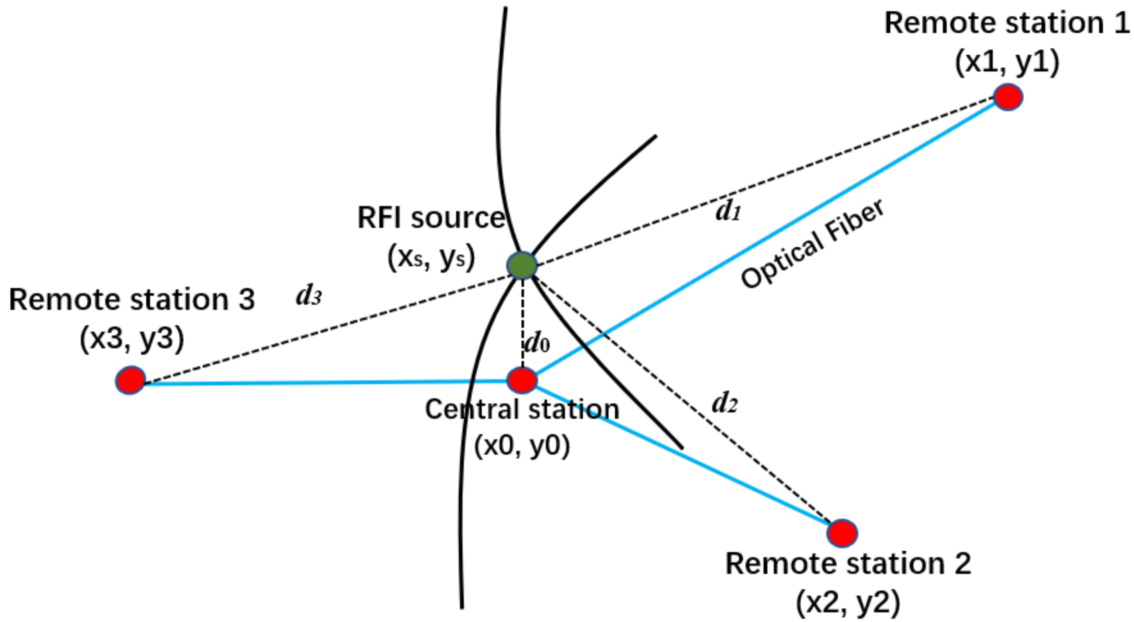
R_{sn}: the cross-correlation between the RFI and noise

Hypothetically, RFI and noise in different stations are uncorrelated:

$$R_{x_1x_2}(\Delta t) = A * R_{ss}(\Delta t - \tau)$$

the time difference τ can be obtained by finding the maximum value of $R_{x_1x_2}(\Delta t)$

RFI Source Localization



Schematic illustration of the TDOA algorithm

Typically, the time measurement error is 109ns for radio signals with a bandwidth greater than 10KHz, and the corresponding distance measurement error is about 30m.

Conclusion and Prospective

Conclusion:

- Established a RFI database for training the model
- Designed parameters for monitoring stations
- Formulated technical routes for signal identification and positioning

Prospective:

- Train the RFI model with appropriate algorithms
- Manufacture and test the prototype of monitoring station
- Check the model accuracy


Thanks!