A Proposed RFI Intelligent Monitoring and Positioning System of FAST

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   • Radio Quite Zone 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: \( r \leq 5 \text{km} \); strictly forbidden to set up or use radio stations, or construct facilities

- Middle Zone: \( 5 \text{km} \leq r \leq 10 \text{km} \)

- Remote Zone: \( 10 \text{km} \leq r \leq 30 \text{km} \)
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:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency band</td>
<td>70MHz-3GHz</td>
</tr>
<tr>
<td>Receiver sensitivity</td>
<td>&lt;-90 dBm</td>
</tr>
<tr>
<td>Monitoring angle range</td>
<td>360°</td>
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</table>
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
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:

\[ x_1(t) = s(t) + n_1(t) \]
\[ x_2(t) = A \ast s(t - \tau) + n_2(t) \]

\( s(t) \), \( A \ast s(t - \tau) \): the same RFI signal received by different stations
\( n_1(t) \), \( n_2(t) \): the noise of different stations

\[ R_{x_1x_2}(\Delta t) = A \ast R_{ss}(\Delta t - \tau) + A \ast R_{sn_1}(\Delta t - \tau) + R_{sn_2}(\Delta t) + R_{n_1n_2}(\Delta t) \]

\( R_{x_1x_2} \): 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:

\[ R_{x_1x_2}(\Delta t) = A \ast R_{ss}(\Delta t - \tau) \]

the time difference \( \tau \) 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!