MATHEMATICAL MODELING IN SEISMOACOUSTIC DETECTION SYSTEMS FOR GROUND TARGET LOCALIZATION

Karimov E.Y., Muradov T.
National Defense University, Baku, Azerbaijan

Effective ground target detection using seismoacoustic systems relies heavily on the accurate analysis and processing of collected sensor signals. This study outlines a multi-stage methodology for signal cleaning, spectral analysis, classification, and geovisualization aimed at enhancing detection accuracy in complex terrain conditions.

Initially, raw seismoacoustic signals captured by 3D piezoelectric sensors undergo automated noise filtering to eliminate environmental interference such as wind and rain.

Harmonic analysis isolates primary waveforms from random components. Next, frequency-domain spectral analysis identifies characteristic features of the signals—amplitude and frequency range—which help determine the type and movement dynamics of the detected object. The processed signals are then matched against a reference database of known seismic-acoustic profiles (e.g., tanks, armored vehicles), allowing accurate target classification.

Mathematical models are introduced to calculate the target's direction and distance using geometrical triangulation based on sensor placement. By arranging three 3D detectors at 120-degree intervals within a Seismic Localization Cell (SWC), signal strength variations are used to determine the propagation vector. Formulas for estimating angular direction and signal error margins are derived, providing a precise method for localization even in noisy or mountainous environments.

Furthermore, output data are visualized in GIS-based systems for operational decision-making. The developed methodology provides a foundation for future studies aimed at optimizing detection under variable environmental conditions and integrating AI-driven analytics into real-time battlefield applications.

References

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