Real-Time Adaptive Approach for Hidden Target Shape Identification Using MATLAB

1. Introduction

Through-Wall Imaging (TWI) systems have gained significant attention for their applications in military, surveillance, and public security. The ability to identify hidden targets behind walls made of dielectric materials like brick, concrete, and plastic is crucial for situational awareness. However, image degradation due to clutter and noise is a major challenge in these systems. This report presents a real-time adaptive approach integrating neural networks and curve-fitting techniques to enhance target shape identification using MATLAB-based implementation.

2. Problem Statement

Traditional through-wall imaging techniques suffer from image blurring, low signal-to-clutter ratio (SCR), and difficulty in recognizing target shapes. Conventional image processing methods are inadequate for handling complex target orientations and environmental variations. This research aims to develop an intelligent model leveraging artificial neural networks (ANN) and mathematical curve-fitting techniques to improve target shape recognition behind walls.

3. Literature Review

Author(s)	Year	Technique Used	Findings
Liu & Sato	2014	GPR Radar	Improved pavement thickness measurement accuracy
Wan et al.	2015	Time-Domain TWI	Improved metal cylinder detection but ineffective for low-dielectric targets
Wu et al.	2016	UWB-SP Radar	Better contour estimation of targets
Singh et al.	2020	ANN-based TWI	Successfully recognized concealed objects behind walls
Suman Anand	2022	ANN based	An Approach to Detect Low and High Dielectric Targets Behind the Wall with Through-Wall Imaging System
Thottempudi Pardhu	2023	CNN based	Human motion classification using Impulse Radio Ultra Wide Band through-wall RADAR model
T. Pradhu	2024	CNN based	Advancements in UWB-Based Human Motion Detection Through Wall: A Comprehensive Analysis

4. Dataset Used

The dataset used in this research comprises TWI radar data collected from an experimental setup. The radar system scans targets in multiple orientations and collects frequency-domain

signals processed into C-scan images. The dataset includes 120 samples of different materials (metal, wood, tiles) and shapes (rectangular, circular, triangular, human dummy), with each target rotated between -45° to +45°.

The .mat file contains the following variables:

- RetVal
- dataMeasured1
- dataMeasuredImag
- dataMeasuredReal
- frequencies
- Metadata fields: __header__, __version__, __globals__

5. Problem Solution Using MATLAB

5.1 Experimental Setup

The experimental system employs a Stepped Frequency Continuous Wave (SFCW) radar operating within a 1 GHz - 3 GHz frequency range. The radar scans the target in two orthogonal directions (horizontal and vertical) to form a 3D dataset, which is later converted into 2D C-scan images.

5.2 Image Pre-processing

1. **Noise Reduction:** A rectangular windowing technique and background subtraction (using statistical averaging) are applied to remove unwanted clutter.
2. **Feature Extraction:** ANN is trained on a dataset of noise-free images obtained after pre-processing.

5.3 Shape Identification Algorithm in MATLAB

1. **Data Training with ANN:**
    - Input: Noisy TWI data
    - Target: Clean, preprocessed TWI images
    - Training using a Multi-layer Feedforward Neural Network (MFFNN) with a scaled conjugate gradient (SCG) training function.
2. **Target Detection & Shape Identification:**
    - Real-time TWI data is correlated with ANN-trained data.
    - Curve-fitting is applied to determine an adaptive threshold.
    - Thresholding refines the detected shape and eliminates background noise.

5.4 Results & Evaluation

The MATLAB implementation successfully reconstructs target shapes with high accuracy. The ANN model achieves robust generalization, identifying targets at different orientations. The use of curve fitting ensures an adaptive thresholding mechanism, enhancing target visibility.

5.5 Conclusion

The developed MATLAB-based approach effectively enhances the identification of hidden targets in TWI systems. By integrating ANN and curve-fitting methods, the system achieves superior noise filtering and shape recognition, making it a promising solution for real-time applications in security and surveillance.