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Sensing through walls: An emerging technology for ASEAN security community

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Introduction

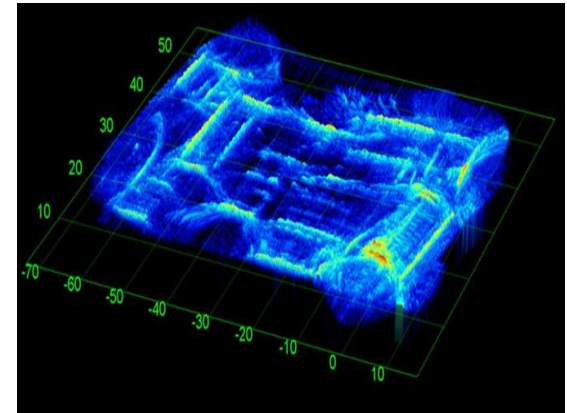
- ⦿ **Through-wall radar imaging** (TWRI) images objects and humans behind walls and enclosed structures using electromagnetic (EM) waves.
- ⦿ Such scenes are **inaccessible** via optical, acoustical, or thermal sensing.
- ⦿ TWRI attracts considerable research interests because of its numerous civilian and security applications.



Potential applications



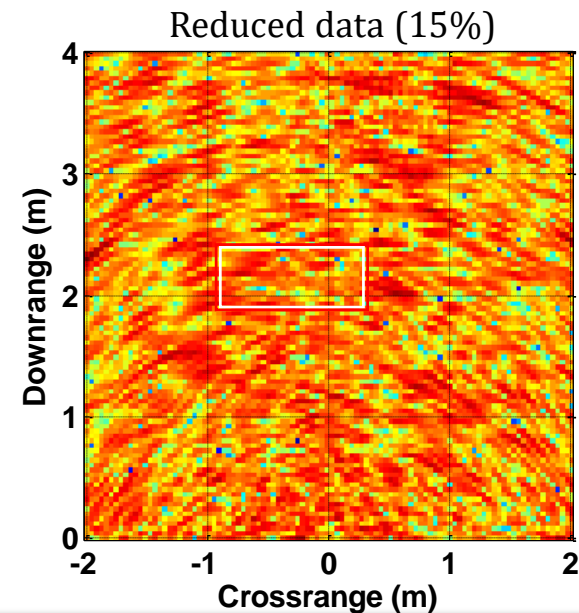
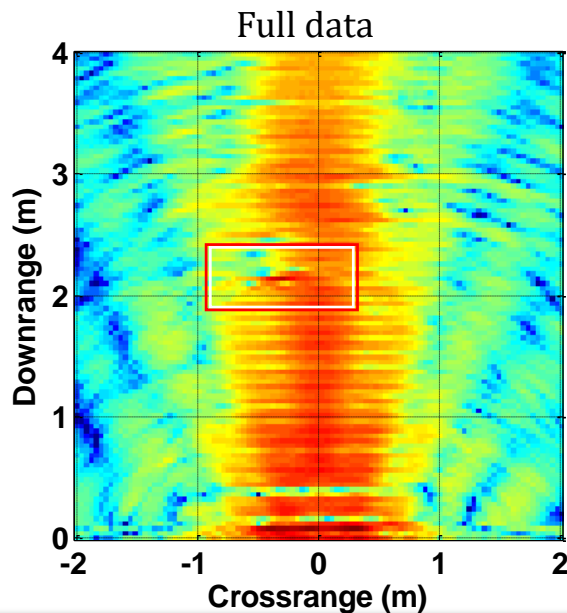
Search-and-rescue missions (mitigating disaster effects)



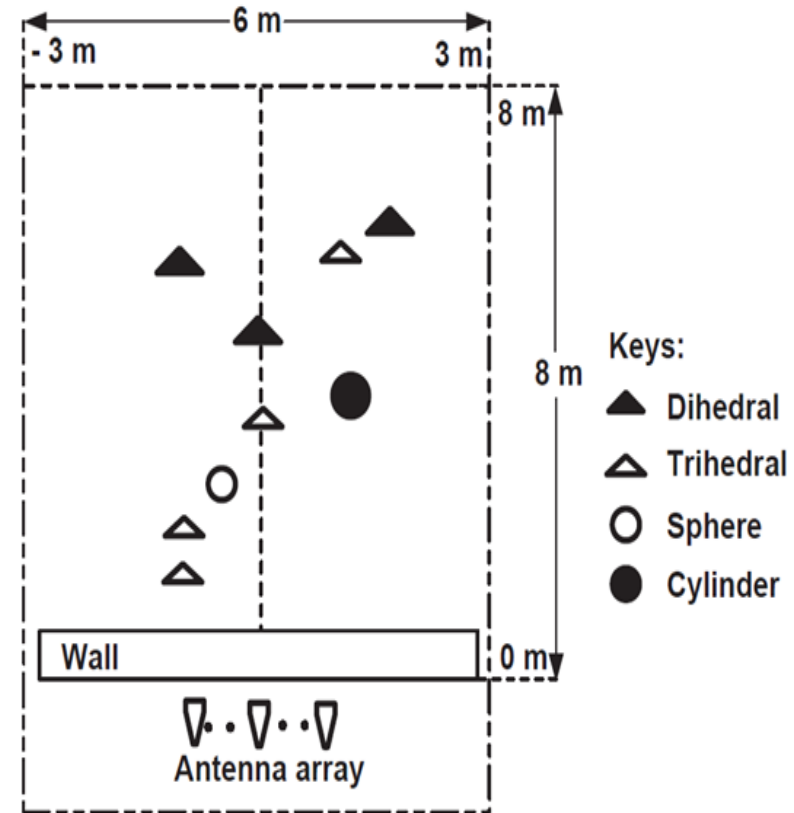
Hostage rescues (securing community)

Major technical challenges

- ⦿ High-resolution radar imaging requires large aperture and bandwidth, leading to **cumbersome systems** and **high-cost operations**.
- ⦿ In TWRI, **strong wall reflections** obscure targets of interest.
- ⦿ Missing data due to **frequency interferences** reduces imaging quality.
- ⦿ **Multipath effects** cause target detection very difficult.

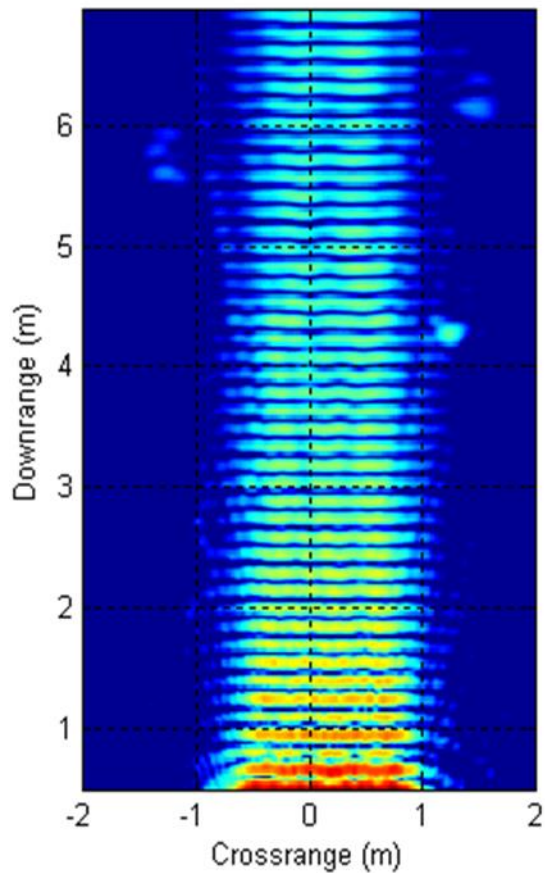


TWRI indoor scene

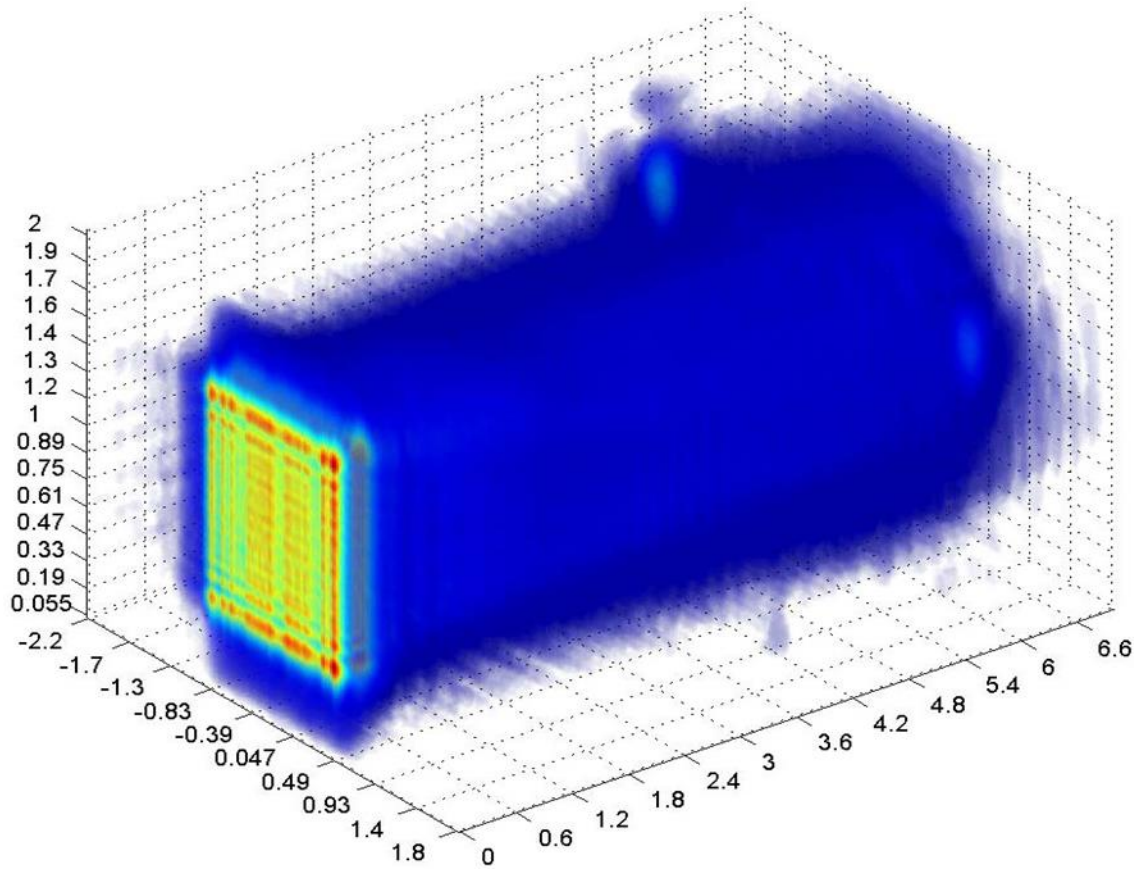


A real scene with 9 targets (different shapes and locations)

Indoor scene reconstruction

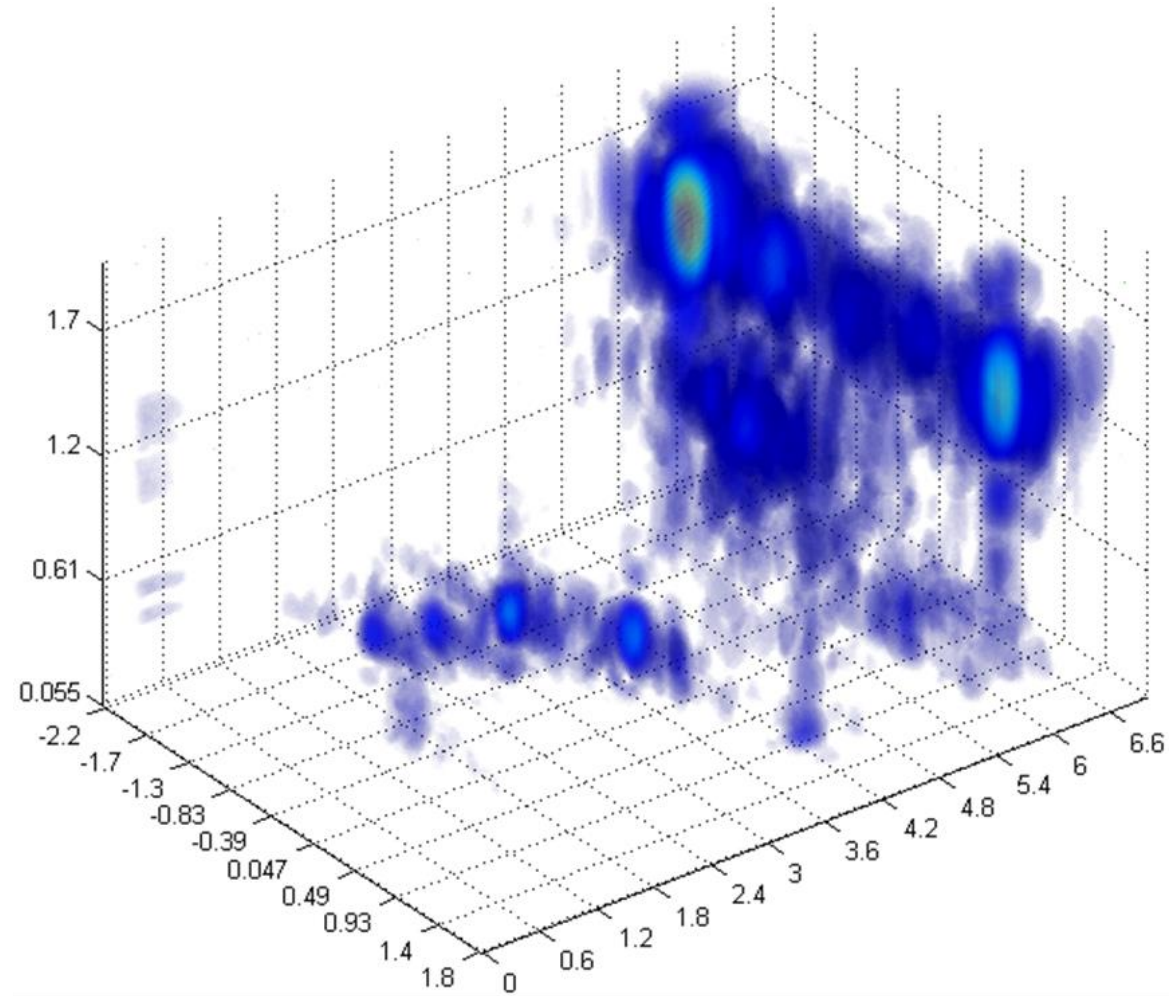
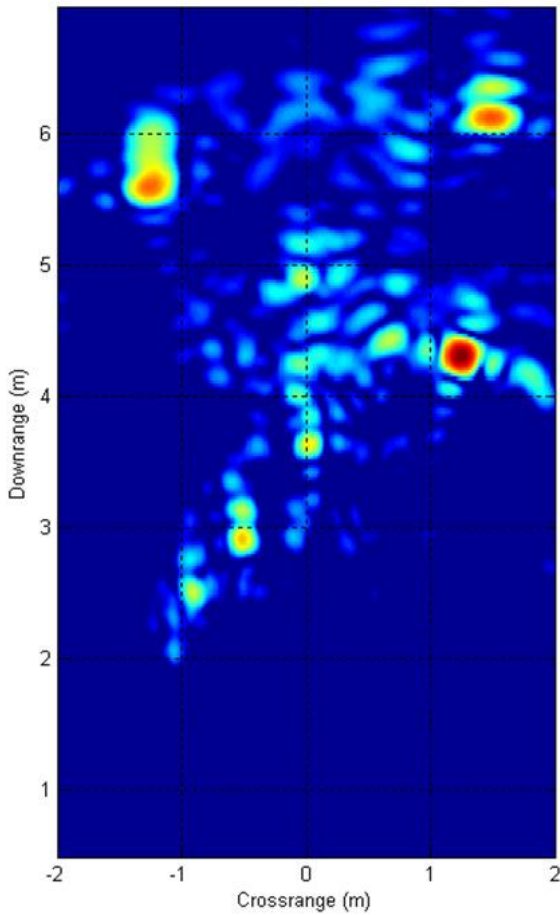


2D-IMAGE

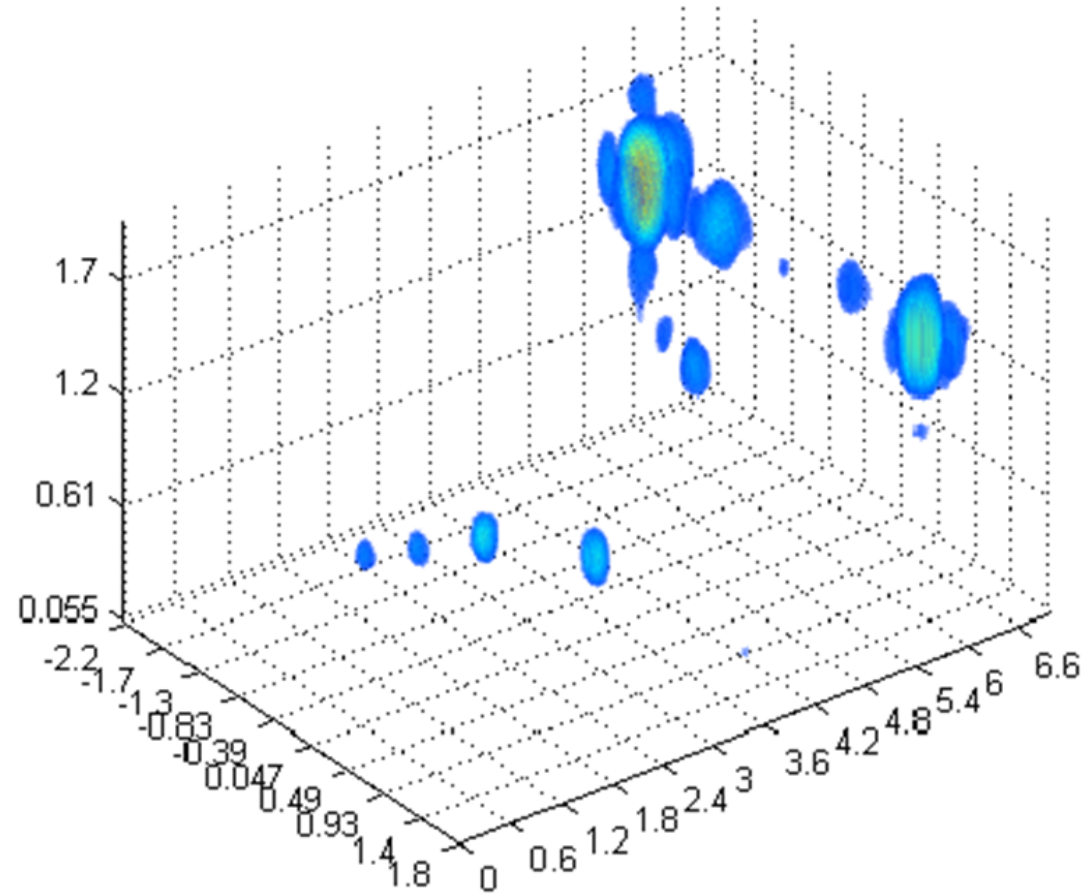
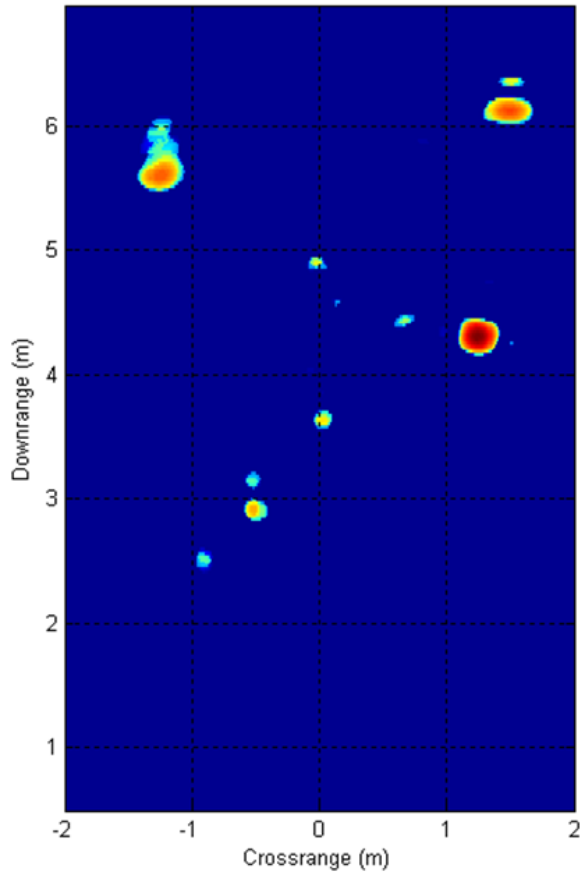


3D-IMAGE

Background clutter removal



Target segmentation and detection





⦿ Proposal objectives:

- Design a lightweight radar imaging system with **compressed sensing**
- Mitigate wall and ground clutter efficiently
- Reconstruct an accurate image of hidden targets
- Enhance target detection and **human motion identification**

⦿ Proposal collaborations:

- Collaborate researchers from ASEAN-IVO members and Japan (joint seminars, research, development, and publications)
- Mitigate common issues including environmental disasters and security concerns in the ASEAN region.

Research framework

⦿ Techniques:

- Through-wall radar and through-ground radar imaging
- **Doppler radar** signal processing
- Bayesian compressive sensing and advanced statistical learnings
- Modern techniques including deep and transfer learnings

⦿ Research tasks:

- Through-wall and through-ground radar **image formation and reconstruction**
- Wall clutter, ground clutter, and multipath mitigation
- Human and object **detection, localization, and classification**

- ⊙ Research:
 - 02 high-quality ISI journals
 - Papers in premier conferences
 - Technical reports
- ⊙ Developments:
 - **Hardware and software** designs and implementations
 - A high-resolution radar system operates in semi-controlled environments
- ⊙ Applications:
 - Mitigate environmental negative effects
 - Protect ASEAN community



Project member tasks

Le Quy Don Technical University (LQDTU), Vietnam	Coordinate the project and handle all research and development stages
Hanoi University of Science and Technology (HUST), Vietnam	Contribute technical supports for computational intelligent tools and organize workshops
National Defence Academy (NDA), Japan	Be responsible for the development of AI systems, including transfer and deep learning techniques
King Mongkut's University of Technology Thonburi (KMUTT), Thailand	Collaborate for processing and manipulating data sets for learning and classification
National University of Singapore (NUS), Singapore	Contribute hardware design and system integrated supports

Acknowledgement



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- ⦿ All ASEAN IVO project contributors