TITLE PAGE

- Problem Statement ID - 1566
- Problem Statement Title- Enhancing body detection in CSSR Operations Using Advanced Technology
- Theme- Disaster Management
- PS Category- Hardware
- Team ID- 21054
- Team Name (Theseus&Co)

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Detection of bodies through AI 3D mapping using EMF spectrum

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- **Proposed Solution :**
  - **Advanced 3D Imaging:** Utilizes multi-frequency electromagnetic waves to generate **detailed 3D maps** of collapsed structures, enabling **accurate body detection**.
  - **Drone-Assisted Scanning:** Drones equipped with radar and sensors capture positional and depth data accurately by **triangulation method**, **integrated with AI** for real-time imaging and analysis.
  - **AI-Enhanced Accuracy:** **AI algorithms** process the data to enhance image clarity and pinpoint body locations with high precision.

- **Addressing the Problem :**
  - **Time-Consuming Traditional Methods:** Manual searches and canine detection are slow and often unreliable, **delaying victim recovery**.
- **Our Solution:**
  - **Faster Detection:** Real-time **accurate 3D imaging** accelerates body detection by **up to 300%**, drastically reducing search times.
  - **Precision in Complex Environments:** Multi-frequency electromagnetic waves penetrate **rubble at different depths**, improving accuracy even in difficult conditions.
  - **Enhanced Safety:** **Automated drone scans** minimize direct human involvement in hazardous areas, reducing risk exposure by 70%.

- **Innovation & Uniqueness :**
  - **Multi-Frequency EM Technology:** Combines low and high-frequency waves for **deep and precise scanning**, providing layered 3D images of debris.
  - **AI-Driven Real-Time Visualization(algorithm made by us):** Instantaneous feedback enables rescue teams to make **faster, informed decisions**.
  - **Scalable & Cost-Effective:** A solution that is **affordable and adaptable** for large-scale rescue operations, outperforming traditional, costly methods.

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TECHNICAL APPROACH

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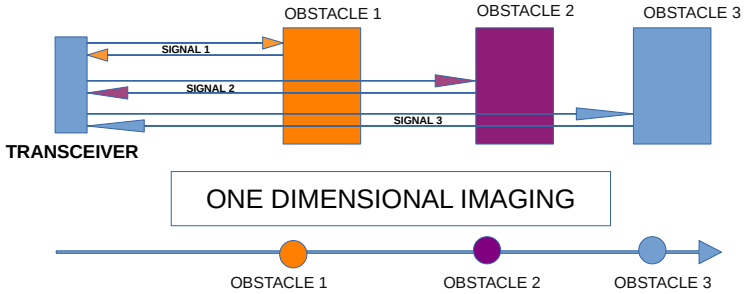
Process:



CLICK HERE FOR BASIC 3D SIMULATION

1. Data Acquisition:
Radar: Conduct scans at multiple frequencies to capture depth data.
Drone: Flies in a grid pattern, recording positional data and depth measurements.
With triangulation method using multiple drones.

2. Data Integration:
MATLAB: Processes data from Raspberry Pi to reconstruct initial 3D model.
Python: Increases pixel density and refines image resolution.

3. Visualization :
Generation and visualization of 3D depth using our own algorithm using Python.
Calibration, frequency optimization, and integration of data.

4. Processing and Enhancement:
CPU Processing: Integrate X, Y, and Z data to form the 3D grid.
Python Enhancement: Apply our own algorithms to enhance image quality, increase resolution, and detail.

Solution Overview:

- **3D Imaging Using Multiple Frequencies: Utilize varying frequencies of electromagnetic waves to probe debris and collapsed structures.**
- The device generate high-resolution 3D maps by integrating wide-band radar data with multiple **drones positional data (triangulation)** and AI processing.
- **UWB Radar** Emits EM waves at various frequencies to measure depth (Z-axis).
- **Skin Depth Formula**:

$$\delta = \sqrt{\frac{1}{\pi f \sigma \mu}}$$

*click here for more details

- By this formula radar determines wave penetration. Lower frequencies **penetrate deeper**; higher frequencies provide finer resolution but for **short range**.
- **Drone with Raspberry Pi : Provides X, Y, and Z positional data** and captures radar data. Raspberry Pi processes and transmits data to server.
- **MATLAB Integration:** Receives data from Raspberry Pi and performs initial processing and **3D reconstruction**.
- **Python for Image Enhancement:** Uses **algorithm made by us** to increase the **pixel density and enhance** the resolution of the 3D image.
- **Libraries:** Utilize libraries such as NumPy, SciPy, and OpenCV for image processing and enhancement.

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FEASIBILITY AND VIABILITY

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- **Feasibility:**
  - UWB radars and drones are proven in military, infrastructure, and SAR operations, making them ideal for detecting **buried bodies** in collapsed structures.
  - The integration of drones with electromagnetic frequency (EMF) **scanners and AI** enhances the effectiveness of the detection process, making it a cutting-edge solution for disaster scenarios.
  - By deploying drone to scan large areas in grid patterns, the solution is **scalable to various environments**, from small building collapses to larger urban disasters.
  - As **drone and radar technologies** evolve, costs are expected to decrease, making this solution more accessible to rescue teams globally.

- **Viability:**
  - Signal Interference: Metals and other conductive materials in the rubble can **distort the radar readings**. Mitigation includes using adaptive filtering and frequency modulation techniques driven by AI.
  - Harsh conditions **like rain** or extreme temperatures can affect drones, but weatherproofing and durable materials can mitigate this.
  - Depth Penetration: High-frequency EM waves might struggle to **penetrate deeply into rubble**. This can be mitigated by combining low and high-frequency scans, ensuring comprehensive detection.

- **Mitigation Strategies:**
  - AI-Driven Real-Time Processing: **Leveraging AI** to process the radar and **triangulation based** positional data allows for real-time updates, reducing latency in search-and-rescue missions.
  - Modular Design: The flexibility of the drone system, combined with interchangeable radar modules, ensures that the system is robust in a wide range of environments. Accuracy of **output is enhanced** by multiple drones(using triangulation method).
  - Expert Collaboration: Working alongside search-and-rescue experts allows for **constant refinement** based on feedback from real-world operations.

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IMPACT AND BENEFITS

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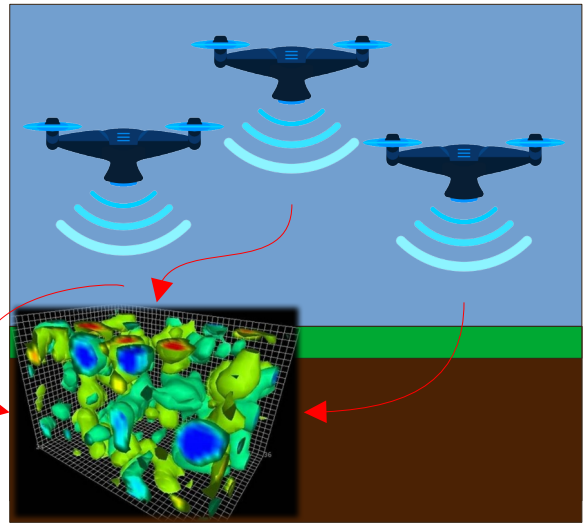
- **NDRF Teams:**
  - **Efficiency Improvement:** The technology can detect buried bodies **up to 300% faster** than current methods, significantly speeding up search and rescue operations.
  - **Safety Enhancement:** By reducing the need for manual searches, this system cuts down on the exposure of rescue teams to hazardous conditions **by approximately 70%**.
- **Rescue Operations:**
  - **Success Rate Increase:** This technology improves the likelihood of locating **victims by up to 500%**, potentially saving more lives in disaster scenarios.
- **Social:**
  - **Timely Recovery:** Speeds up recovery efforts by **as much as 50%**, allowing families quicker closure and potentially saving lives in time-sensitive situations.
  - **Rescuer Safety:** Reduces direct exposure to dangerous conditions by **up to 200%**, as fewer rescuers will need to enter hazardous environments.
- **Economic:**
  - **Cost Savings:** The solution could reduce overall rescue operation **costs by 20-30%**, thanks to optimized resource allocation and faster operations.
  - **Resource Efficiency:** With a more efficient system, the use of personnel and equipment can be optimized, **saving 15-20%** in resources.
- **Environmental:**
  - **Reduced Impact:** The system minimizes the disruption to the rescue site by **about 25%** compared to traditional methods, preserving the integrity of the debris and surrounding area.



BASIC ILLUSTRATION

Additional Use Cases:

Detects buried artifacts in archaeology, monitors infrastructure for damage, locates hidden objects in law enforcement, tracks endangered species, identifies underground water in agriculture, improves mineral extraction in mining, and predicts landslides for disaster risk management. expand the content with more technical approach

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RESEARCH AND REFERENCES

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- A 100 GHz FMCW MIMO radar system for 3D image reconstruction
- WiTrack - 3D motion tracking sensor
- LiMobile M1 - mobile laser scanning(MLS) system
- WiFi Routers Used to Produce 3D Images of Humans
- 3D Tracking via Body Radio Reflections
- How To See Through Walls For Under $20! (Wi-Fi Vision)
- A book on Ultra Wideband Wireless Communication
- DensePose From WiFi - 3D Mapping using WiFi
- Ground-Penetrating Radar and Interactive Augmented Reality for Urban Search and Rescue
- Accurate sensing of multiple humans buried under rubble using IR-UWB SISO radar during rescue
- Collapsed Debris Distribution of RC Frame Structures Under Earthquake Excitation