

# Graph-e-thon 2.0 Submission

## ThermalGuard: AI-Powered Threat Detection

**Team Leader Name:** Ruturaj Rahul Sonkamble  
**Team Member(s) Name:** Ruturaj, Mansi, Shadab  
**College Name:** Atharva College, Mumbai, Maharashtra, India  
**Sector:** Defence

Jai Hind!



# Problem Statement

- Problem Statement:

Conventional security systems struggle with reliable **weapon detection** and **suspicious movements** in low-light and **nighttime** conditions, creating critical vulnerabilities in military operations or surveillance . **Current solutions either require excessive lighting, invasive screening methods, or are prone to high false-positive rates**. The challenge is compounded by the increasing sophistication of concealment techniques and **the need for non-invasive, rapid screening** .

- Detailed description about the problem:

- Conventional security screening struggles with detecting concealed weapons in low-light conditions, **thermal imaging-based surveillance (IEEE, 2022)**.
- Metal detectors and X-ray scanners require close proximity and manual operation, **(US Patent No. 10,305,567, 2019)**.
- Traditional surveillance cameras rely on visible light, making them ineffective in darkness or adverse weather conditions, as stated in **FLIR Systems' thermal imaging research (2021)**.
- AI-driven thermal imaging significantly enhances security by detecting concealed weapons based on temperature variations, supported by **recent advancements in deep learning for thermal vision (Springer, 2023)**.
- Terrorist attacks and mass shootings often involve hidden firearms or explosives, necessitating **automated, non-invasive threat detection systems (Homeland Security Research Report, 2021)**.
- Existing AI models for object detection lack robustness in differentiating weapons from everyday metal objects in thermal imagery, **MIT CSAIL's object classification research (2022)**.
- FLIR-based weapon detection has been successfully deployed in border security and defense applications, proving its viability in real-world military scenarios **(Defense Advanced Research Projects Agency - DARPA, 2020)**.
- **U.S. Patent No. 9,639,182 (2017)** describes a method for detecting concealed firearms using thermal imaging, but lacks AI-powered classification and motion tracking capabilities.

# Proposed Solution

## ➤ Solution Statement:

**ThermalGuard** is an **AI-powered thermal imaging security platform** designed for **military applications**, providing **real-time concealed weapon detection** and **suspicious movement analysis** in **low-visibility conditions**. By integrating **high-resolution thermal cameras (FLIR series)**, **AI-driven image processing**, and **motion tracking**, it detects **concealed weapons**, **unusual behavior**, and **potential threats** with **>90% accuracy**.

The system utilizes **temperature differential mapping**, **shape recognition**, and **movement trajectory analysis** to classify threats, minimizing **false positives (<5%)**. ThermalGuard's AI-powered detection pipeline ensures **rapid threat identification (<500ms per frame)**, instantly alerting military personnel.

Unlike **conventional security systems**, it is **non-invasive**, **operational 24/7**, and **scalable** across multiple locations. Additional features include **3D thermal mapping**, **predictive behavioral analysis**, and **integration with security networks** for enhanced military surveillance.

ThermalGuard provides **proactive threat detection**, improving **response efficiency**, **situational awareness**, and **national security** at **military bases**, **border checkpoints**, and **restricted zones**.

## ➤ Military & Defense Applications:

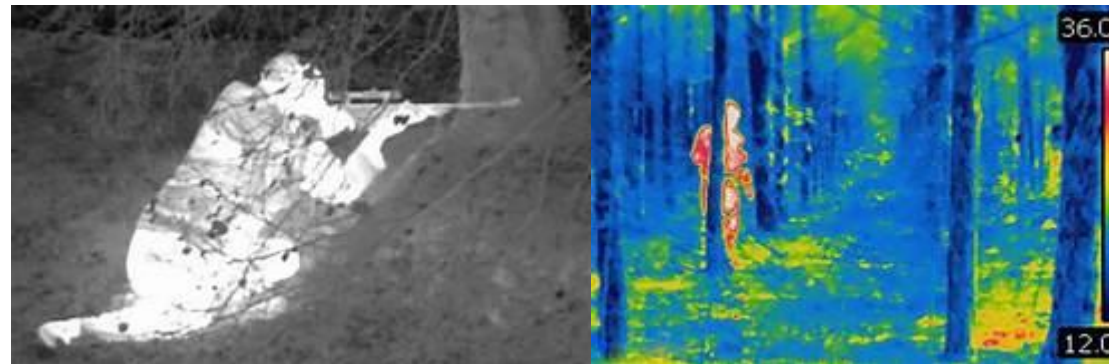
- **Operation Barkhane (France, Sahel Region):** French military forces used **thermal imaging drones** and AI-powered surveillance to track insurgents in low-light conditions.
- **U.S. Military Bases (Pentagon & Forward Operating Bases):** Implement **thermal perimeter security systems** to detect unauthorized personnel and concealed weapons.

## ➤ Key Use Cases

- **Military Bases** – Detects concealed weapons & threats
- **Border Security** – Operates in all-weather conditions
- **Urban Defense** – Tracks suspicious movement in real-time

## ➤ Potential Outcomes

- **>90% Detection Accuracy** – AI-powered surveillance
- **Real-Time Alerts (<500ms)** – Faster threat response
- **24/7 Autonomous Monitoring** – Minimal human intervention



**threat** but isn't clearly noticeable this will lose the surprise element if went too close, Trust Guard confirms it!!

# Technical Approach

## ➤ Technologies to Be Used:

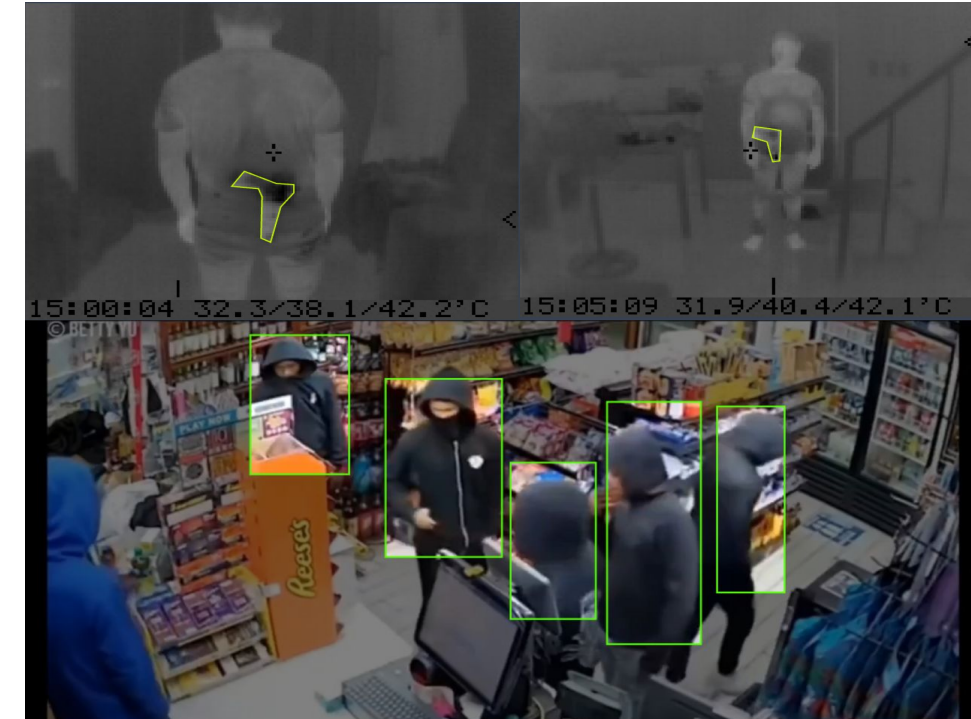
### Approach & Implementation Workflow

- 1 **Thermal Image Acquisition** → High-resolution thermal cameras capture real-time infrared data.
- 2 **Preprocessing & Enhancement** → AI algorithms enhance image clarity, reduce noise, and normalize background temperatures.
- 3 **Weapon & Suspicious Movement Detection** → Deep learning models analyze temperature patterns and motion behaviors.
- 4 **Threat Classification & Alert Generation** → AI-based anomaly detection categorizes threats and triggers alerts.
- 5 **Integration & Deployment** → System integrates with **military command centers, security networks, and surveillance infrastructure** for real-time monitoring.

## ➤ Detailed Description:

Provide a list of the key technologies, tools, and frameworks involved in your solution, categorized as follows:

- **Hardware:**
  - Thermal Cameras (FLIR Series, 640x480+ resolution)(if available or else will use datasets)
- **Software:**
  - **Programming Languages** → Python (TensorFlow, PyTorch), C++ (real-time image processing).
  - **Deep Learning Models** → Custom **CNNs, YOLOv8, and LSTMs** for weapon shape recognition and movement tracking.
  - **Computer Vision Frameworks** → OpenCV, MediaPipe for preprocessing and feature extraction.
  - **Real-Time Processing Pipelines** → TensorRT for low-latency inference (<500ms per frame).
  - **Threat Detection Algorithms** → Anomaly detection, trajectory analysis, and heat signature classification.
- **Other Tools:** Mention any additional technologies or resources supporting your solution (e.g., cloud services, databases, APIs).
  - **Cloud Services** → AWS S3 (storage), AWS Lambda (serverless processing), Google Cloud AI.
  - **Databases** → MongoDB (real-time logs), PostgreSQL (structured analytics).
  - **APIs & Security Networks** → Integration with **military command centers, defense AI systems, and CCTV networks.**
  - **3D Thermal Mapping** → LiDAR and multi-camera fusion for enhanced situational awareness.



suspicious movement tracking and weapon detection

### Future Enhancements

- **Integration with existing military networks**
- **Autonomous threat detection using drones**
- **AI-driven behavioral analysis for predictive security**

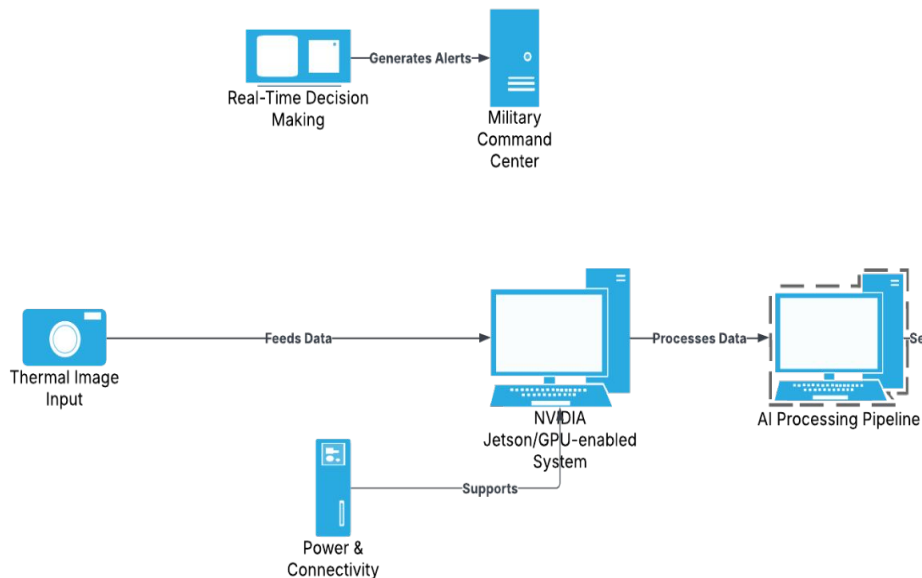
# Impact and Benefits

Impact Metric	Details
Social Impact	<ul style="list-style-type: none"> <li>➤ <b>Enhances National Security</b> → Reduces the risk of armed threats at <b>military bases, border checkpoints, and restricted zones</b>.</li> <li>➤ <b>24/7 Surveillance</b> → Ensures <b>round-the-clock security</b>, preventing unauthorized intrusions.</li> <li>➤ <b>Early Threat Detection</b> → Identifies <b>concealed weapons and suspicious movements</b> before an attack occurs.</li> <li>➤ <b>Non-Invasive Security Screening</b> → Eliminates intrusive manual inspections</li> </ul>
Economic Impact	<ul style="list-style-type: none"> <li>➤ <b>Reduces Security Costs</b> → Automates <b>threat detection</b>, reducing the need for <b>manual patrols and physical checks</b>.</li> <li>➤ <b>Boosts Operational Efficiency</b> → AI-powered <b>real-time detection (&lt;500ms)</b> enhances <b>military response time</b>.</li> <li>➤ <b>Prevents Potential Attacks</b> → Avoids <b>financial and human losses</b> caused by security breaches.</li> <li>➤ <b>Creates Defense Tech Opportunities</b> → Opens pathways for <b>R&amp;D investments and AI-driven security advancements</b>.</li> </ul>
Environmental Impact	<ul style="list-style-type: none"> <li>➤ <b>Reduces Dependence on X-ray &amp; Metal Detectors</b> → Uses <b>AI &amp; thermal imaging</b>, minimizing energy-intensive screening equipment.</li> <li>➤ <b>Supports Sustainable Defense Tech</b> → Utilizes <b>low-power AI edge devices</b>, reducing <b>energy consumption</b>.</li> <li>➤ <b>Minimizes Waste</b> → Digital <b>record-keeping and automated detection</b> eliminate excess use of <b>physical security documents</b>.</li> </ul>
Target Audience	<ul style="list-style-type: none"> <li>➤ <b>Military &amp; Defense Forces</b> → <b>Border security agencies, military bases, high-risk defense zones</b>.</li> <li>➤ <b>Government Security Agencies</b> → Supports <b>national security operations &amp; intelligence surveillance</b>.</li> <li>➤ <b>Critical Infrastructure Protection</b> → Ideal for <b>airports, power plants, and restricted government facilities</b>.</li> </ul>

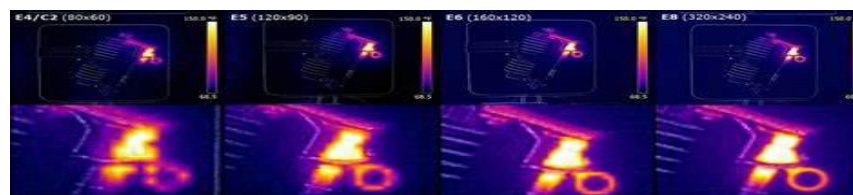


# Prototype

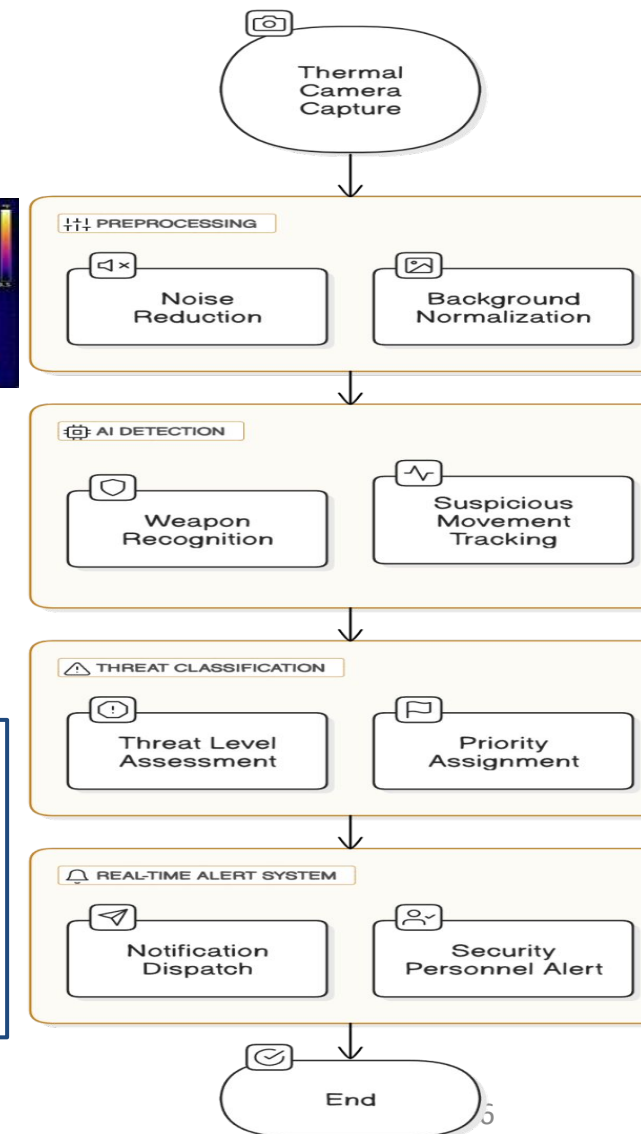
## Network processing:



## Real time detection



## Thermal Camera Surveillance Flowchart



# Research and References

- **Research Work:**

1. [Autonomous Surveillance](#) Enhancing Military Intelligence
2. [Advancements in Military](#) Applications through AI and Thermal Imaging
3. Artificial Intelligence in [Military Applications](#)
4. [Thermal Imaging](#) and Its Application in Defense Systems
5. Transforming the Multidomain [Battlefield with AI](#): Object Detection
6. [Defense Department Tests AI Software to Improve Physical Security](#)

- **Links:**

1. [Ukraine Collects Vast War Data Trove to Train AI Models](#)
2. [The Invisible Russia-Ukraine Battlefield](#)
3. [Upgraded-Thermal-Pistol Object Detection Dataset](#)
4. [Suspicious Object detection dataset](#)
5. [TNO-Infrared Object Dataset](#)
6. [Infrared Surveillance Dataset \(ISD\)](#)
7. [Thermal Image Dataset for Concealed Handgun Detection](#)