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Team Name: SIX_AVENGERS

PS ID: 1565

Target Detection by Optimizing Anomoly Detection in Hyperspectral image processing using AI / ML

SIX_AVENGERS

TEAM DETAILS

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NAME / EMAIL	STREAM	YEAR	TECHNICAL SKILLS	ROLE IN SIH
VIGNESH N (LEAD)/ vigneshkilari13@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	AIML, SQL, PYTHON	MLOPS HARDWARE IMPLEMENTATION
SHAIK MUZAMIL REHAMAN/ rmuzamil856@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	JAVA DEVELOPER	FRONTEND DEVELOPMENT
SOUNDARYA D/ soundarya.d07@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	PYTHON FULLSTACK DEVELOPMENT	FRONTEND DEVELOPMENT
MOHAMED FAIZAAN/ 5zaanu@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	ETHICAL HACKING, NETWORKING & CYBERSECURITY	HARDWARE IMPLEMENTATION & SECURITY
RITHICK M/ rithick225@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	SOFTWARE DEVELOPMENT	DATA ANALYST & HARDWARE IMPLEMENTATION
SAKTHIVEL R malar13rajesh@gmail.com	COMPUTER SCIENCE AND ENGINEERING	IV YEAR	CYBERSECURITY AND HTML & CSS	DATA ANALYST & FRONT END

ABSTRACT

This project presents a hybrid pipeline for improving anomaly detection in hyperspectral imaging by integrating deep learning, unsupervised learning, and quantum-inspired models. It utilizes advanced preprocessing techniques, including dimensionality reduction and atmospheric correction, to enhance data quality. The solution employs a multi-branch ensemble model combining CNNs, Transformers, and quantum-classical autoencoders for robust anomaly detection. Real-time processing is enabled through GPU acceleration, with a user-friendly platform for visualization and explainable AI tools. This approach provides accurate and efficient detection of anomalies in complex hyperspectral datasets.

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IDEA / SOLUTION

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The solution offers a hybrid pipeline to improve anomaly detection in hyperspectral imaging, integrating deep learning, unsupervised learning, and quantum-inspired models.

- **Data Acquisition & Pre processing:**

  Hyperspectral data from sensors (e.g., Hyperion) is cleaned using dimensionality reduction and atmospheric correction techniques.

- **Hybrid Ensemble Model:**

  - **Branch 1 (Deep Learning):**

    Combines CNNs for spatial features and Transformers for spectral relationships, supported by attention mechanisms for explainability.

  - **Branch 2 (Unsupervised Learning):**

    Autoencoders identify anomalies without labeled data.

  - **Branch 3 (Quantum Classical Autoencoder):**

    Detects anomalies through high reconstruction errors in the model

IDEA / SOLUTION (Contn...)

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- **Spectral Signature Matching:**

  Anomalies are matched with a spectral library to identify materials or targets.

- **Post-Processing & Analysis:**

  Anomaly maps are refined using objectbased image analysis (OBIA) to reduce false positives.

- **Hardware Implementation:**

  The solution supports real-time processing by leveraging GPU and FPGA acceleration, optimizing the deep learning and quantum-inspired models for fast and efficient anomaly detection.

- **Visualization:**

  The system includes a user-friendly platform for visualizing results and providing insights via explainable AI tools.

RESEARCH PROPOSAL

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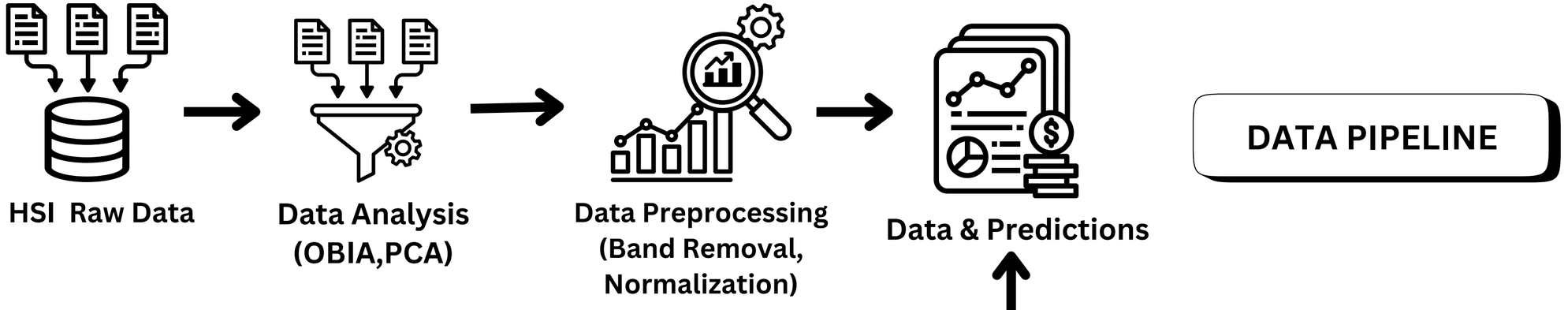

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TECH SPECS

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PROGRAMMING LANGUAGE: PYTHON

LIBRARIES AND FRAMEWORKS:

- NUMPY
- MATPLOTLIB
- TENSORFLOW
- SCIPY
- PYWAVELETS
- SCIKIT-LEARN

GPU: NVIDIA JETSON NANO

NVIDIA GEFORCE RTX 3050

MINIMUM MEMORY & STORAGE: 2GB & 32 GB

DATA PIPELINE

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PRE PROCESSING

- Shape - Alignment & Loading data
- Band Removal
- Radiometric & Atmoshpheric Corrections
- Dimensional Reduction
- Denoising
- Band Selection & Refinement
- SNR Calculation

ML ARCHITECTURE

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Ensemble Voting Classifier

RX Algorithm

1. Covarience
2. Threshold
3. Mask
4. Image Generation

ABOUT

The RX algorithm detects anomalies using covariance matrices, applying threshold-based masking for tasks like hyperspectral image generation and segmentation.

SRCR - ECEM

1. Cluster
2. L2 Normalization
3. Residuals
4. Anomaly Scores
5. Image generation

ABOUT

The SRCR ECEM mode uses clustering and L2 normalization to analyze residential data, calculate anomaly scores, and enhance image generation processes.

CNN + Transformer

- CNN
  1. Conv 2D layers
  3. Maxpooling layers
  4. Fully Connected layers
- Transformer
  1. Encoder

ABOUT

CNN uses Conv2D layers, max pooling, and fully connected layers for feature extraction, while the Transformer employs an encoder for capturing sequence-based dependencies.

HARDWARE

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NVIDIA JETSON NANO

- RAM: 2 GB
- Storage SD: 64 GB
- Core: 128 NVIDIA Maxwell’s
- ARM Arch: Quad-core Cortex A57

NVIDIA GEFORCE RTX 3050

PC HARDWARE

- RAM: 6 GB
- Storage: 512 GB
- Core: 2304 NVIDIA
- ARM Arch: NVIDIA Ampere

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OUTPUT

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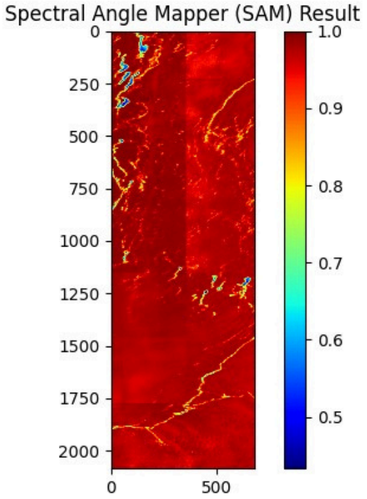
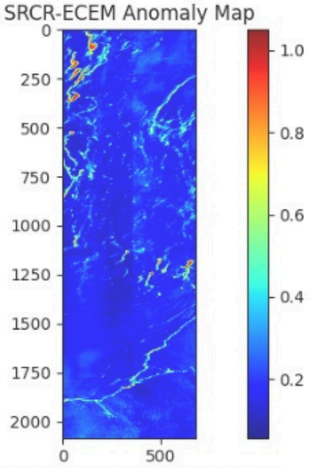
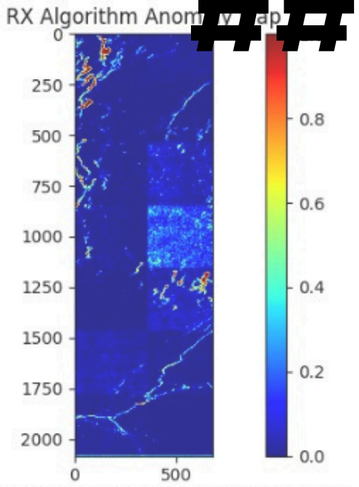
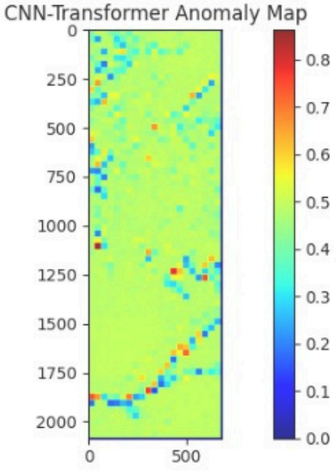
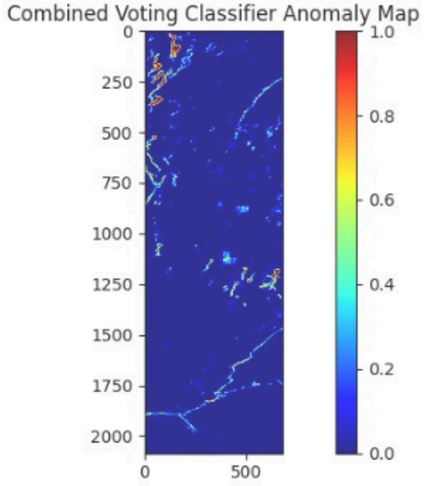
INP SEND PENDING

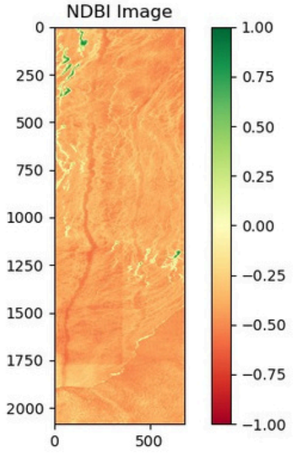


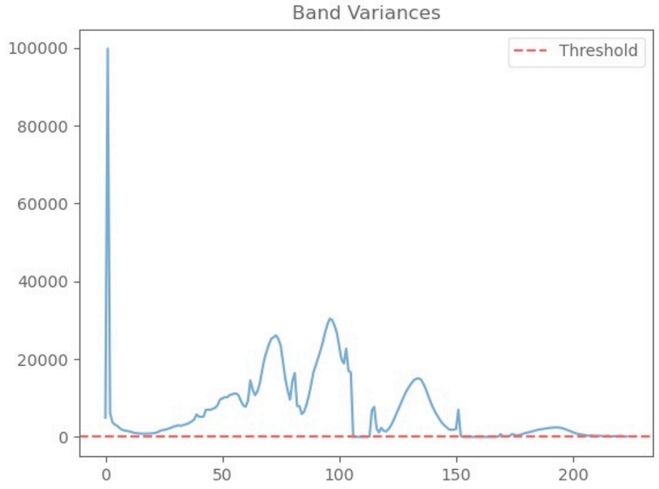












FUTURE ENHANCEMENT

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Hardware Acceleration:

Utilize GPUs, TPUs, or FPGAs to accelerate model inference and reduce processing times for real-time applications.

Benefit: Achieves faster detection rates suitable for large-scale deployment.

Integration with Live Camera Feeds:

Develop a pipeline to process real-time video feeds from cameras for dynamic anomaly detection.

Benefit: Enables live monitoring of environments such as industrial sites, surveillance, or medical imaging.

Automated Hyperparameter Tuning:

Implement automated hyperparameter optimization using frameworks like Optuna or Hyperopt to improve model performance.

REFERENCE

"Deep Learning for Hyperspectral Image Classification: An Overview"
Link:https://www.researchgate.net/publication/332699763_Deep_Learning_for_Hyperspectral_Image_Classification_An_Overview

"Quantum-Inspired Spectral-Spatial Pyramid Network for Hyperspectral Image Classification"
link: https://ieeexplore.ieee.org/document/10203069

"Anomaly Detection in Hyperspectral Images Using Unsupervised Learning"
link: https://www.mdpi.com/2072-4292/14/9/1973

"Explaining Deep Neural Networks" link:https://arxiv.org/abs/2010.01496

"An Overview of Pre-processing Methods Available for Hyperspectral Imaging Applications"
link:https://www.sciencedirect.com/science/article/abs/pii/S0026265X23007488

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Thank you