**Objective:**

The objective of this project is to propose a novel model for detecting multiple targets from a live video feed. The model integrates Stationary Wavelet Transform (SWT), Principal Component Analysis (PCA), and a fusion of Convolutional Neural Networks (CNN) and Temporal Convolutional Networks (TCNs).

**Key Features:**

* **Enhanced Feature Extraction**: SWT is used to extract spectral information from each video frame, providing better feature identification, especially for edges.
* **Dimensionality Reduction**: PCA is applied to the SWT output, reducing dimensionality while preserving essential information, allowing the hybrid model to process data efficiently.
* **Hybrid CNN-TCN Architecture**: The fusion of CNN and TCN allows the model to extract spatial features and temporal dependencies, improving target detection accuracy across various terrains and scenarios.
* **Explainability Integration**: Grad-CAM is incorporated to visualize the decision-making process, highlighting which parts of the input frame influenced the model's predictions. This is crucial for critical applications like identifying friendly, hostile, and alien objects.

**Methodology:**

1. **Frame Extraction**: Extract individual frames from the live video feed.
2. **Stationary Wavelet Transform (SWT)**: Apply SWT to extract meaningful spectral features from each frame, aiding in image edge and feature identification.
3. **Principal Component Analysis (PCA)**: Reduce the dimensionality of the SWT output while preserving critical information.
4. **Hybrid CNN-TCN Model**:
   * **CNN Component**: Extracts spatial features from the PCA-transformed input.
   * **TCN Component**: Processes the CNN output to capture temporal dependencies, enhancing the model's understanding of video dynamics.
5. **Explainability Feedback Loop**:
   * **Grad-CAM for Real-Time Explainability**: Visualize the areas of the frame that the CNN focuses on during predictions, ensuring the model's decision-making process is transparent.
   * **Adaptive Learning**: Integrate a feedback mechanism where explainability insights are used to adjust the model in real-time, enhancing future predictions by dynamically tuning learning parameters.

**Novelty and Contributions:**

1. **Real-Time Explainability with Grad-CAM**:
   * Provides visual insights into model decisions, highlighting regions of interest in real-time.
   * Enhances transparency and trust in critical applications by showing what influenced predictions.
2. **Adaptive Feedback Loop**:
   * Grad-CAM outputs are used to evaluate model focus, feeding discrepancies back into the model to adjust learning parameters dynamically.
   * This feedback mechanism enables the model to self-correct and improve its predictions based on real-time performance, simulating reinforcement learning.
3. **Edge-Ready Optimization**:
   * The model is optimized for deployment on hardware like Raspberry Pi, utilizing quantization, pruning, and other techniques to reduce computational complexity while maintaining performance.
   * Designed to operate efficiently in various terrains and scenarios, such as urban, combat, and surveillance settings.

**Optimization and Deployment:**

* **Quantization and Model Pruning**: Techniques like reducing precision of weights and removing unnecessary parameters are applied to minimize model size and enhance performance on edge devices.
* **Iterative Optimization**: Continuous deployment testing and refinement to balance accuracy, speed, and resource usage.

**Deliverables:**

* A comprehensive model integrating video frame extraction, SWT, PCA, and the hybrid CNN-TCN architecture for real-time target detection.
* Experimentation and validation on a dataset containing over 7,000 images of various targets, including friendly, hostile, and alien objects.
* Real-time adaptability and improved detection accuracy across multiple terrains and operational modes, not limited to combat scenarios.

**Expected Outcomes:**

* Achieve high classification and target detection accuracy in real-time across diverse environments.
* Demonstrate the model’s ability to adapt and improve its predictive accuracy through the integrated feedback mechanism.