**Step 1: Preprocessing**

The first step is to ensure all images are in the correct format and aligned.

1. **Image Alignment and Cropping**: Ensure that all images, including the background image, are aligned. Misalignment can lead to false positives when comparing images pixel-wise.
2. **Histogram Equalization/CLAHE**:
   * Perform histogram equalization on each image to enhance contrast, or use Contrast Limited Adaptive Histogram Equalization (CLAHE) to normalize lighting conditions. This helps in making features of interest (people) more prominent.
3. **Normalization and Resizing**:
   * Resize all images to have the same resolution if not already matching, to ensure consistent comparison.
   * Normalize pixel values to bring them within a consistent range (e.g., 0 to 1) to standardize input values for subsequent calculations.

**Step 2: Background Subtraction Using Image Averaging**

1. **Image Averaging**:
   * Use the provided background image as a reference. Compute an average image from the background to smooth out any noise and minor lighting variations. This will serve as a clean background reference.
2. **Pixel-wise Comparison**:
   * Subtract the background image from each of the images containing people to get a differential image. Use an appropriate threshold to differentiate between static and dynamic (moving/person) areas.
   * Thresholding could help in eliminating the subtle differences and only keeping prominent foreground (people) features. Any significant difference in the pixel values can be considered a possible detection of a person.

**Step 3: Feature Enhancement**

1. **Spatial Filters - Derivatives and Laplacian**:
   * Use **first-order derivatives** (e.g., Sobel filters) to identify edges and regions of high-intensity change, which correspond to the boundaries of people.
   * Use the **Laplacian** operator to enhance regions with rapid intensity change and accentuate the presence of human figures.
2. **Edge Detection**:
   * Use **Canny Edge Detection** to find the edges of potential people in the foreground images.
   * The edge detection, combined with the difference from the background, will give more confident regions where people are located.

**Step 4: Morphological Operations**

1. **Morphological Thinning**:
   * After applying edge detection, you may have noisy edges. Use morphological operations like **thinning** or **closing** to clean up these edges and potentially link disconnected parts of detected humans.
   * **Erosion and Dilation** can also be used to fill small gaps in detected regions (e.g., connecting fragmented parts of the same person) and remove small noisy detections.

**Step 5: Blob Detection and Filtering**

1. **Blob Detection**:
   * Apply a blob detection algorithm (e.g., connected components labeling) on the resulting foreground mask.
   * Identify and label distinct blobs which correspond to detected persons.
2. **Filtering**:
   * Filter out blobs based on size and aspect ratio to remove false positives (e.g., waves or other beach elements).
   * For each blob that matches the typical size of a person, increment the count.

**Step 6: Use Kernels Specifically Designed for Crowd Detection**

* **Crowd Detection Kernels**:
  + Implement Gaussian filters or other convolutional kernels tuned to enhance areas that have characteristic textures and shapes of people. This helps to highlight potential areas of crowd presence.
* **Heatmap Generation**:
  + Generate density maps that represent potential person locations using Gaussian kernels centered on the blobs. These density maps can help estimate the count by integrating the resulting density.

**Step 7: Post-processing and Validation**

1. **Combine Results from Multiple Techniques**:
   * Combine results from the pixel-wise difference, spatial filters, and blob detection to finalize the count. Implement a voting mechanism where multiple techniques agree on the presence of a person.
2. **Manual Validation and Parameter Tuning**:
   * Manually validate a subset of images to adjust thresholds and parameters for the various filters and morphological operations. This is particularly important given the variability of lighting and background conditions.

**Step 8: Evaluation and Metrics**

* **Counting Accuracy**:
  + Compare the results with the ground truth labels provided in your CSV annotation file.
  + Calculate standard crowd counting metrics such as **Mean Absolute Error (MAE)** and **Root Mean Squared Error (RMSE)** to evaluate the counting accuracy.