**Image processing methods and machine learning model for enhanced background subtraction**

**3.1. Four Image Processing Methods**

**1. Grayscale Conversion**

Translates color frames into grayscale to decrease computational complexity and enhance contrast.

Simplifies subsequent processing steps by removing redundant color information.

**Output:** A grayscale copy of the original frame, with pixel values varying from 0 (black) to 255 (white).

**2. Image Smoothing (Gaussian Blur)**

Decreases noise and small variability in the image by means of a Gaussian filter.

Assists in the elimination of high-frequency noise that can influence background modeling.

A moderately blurred image with unwanted noise minimized.

**3. Edge Detection (Canny Algorithm)**

Identifies object edges by detecting areas with high intensity gradient.

Critical in properly segmenting objects from background.

**Output:** A binary image with object edges marked with white pixels (foreground) and black pixels (background).

**4. Morphological Operations (Erosion & Dilation)**

Erosion: Eliminates small white noise and sharpens object boundaries.

Dilation: Widens foreground objects to improve object visibility.

**Output:** A refined mask where foreground objects are more distinguishable from the background.

**3.2. Machine Learning Model: CNN-Based Background Subtraction**

For improved detection accuracy, we use a Convolutional Neural Network (CNN) that is trained on labeled background subtraction datasets.

**Steps Involved:**

**Dataset Selection:** Utilize benchmark datasets such as CDNet (Change Detection Dataset) for training.

**Feature Extraction:** Extracts spatial features from video frames to distinguish foreground and background.

**Model Training:** Train the CNN on labeled background-foreground images.

**Foreground Segmentation**: The trained model identifies pixels as background or moving objects.

**Output of CNN Model:**

Enhanced segmentation of moving objects.

Reduced false positives and noise in dynamic backgrounds.

Flexibility to different lighting conditions and occlusions.