

# Video Surveillance System with Smart Motion Detection Documentation

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## 1 Project Overview

This project focuses on a video processing system with motion detection and smart home camera functionalities. The key functionalities include identifying frames with no significant motion (marking them visually), detecting and classifying human movement relative to the camera, tracking individuals across frames, sending door alert notifications and generating heatmaps. All while also taking snapshots of possible intruders.

## 2 Running the Project

1. Install dependencies: OpenCV, NumPy, ultralytics, scipy, requests.
2. Configure parameters in the JSON configuration file.
3. Run the project (<config\_path> is the path to the JSON configuration file):

```
1 python main.py --config <config_path>
2
```

4. Optionally, select a Region of Interest if enabled.

## 3 Configuration File Structure

The JSON config file defines system behavior. A sample structure:

```
1 {
2   "video_path": "input.mp4",
3   "camera_mode": false,
4   "roi_mode": false,
5   "save_detections": true,
6   "save_motion_video": true,
7   "motion_detector": { ... },
8   "tracker": { ... },
9   "movement_classification": { ... },
10  "door_detection": { ... },
11  "heatmap": { ... }
12 }
```

Each nested object configures specific modules such as motion detection, tracking, door alerts, movement classification and heatmap generation.

## 4 Configuration Parameters

Table 1: Configuration Parameters

| Parameter                       | Description   |
|---------------------------------|---|
| video_path                      | Path to the video file or camera index.   |
| camera_mode                     | Use live camera feed if true.   |
| roi_mode                        | Enable Region of Interest mode. If on, door alerts and heatmap generation are turned off. |
| save_detections                 | Save images of detected persons if true.  |
| save_motion_video               | Save video segments with motion.  |
| <b>motion_detector:</b>         |   |
| history                         | Frames for background model history.  |
| var_threshold                   | Sensitivity for foreground detection.   |
| detect_shadows                  | Enable shadow detection in background subtractor.   |
| area_ratio                      | Minimum ratio of changed area to trigger motion.  |
| min_countour_area               | Minimum contour size to consider valid motion.  |
| <b>tracker:</b>                 |   |
| iou_threshold                   | Overlap threshold for associating detections.   |
| max_missed                      | Max frames a track can be unseen before removal.  |
| feature_threshold               | Similarity threshold for matching features.   |
| reid_threshold                  | Threshold for re-identifying lost tracks.   |
| max_reid                        | Max tracks to keep for potential re-identification.                                       |
| <b>movement_classification:</b> |   |
| history                         | Frames history for movement analysis.   |
| certainty_frames                | Frames required to confirm a movement.  |
| deadband_threshold_position     | Threshold to ignore minor positional changes.   |
| deadband_threshold_size         | Threshold to ignore minor size changes.   |
| <b>door_detection:</b>          |   |
| alert                           | Enable door alert feature.  |
| width_ratio                     | Width proportion to trigger door alert.   |
| y_position_ratio                | Vertical position threshold near door.  |
| push                            | Enable push notifications.  |
| <b>heatmap:</b>                 |   |
| active                          | Enable heatmap generation feature.  |
| live                            | Showcase the heatmap generation live on the video.  |

## 5 Implementation Details

- **Full Mode:** In this mode, when significant movement is found in a frame, the program will make use of an object detector to recognize people and detect their type of movement in regards to the camera (if they're moving toward or away from the camera, lateral movement or just standing still). For this, it will make use of a tracker based on IoU and appearance similarity (color histogram) matching between the tracks and detected bounding boxes. It will also take snapshots of detected people, build a video of frames with motion, provide door alert notifications and heatmap generation.
- **RoI Mode:** It's a mode specifically designed to detect motion and only motion in a specified RoI. It also takes snapshots of movements and a video when movement is detected in the RoI. In this mode, features such as door alerts, movement classification and heatmap generation are turned off.
- **Person Detection:** if RoI mode is off, then person detection is done via YOLO model. If RoI mode is on, the code skips using YOLO for detections. Instead, it applies background subtraction specifically within the selected RoI. It then finds contours inside that region, filters them by area, and draws bounding boxes for those contours (using NMS to handle overlap).