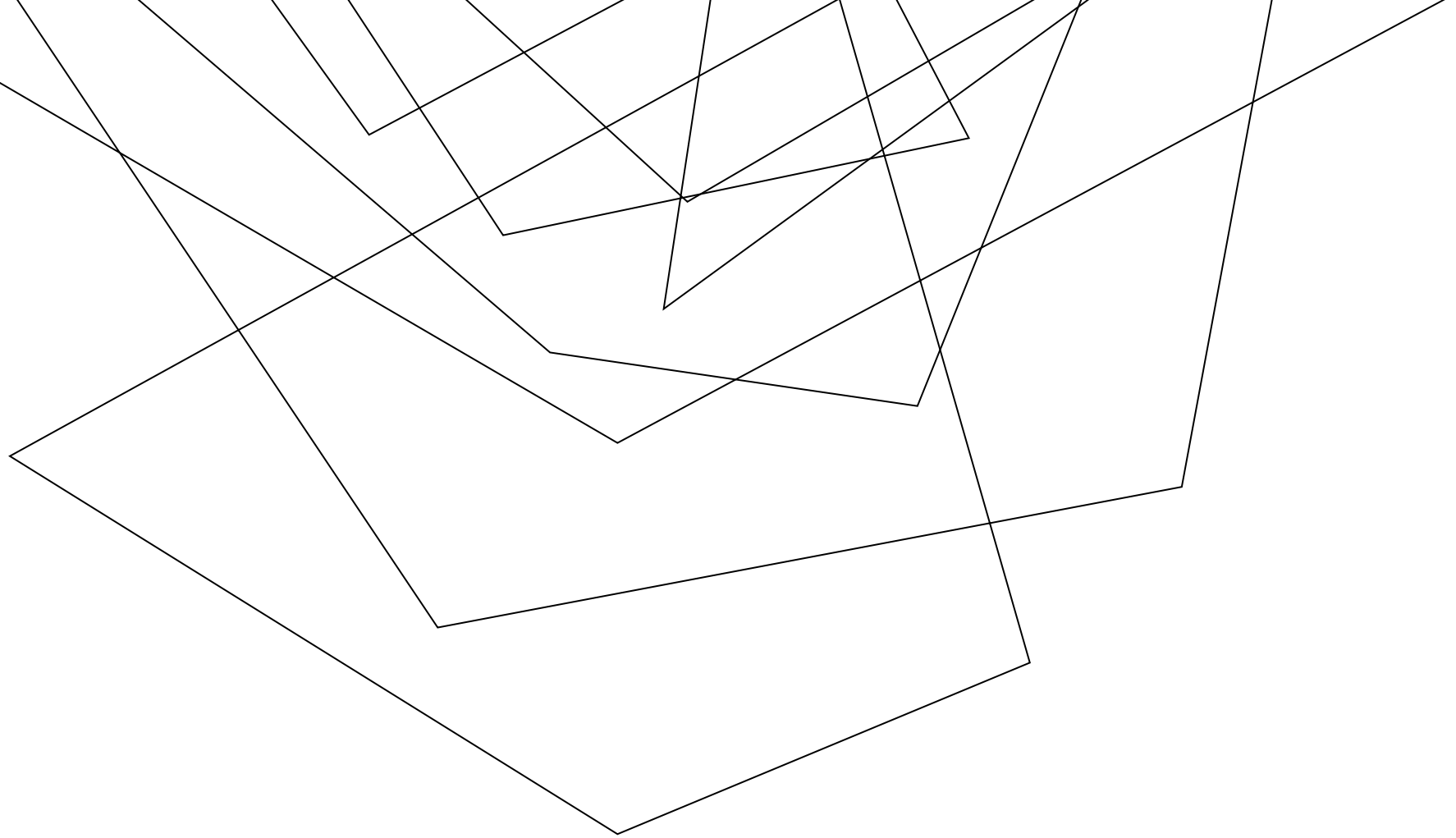
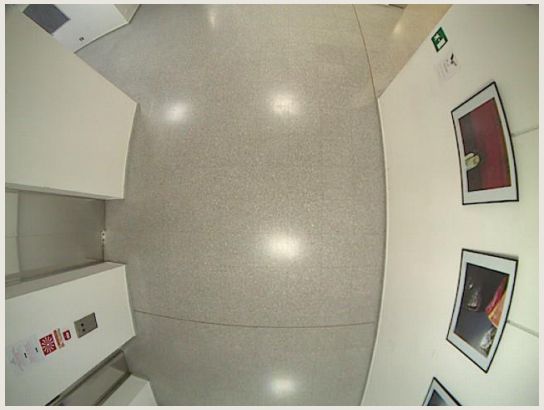


PROJECT - SIGNAL, IMAGE AND VIDEO

Luca Zanolo

INTRODUCTION

Given a video sequence representing a person moving within an environment, the goal is to track their movements and generate a spatio-temporal heatmap that represents the probability of occupancy in various areas of the monitored environment.



- 327 Available videos
- Resolution 640x480p
- Frame rate 30 FPS
- AVI video files
- 5 minutes on average

DATASET

The dataset utilized for this project is made of videos, which were captured by a ceiling camera located in a corridor at the University of Trento's Povo 2.

Group	Duration	Start Time	End Time	Total Frames	Available Videos
1	03:29:50	08:00	08:30	377707	42
2	03:29:57	08:30	09:00	377935	44
3	03:35:16	12:00	12:30	387504	44
4	03:27:27	12:30	13:00	373411	42
5	03:10:34	13:00	14:00	343024	41
6	03:29:52	16:00	17:00	377778	42
7	02:59:57	17:00	17:30	323922	36
8	02:59:57	17:30	18:00	323939	36
Average	03:20:22	-	-	360653	36

PROJECT COMPONENTS

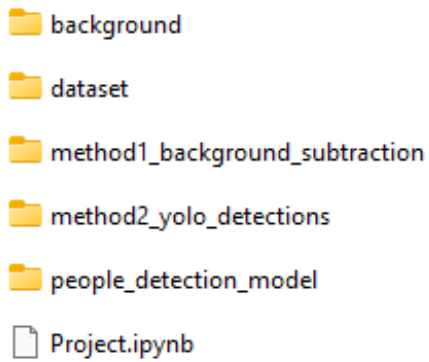
Background — Manually chosen background image

Method 1 — Heatmaps generated with background subtraction method

Method 2 — Heatmaps generated using YOLOv4-Tiny detections

People Detection Model — YOLOv4-Tiny

YOLOv4-tiny is a lightweight version of the YOLO (You Only Look Once) object detection algorithm. Specifically designed for real-time and resource-constrained applications.



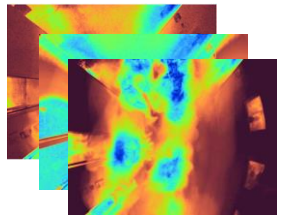
ENVIRONMENT FOLDERS

Section 1

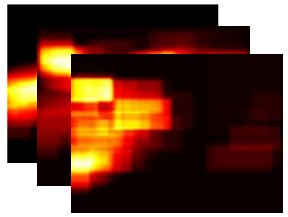
Dataset videos

Section 2

Detect movement inside each video and incrementally build the heatmap



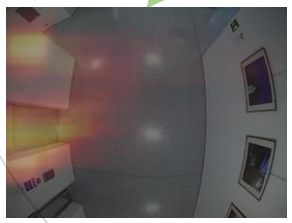
Heatmaps generated with Background Subtraction



Heatmaps generated with YOLO Detections

Section 3

Group heatmaps over a period in order to compute the average heatmap and occupancy



Average Heatmaps for a chosen period

PIPELINE

HEATMAP WITH BACKGROUND SUBTRACTION

1. **Extract frame from video**

2. **Update the background model**

   Update the KNN background subtraction model.

3. **Erodated boundaries of foreground objects**

   Apply the morphological operation cv2.MORPH_ERODE to erode the boundaries of the objects.

4. **Add erodated image to the accumulated image**

   Add the current processed image to the accumulated one.

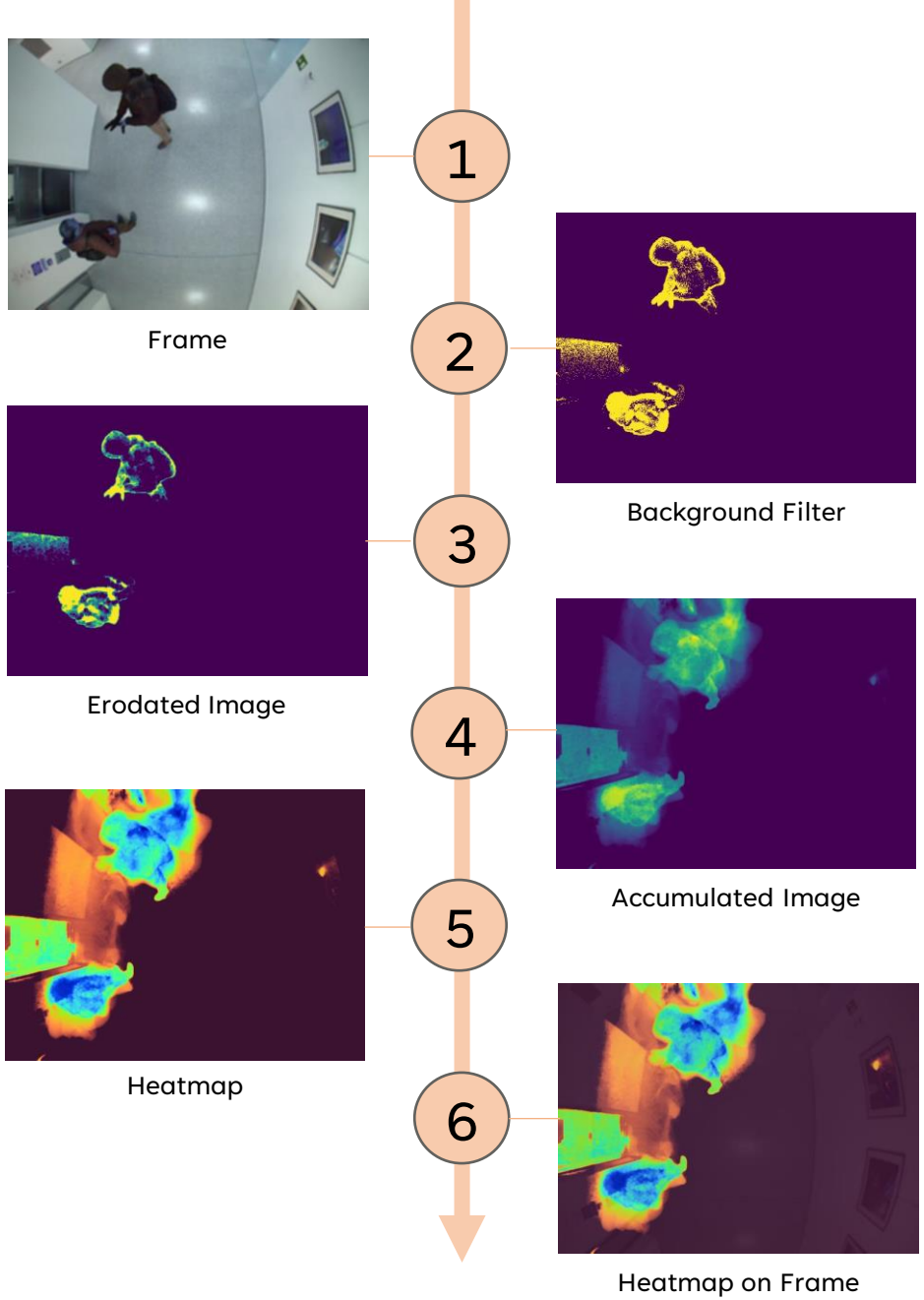
5. **Normalize the image and apply heatmap colors**

   Normalize the image and apply heatmap colors. The image is normalized in the 255 range, and then a color map is applied.

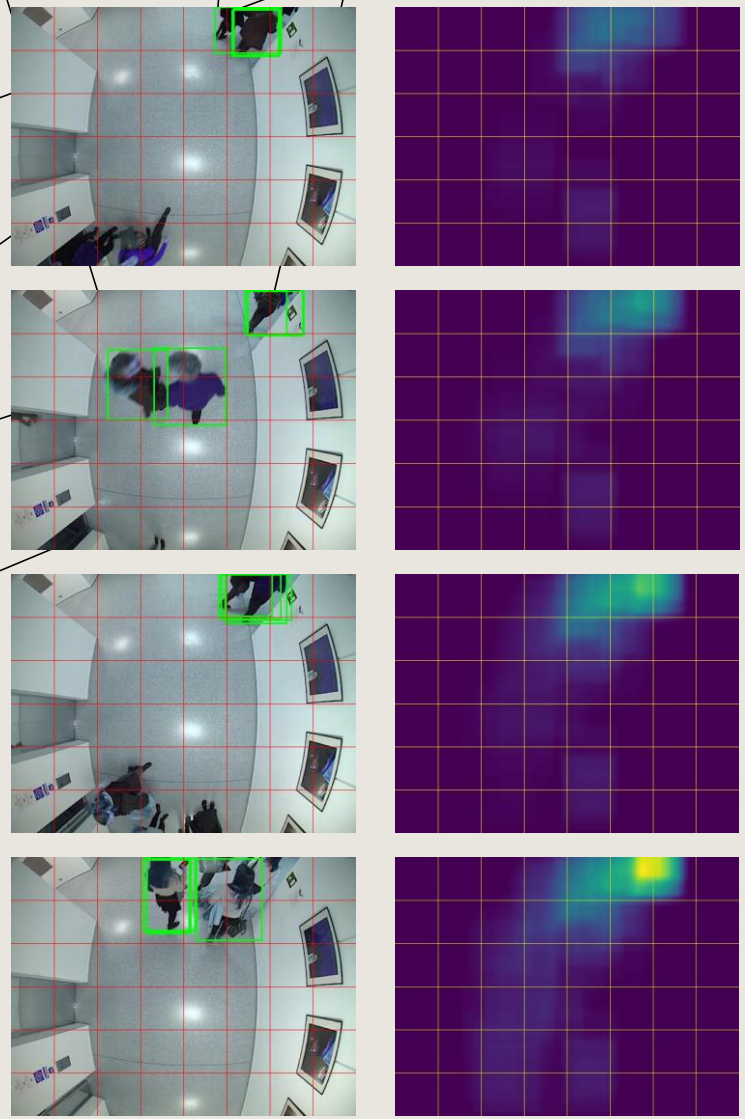
6. **Show heatmap on background**

   Image is superimposed to the current frame. This is the image that will be used to build the video

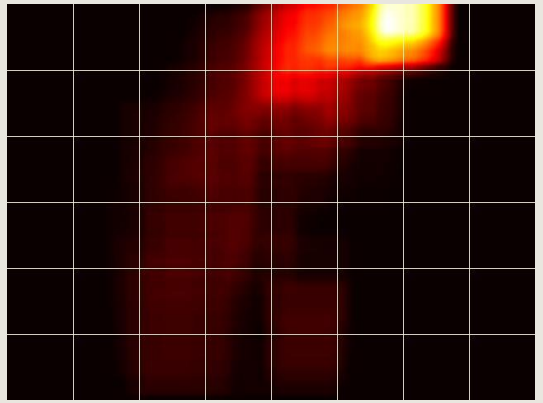
7. **Save the final heatmap (5) of the process to a target folder.**



HEATMAP WITH YOLO DETECTION



1. Initialize the heatmap matrix
2. Extract frame from video
3. Inspect the frame with YOLO and obtain detections of persons only.
4. Draw a rectangle around the centroid of the detections
5. Increment the corresponding area within the heatmap
6. Save the heatmap using a heat color scheme



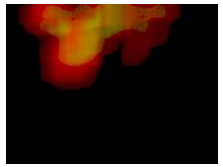
HEATMAPS ANALYSIS

Time range :

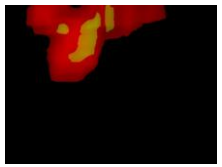
Heatmaps :

Heatmaps :

Set to 0 values under a predefined threshold



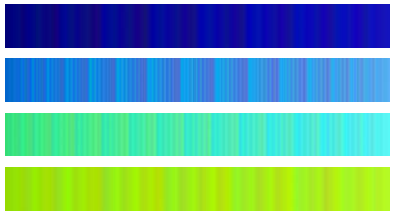
Threshold: 20



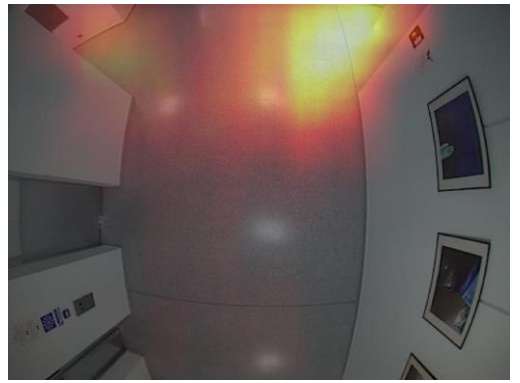
Threshold: 70

Threshold: 150

Highlight hot areas accordingly to different color ranges



Estimate occupancy

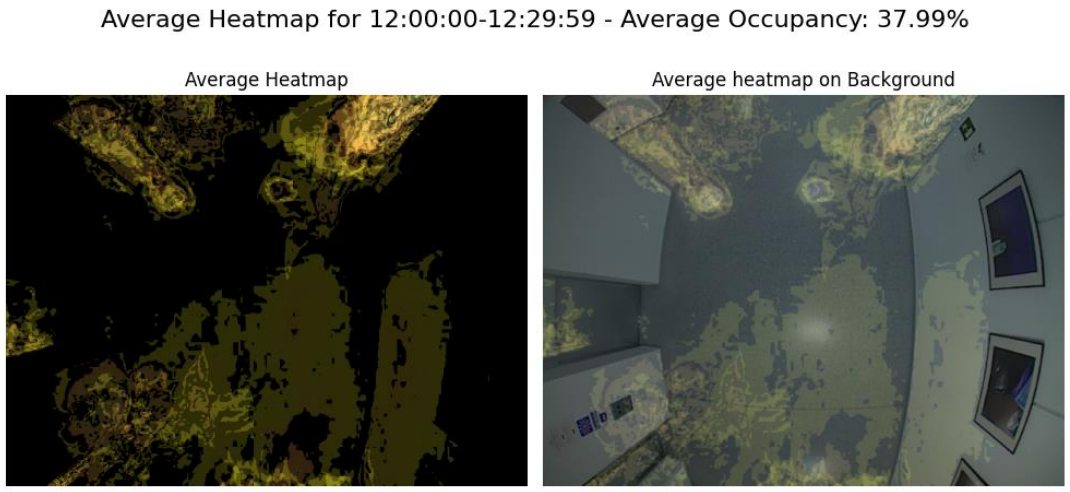


Average occupancy between 8:30 and 9:30 is 41.9%

CONCLUSION

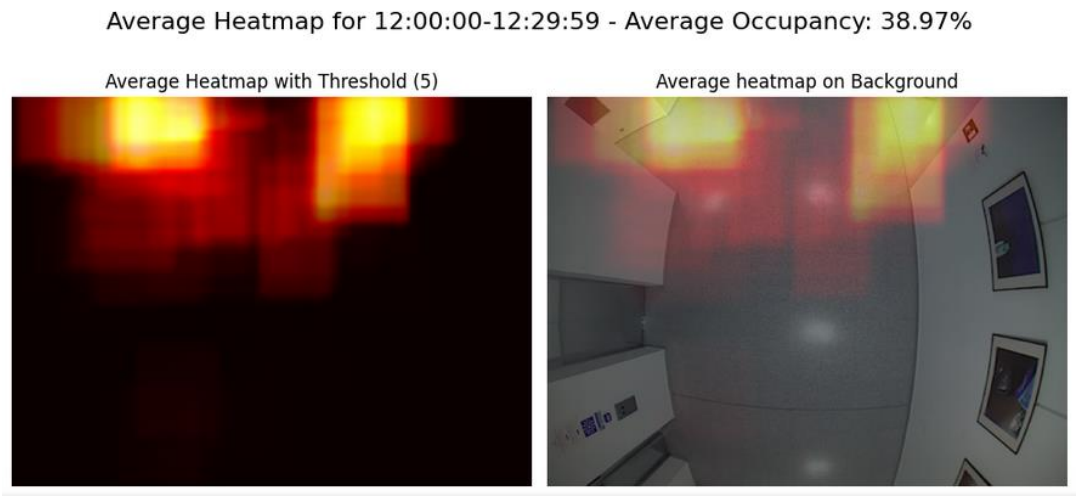
HEATMAP WITH BACKGROUND SUBTRACTION

The first method was utilized under the assumption that all movement is generated by people. However, despite this simplification, it isn't very reliable in assessing occupancy, because it is subject to variations in illumination, and it was challenging to identify the actual movement areas in the resulting heatmap.

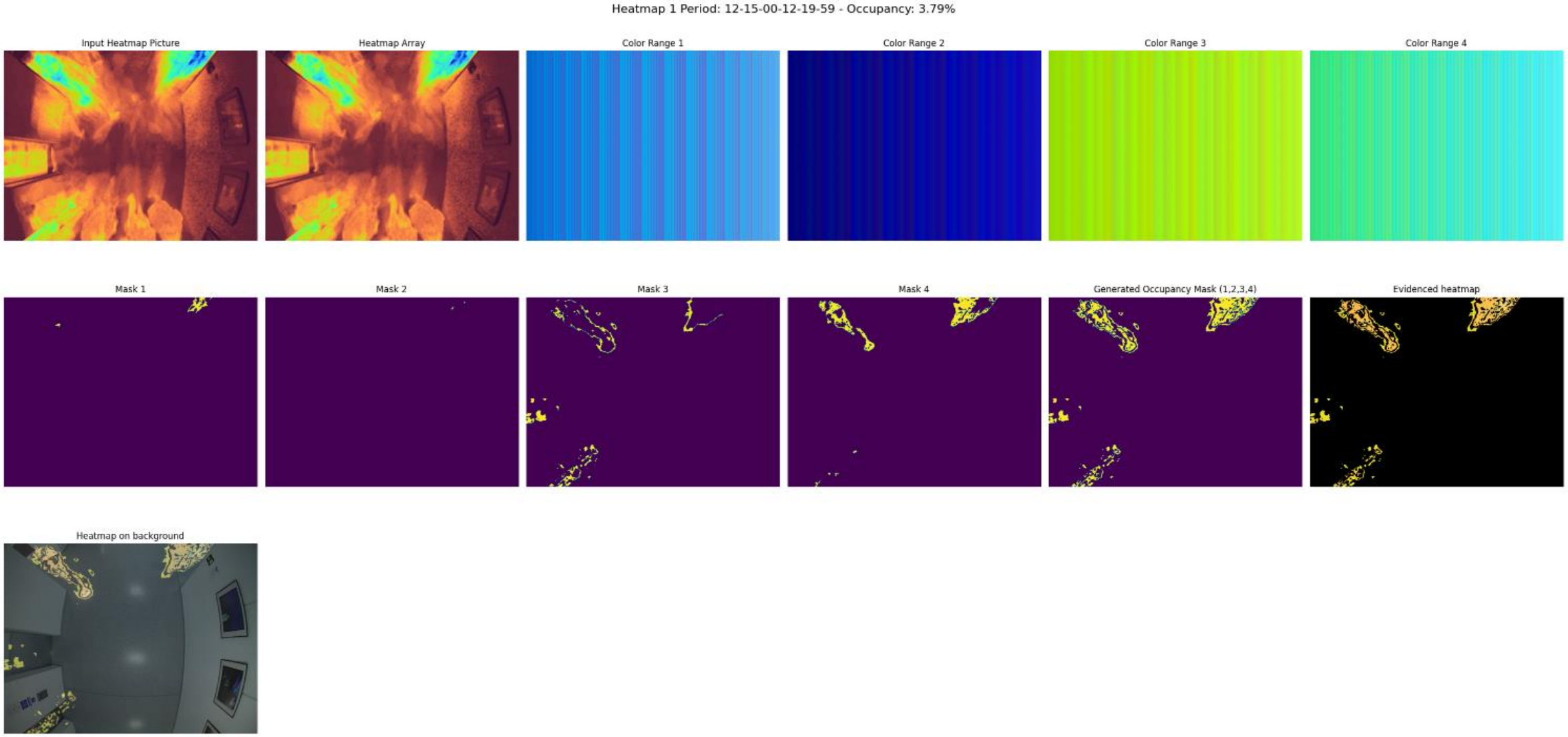


HEATMAP WITH YOLO DETECTION

The second approach, using YOLO, is more reliable as the heatmap is built exclusively on potential human detections. The YOLO detections were performed at alternate frames, using a YOLO confidence threshold of 0.25. However, it's more computationally intensive than the other method.



INTERMEDIATE OUTPUT IN HEATMAP ANALYSIS (WITH BACKGROUND SUBTRACTION)

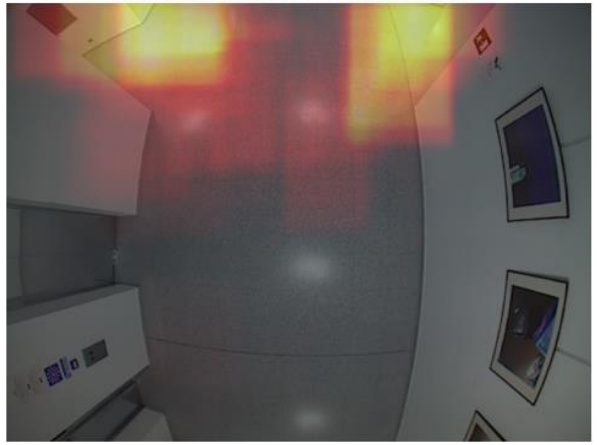


OUTPUT IN HEATMAP ANALYSIS (WITH YOLO DETECTIONS)

Average Heatmap for 12:00:00-12:29:59 - Average Occupancy: 38.97%

Average Heatmap with Threshold (5)

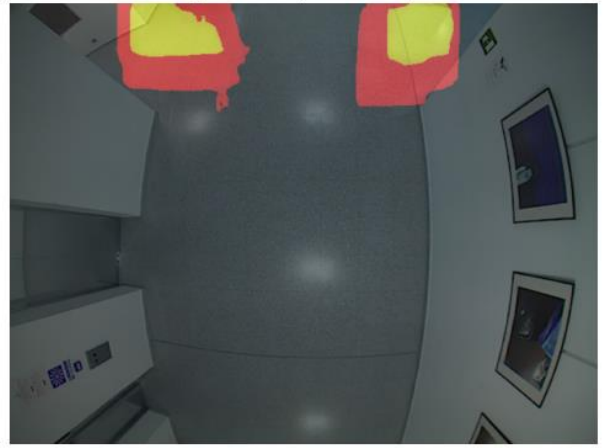
Average heatmap on Background



Average Heatmap for 12:00:00-12:29:59 - Average Occupancy: 3.61%

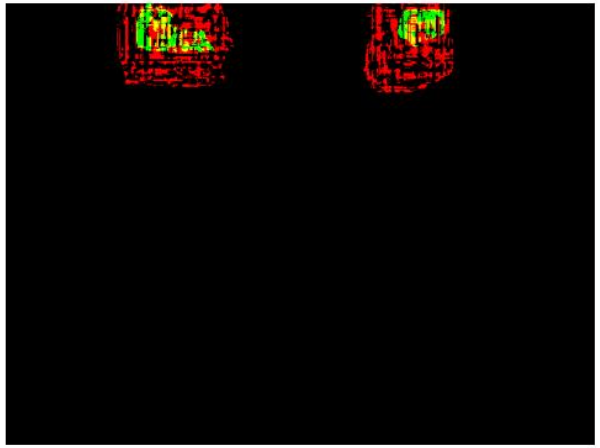
Average Heatmap with Threshold (200)

Average heatmap on Background

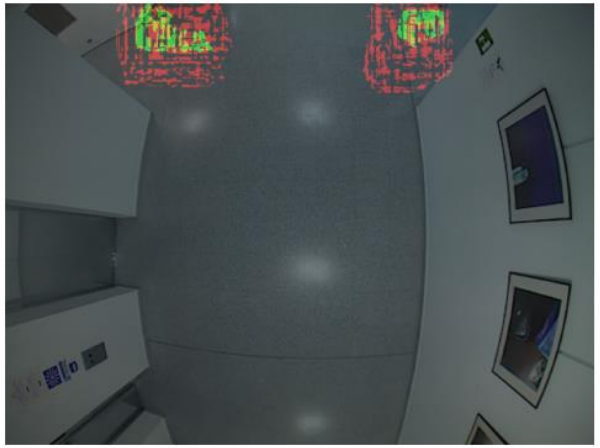


Average Heatmap for 12:00:00-12:29:59 - Average Occupancy: 1.08%

Average Heatmap with Threshold (254)



Average heatmap on Background



THANK YOU

Luca Zanolo