

# PEDESTRIAN DETECTION USING LOW-RESOLUTION THERMAL IMAGER VERSUS VISUAL IMAGER

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**Key words:** Image Processing, thermal imaging, visual imaging, segmentation, background removal, pedestrian detection.

**Key Results:** Thermal imaging can ease the problem of detecting pedestrians in outdoor environments.

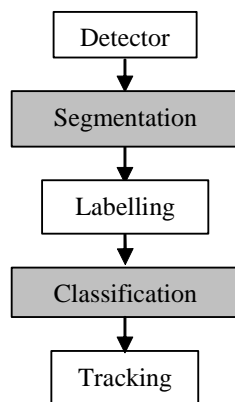
**How does the work advance the state-of-art:** By reducing the complexity of pedestrian detection algorithms, it becomes possible to implement the algorithms in relatively simple embedded systems, such as microcontroller and FPGA-based systems.

**Motivation (problem addressed):** How to implement pedestrian detection algorithms in embedded systems.

## Introduction

Vision based pedestrian detection systems for outdoor applications are very demanding of computer power and memory due to the processing needed to deal with changes in ambient conditions encountered in visible light imaging.

The two key processes used in most visual image pedestrian detection algorithms that are expensive in processor time and memory space are image segmentation and object classification. These processes are marked in grey in Figure 1. Segmentation defines the regions of interest within the image and classification attempts to categorise these regions as known objects. Both these processes require complex algorithms to deal with changes in ambient light conditions.



**Figure 1:** The main processes during pedestrian detection. The grey areas are the most computational and memory consuming in the system.

The complexity of these processes prevents the viability of real time monitoring systems particularly in an embedded processor environment. Here we

will show that the use of a thermal array sensor for pedestrian detection will reduce the processing power and time required for pedestrian detection and thus increase the viability of using an embedded system.

The key problem with outdoor video surveillance is that the illumination changes throughout the day and they are prone to strong local variations due to environmental and weather conditions. The benefit of using thermal array detectors is that there is less variance in background intensity and regions of interest e.g. people as they are radiation emitters.

## Segmentation

Two main methods for segmentation that are used in pedestrian detection are:

1. Background subtraction
2. Motion analysis

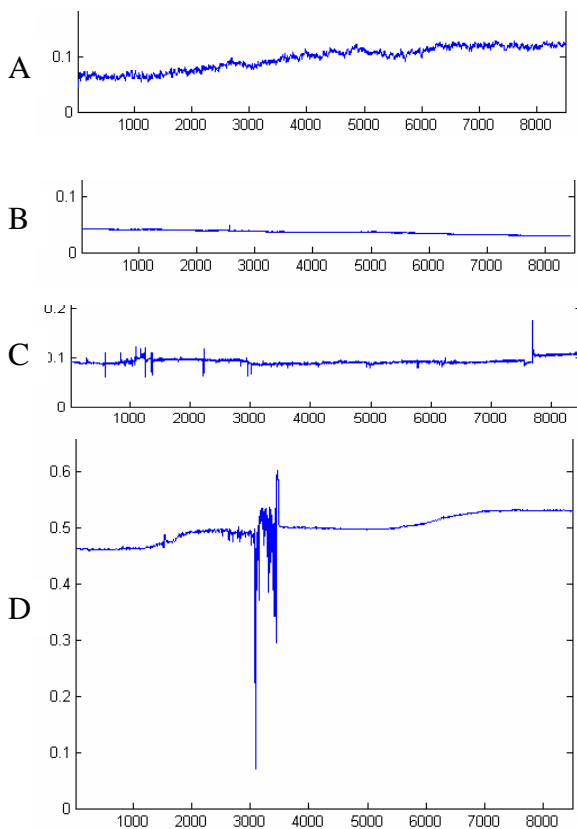
Both methods use temporal frame differencing. The difficulty in using these methods with visual array sensors is that they are very intolerant to intensity changes. This is shown in Figure 2, which compares intensity changes over time between a thermal and a visual detector. It can be seen that thermal detectors are less prone to high frequency intensity changes. There is only a slow calibration drift for the thermal array sensor, seen as a total intensity increase in Figure 2a. This implies that a thermal detector can be used with similar algorithmic method as a visual detector in an indoor environment.

Background subtraction requires a stationary background model and fails if intensity fluctuations are too large. Different statistical methods are used which results in all frames being stored before

segmentation can take place. For example [1] uses 600-1000 frames to build up a background model.

A perfect (unchanging) environment would only need one frame; an indoor environment is a close approximation to this. A simpler method can be used, such as a running average, which is calculated without saving frames first.

Motion analysis methods commonly use optical flow [2] to calculate the intensity variation. They work with moving objects, but fail when objects stop or move too slowly. These methods use less memory, and more computer power, and would benefit from a more uniform intensity condition.

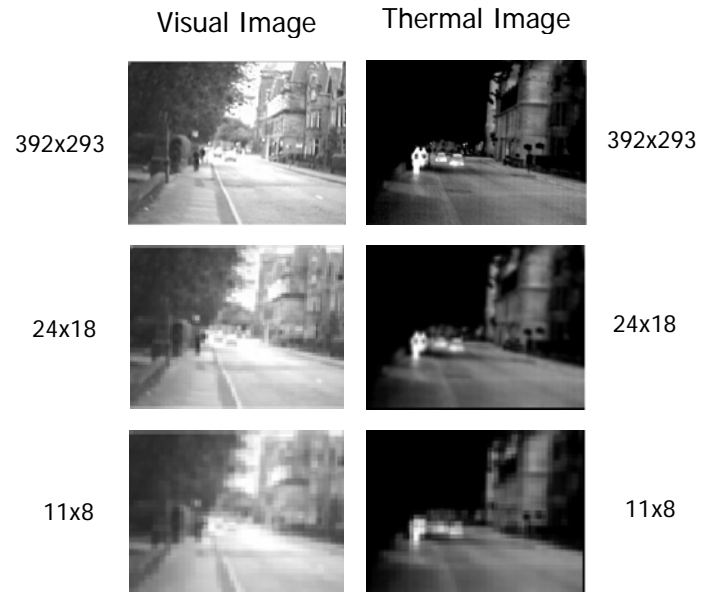


**Figure 2:** The difference in intensity changes between thermal and visual detectors. From the top: **a:** Thermal outdoor, **b:** Visual indoor, **c:** Visual outdoor, **d:** Visual Outdoor light reflex

### Resolution

The most effective way to speed up and reduce the memory usage in an array based detection system is to decrease the volume of data used. Thermal detectors can both be reduced in resolution and reduced in number of frames used yet still detect

people in an outdoor scene. From Figure 3 it can be seen that reducing the resolution in a thermal image does not reduce the detectability of a pedestrian in the same manner as reducing the resolution in a visual image would. However, there is a limit to this process: if the resolution is too low, objects may merge together.



**Figure 3:** The difference in thermal and visible images as resolution is reduced. Pedestrians can be identified at lower resolutions in the infrared than in the visible images.

### Conclusion

Changes in ambient illumination have been shown to add to both memory size and processing time in image processing. When a thermal imaging system is used instead of the usual visual system, resolution can be reduced, decreasing computational complexity. Reduction of the resolution has one disadvantage: objects may merge together when they are too close to each other.

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