USING LOW-RESOLUTION THERMAL SENSORS IN STEREO TO MEASURE PEDESTRIAN MOVEMENT.

Timothy Chamberlain, Alistair Armitage, Malcolm Rutter, David Binnie (School of Engineering)
School of Computing, Napier University,10 Colinton Rd Edinburgh, EH10 5DT, t.chamberlain@napier.ac.uk

Key words to describe the work: Pedestrian measurement, Thermal sensors, Stereo thermal sensing.

Key Results: Additional information is available using low-resolution thermal imaging in stereo.

How does the work advance the state-of-the-art?: This work presents a new system for gathering and analysing information from low resolution thermal imagers.

Motivation (problems addressed): Behavioural studies and security application require accurate pedestrian movement measurement systems.

Introduction

Existing pedestrian counting and movement analysis relies heavily on human observation. This proves an expensive and error prone means of determining the number and flow of pedestrians. Most methods only produce the number of people that pass a fixed point.

It is useful to be able collect more information about the pedestrian movement than simple counts. For example, people studying behavioural aspects of pedestrian movement, or those interested in safety and security applications require more detailed time and trajectory information.

There have been several attempts to achieve automatic pedestrian trajectory tracking, however each has its flaws. The most successful would appear to be that proposed by Nobuaki Ishihara [1] using laser scanners also known as LADAR[1], however the cost of LADAR is prohibitive for most applications. The others tend to use video footage analysis to track pedestrians.

Visual based tracking

There has been a plethora of research into using visual images to track movement. The most notable being the VSAM[2] and PASSWORDS[3] projects, both with substantial focus on tracking pedestrians. All existing solutions split the task into two initial phases, both error-prone. Firstly, the image must be processed to remove the background. This is a complex task requiring maintenance of a changing background model. The publication of a method for performance evaluation models for background subtraction [2] indicates the complexity and quantity of work in this field. Secondly, the foreground regions must be classified into object types, such as pedestrian or car. Gait analysis is sometimes used to classify objects as pedestrians and provide more information about them.

Thermal detection

The use of thermal imaging, as opposed to visible light imaging, removes the most complex background subtraction issues. The nature of thermal detection is such that the background tends to be at a constant or slowly varying temperature thus easing the task of background subtraction.

High-resolution thermal imagers present similar cost implications to LADAR without the advantage of range information. However recently, low cost low-resolution thermal array detectors have become available. For example the IRISYS people counters [3]. Provide a potentially good source of pedestrian information with little or no background subtraction required. This position is supported by Jones [4].

Proposed solution

We propose to build a software system that can collate information from several different thermal array sensors to track the movements of pedestrians. There are problems in taking a simplistic approach of segmenting hot objects into targets and then tracking them. It is usually impractical to locate the sensors in such positions that objects flow smoothly from one field to another. Further, real world objects can occlude the view of the pedestrian from the sensor for some of the scene.

The information that LADAR provides, that eases the task in hand, is range information. This

[1] LAser Detection And Ranging
[2] Visual Surveillance And Monitoring, Carnegie Mellon University
[3] Parallel and real time Advanced Surveillance System With Operator assistance for Revealing Dangerous Situations: Esprit P-8433

information is also available in visual images by using stereo. As mentioned earlier, the use of visual imaging presents complex processing problems so if thermal images could be obtained in stereo these problems might be avoided.

Stereo low-resolution thermal images

By positioning two of the IRISYS people counter thermal sensor arrays approximately 60cm apart at a height of 3m, looking vertically down towards the floor, a good view of the pedestrian movement area can be obtained.

One complication of using such low-resolution thermal images for stereo is that there might not be enough information to extract any range data. The IRISIS people counters have an added function of being able to identify ellipse shaped objects as potential targets. By using this target information it is possible to obtain sub-pixel accuracy for the centroid of each target. This allows a more accurate comparison of the differences for each target from one sensor to the other.

The experiment

Four different people walked under the stereo sensors. The objective is to see whether height or gait information can be obtained. In addition to this a warm target was transported under the detectors on a wheeled medium providing no movement in the vertical direction and relatively steady movement in the horizontal. The target information considered was the horizontal x and y coordinates of the objects identified.

Discussion of the results

As the sensors used process the detector array to determine the target's location, it is difficult to establish if any range information can be determined from the results. The initial analysis was to look at the difference in the x and y coordinates from one sensor to the other, named ΔX and ΔY respectively.

The standard deviations from the mean for each of ΔY and ΔY's are shown in **Table 1.**

Experiment	ΔX	ΔY
Person 1 (female)	0.9567	0.967
Person 2 (male)	0.267	0.243
Person 3 (male)	0.453	1.079
Person 4 (male)	0.144	0.431
Warm Target	0.126	0.147

Table 1, difference of x and y coordinates

It is not clear from the results that there is a substantial difference in the variations of ΔX and ΔY between the people and the target. As expected the target has the lowest variations of ΔX and ΔY of all those measured.

In addition when the values of ΔX and ΔY are plotted on a graph an oscillation is observed for the people but is not for the target shown in figure 1. It appears that the oscillation noted corresponds to gait of the target; further investigation is ongoing.

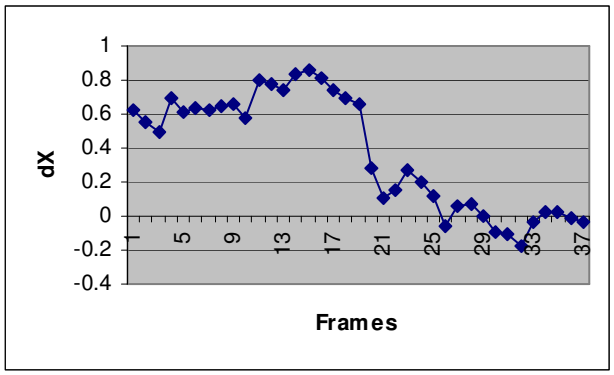

Figure 1, ΔX from person 1

dX. Denotes the difference between the X coordinates from each sensor.

Conclusion

The experiments have shown that there is some additional information to be gained from using the sensors in stereo. It has not been possible to clearly ascertain range information from the stereo data examined. It would appear that there is additional information gained from using the sensors in stereo that might relate to an individual's distinctive walk, however this is still to be examined.

References

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