WORKING TOWARDS IDENTIFIABLE FEATURE EXTRACTION FROM A PEDESTRIAN'S GAIT

T. J. Chamberlain	A. Armitage	M. Rutter	T.D. Binnie
Research Student	Lecturer	Lecturer	Reader
School of Computing	School of Computing	School of Computing	School of Engineering
Napier University	Napier University	Napier University	Napier University

Abstract

This paper describes our work measuring the movement of pedestrians. We describe our data collection system, processing techniques and introduce our data analysis software system. Our work aims to provide data to improve security and monitoring of pedestrians in public areas that would otherwise be unavailable. This data is important to those working in market research, behavioural psychology or safety and security.

1. Introduction

Pedestrian detection and tracking is an area gaining increasing importance in transport. Current world events are resulting in increasing demands on the surveillance and security of the transport infrastructure. There is a steady increase in the amount of CCTV footage collected. In the UK almost every type of transport system involves a substantial amount of CCTV monitoring. The problem this surveillance poses is what to do with the information collected; traditionally the footage has been recorded and only used after an event, accident or crime. Reports from the security services following the July 7th bombings in London suggested that substantial amounts of time were required to view the many thousands of hours of CCTV footage collected. This time-consuming task introduces a substantial delay in the detection of relevant information.

In addition to providing pedestrian motion information for analysis, technological solutions that can extract identifiable features of pedestrians may substantially increase the efficiency of relevant event detection. This is often achieved by automatically registering the most appropriate time points in the surveillance information for operators to view later.

We present a method for capturing human motion information and a novel system for extracting stride information. We expect it to enable the extraction of biometric features based on human gait.

Human Gait

Human gait has been studied in medical research since Wilhelm and Eduard Weber started their studies in 1836. Improvements in technology and understanding have accelerated the measurement of human motion since the early studies. Various researchers have furthered this work [1]. Work in the field has shown that there are substantial differences in gait between the genders [2] and there is a substantial body of active research in the area of using human gait as a form of biometric (e.g. [3]).

Data Collected

IRISYS people counters are pyroelectric low resolution (16 by 16) detector arrays that produce a data matrix of short term temperature change in the field of view. [4] As a pedestrian walks under the detectors the changes in temperature are detected by the elements of the array that cover the area where the pedestrian is walking. This manifests itself as a hot (bright) round object representing the temperature increase caused by the pedestrian's movement – see Figure 1. The dark trail adjacent (lower right) to the brighter area is the negative cooling effect. As the detector measures change in temperature, the area the pedestrian has just passed through is shown as a darker area.

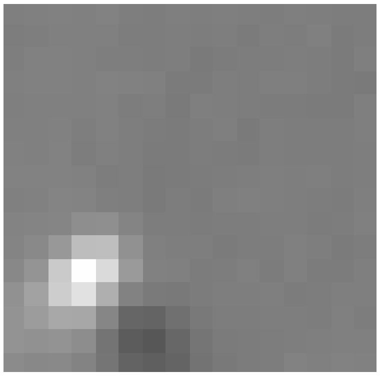

Figure 1: Sensor Image

Each detector has an onboard digital signal processor that can find and match ellipses to the area or areas which representing pedestrians found in the field of view. Figure 2 shows a scene with two pedestrians detected and their paths superimposed.

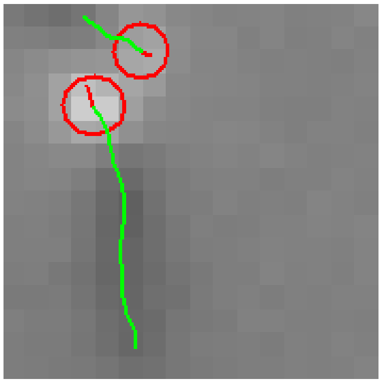

Figure 2: Pedestrians Detected and Tracked

A weighted centre location for each of these ellipses (pedestrians) is then sent to an attached PC in an X,Y format at a rate of thirty frames per second. This provides a sub-pixel accuracy for the location of the pedestrian. Additional status information is also provided for each ellipse found (see Table 1).

X	Y	A	B	Theta	Mode	TargetID	ParentID
The X coordinate of the pedestrian	The Y coordinate of the pedestrian	The Major axis of the ellipse	The Minor axis of the ellipse	The angle of A with respect to the X axis	Status information about the pedestrian detected	A unique identifier.	The identifier of a pedestrian walking closely in the same direction

Table 1: Data from Ellipse matched to pedestrian

Our experiments consisted of collecting a range of personal information from each participant such as height, leg length measurements, weight, and gender. We then asked each participant to walk under our sensors in straight lines several times, measuring their walk each time with the IRISYS people counters. Each trajectory was then stored for further processing as described below.

Processing the data

There are several processing steps required to take the information collected and extract information that can be used. Each step builds on the last, to put the data in a format that should help produce an identifiable feature about the pedestrian.

Firstly a correction equation must be applied to the data to compensate for the substantial barrel distortion caused by the low cost wide-angle germanium lens that each sensor contains. This distortion is not easily corrected, as it varies from sensor to sensor, but through experimentation we have obtained an algorithm that corrects most of the distortion.

Secondly the path of the pedestrian must be extracted; our current algorithm relies on the pedestrian walking in a straight line and by performing linear regression we find a best fit line for the walk of the pedestrian shown in Figure 3. The straight line is a best fit line for the data, established using regression as there is statistical error in both x and y measurements, the line in expressed in its parametric form. Any trajectories where the fit of this line is substantially below the norm are discounted at this stage as being poorly matched data. The experiments conducted so far have relied on the participants' cooperation, maximising the usefulness of data at this stage. Future work would be needed to improve this stage. Options include the fitting of a polynomial instead of a straight line.

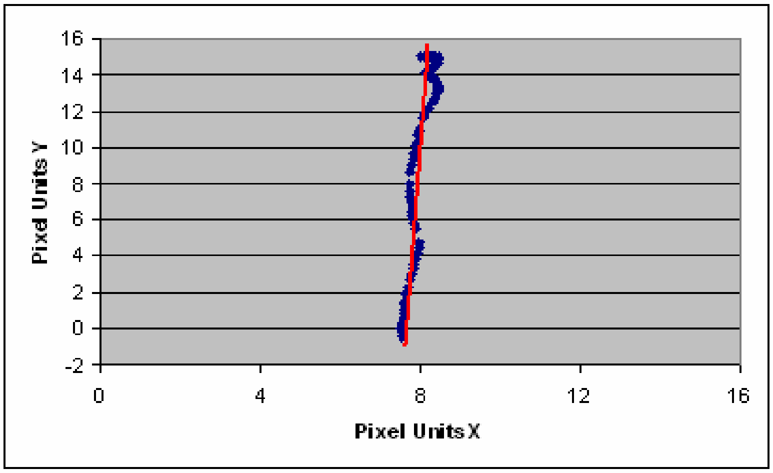

Figure 3: Pedestrians Path

The third stage is to extract the distance from each point to the line that denotes the general direction taken (Figure 4). It is apparent from the diagram that there is a significant variation from left to right and our work is based on the correspondence of this to the location of each step the pedestrian takes.

This data is then filtered, windowed and put through a Discrete Fourier Transform (DFT) to extract frequency information. This frequency information is based on the rate at which the pedestrian walks, which in turn is dependant on personal physiological factors such as leg length. We have still to confirm to what extent the frequency view of this data relates to the individual or their physical features but initial examination shows some correlation.

Analysis of results

The results collected so far have proved promising. When viewing the plot presented in Figure 3 it is possible to see that there is a left to right swinging motion as the pedestrian walks through the field of view. This left to right motion is more clearly visible in Figure 4 where the motion has been rescaled and each point expressed as a distance from the best fit line against time (a pixel unit corresponds to approximately 20 cm). This information provides an interesting source of data relating to the frequency of the pedestrians stride and enabling the length of their stride to be measured.

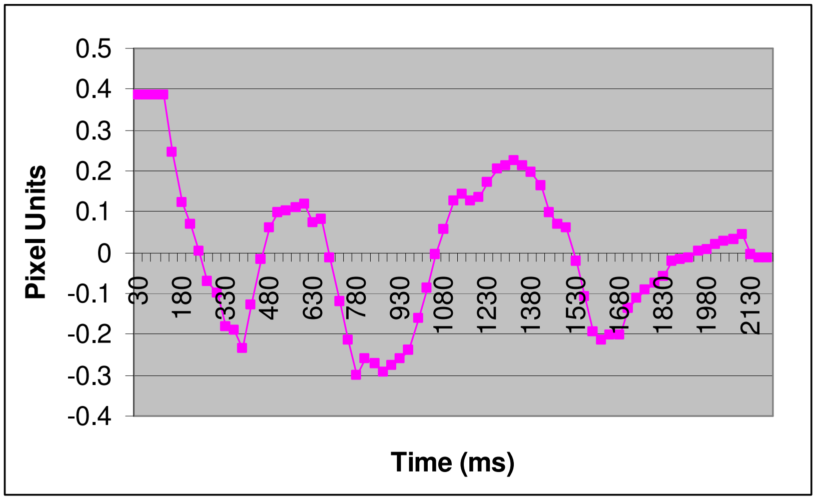

Figure 4: Graph of left to right swing v time

This information is then put through a low-pass filter and processed to extract our form of differential. We find the differential by calculating the gradient of the last five points using a restricted form of linear regression. The gradient is expressed in radians relating to the parametric description of a line (see [5] for a description of this representation).

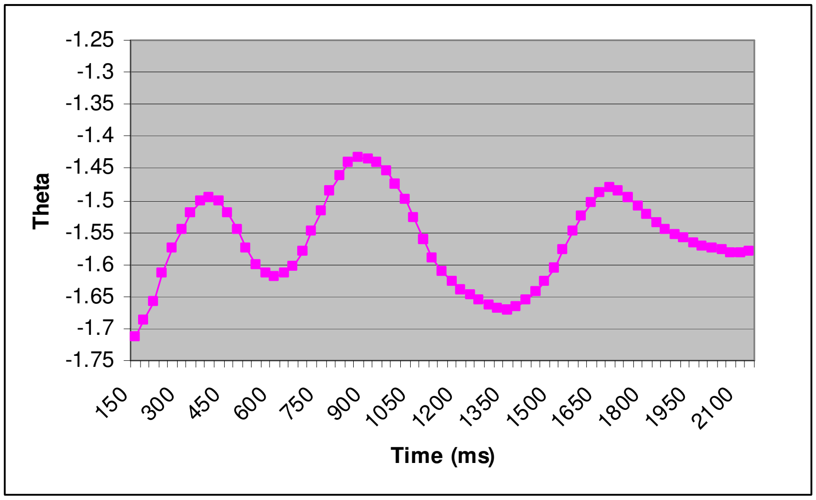

Figure 5: Best fit differential

This best fit differential data can then be windowed and viewed in the Fourier domain where it is possible to see the most significant frequency features shown in Figure 6. This information provides some interesting features and we are currently attempting to relate these to features relating to the individual.

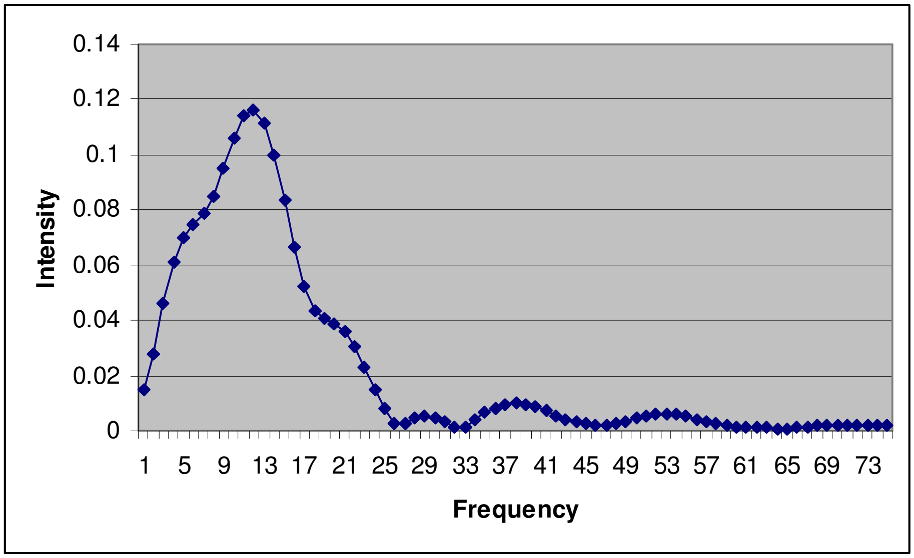

Figure 6: Fourier series

This Fourier spectrum of the data is being used to calculate a weighted count of the number of footsteps in the field of view. Equation 1 shows the formula used for the calculation where D is the array of data from the Fourier transform.

$$\sum_{i=0}^{n} D_i \times i$$ ← This (take my word for it) is not actually an equation – m .

Equation 1

The results are currently being analysed to determine what useful information is present. There is unsurprisingly a broad correlation between the average footstep size and leg length of participant.

The data displayed in this section is only a single walking sequence; we have collected the walks from twelve different pedestrians, measuring a minimum of ten walks from each. As the quantity of data is substantial a software system has been developed to automate much of the analyses.

Software system

As there is a substantial amount data collected, a software application is being developed to automate the processing of the data. This enables each pedestrian's walk to be visualised at each of the different stages of processing. This software has saved substantial amounts of time analysing data collected as it performs all of the processing steps required at the click of a button. Its use will become more apparent throughout the future series of experiments as the analysis of the data is becoming more automated. Figure 7 shows a screen shot of the software system, the list box at the right shows details each different walk collected by the sensors. This enables the user to select the walk of interest and display its path, filtered data and Fourier series at the click of a button.

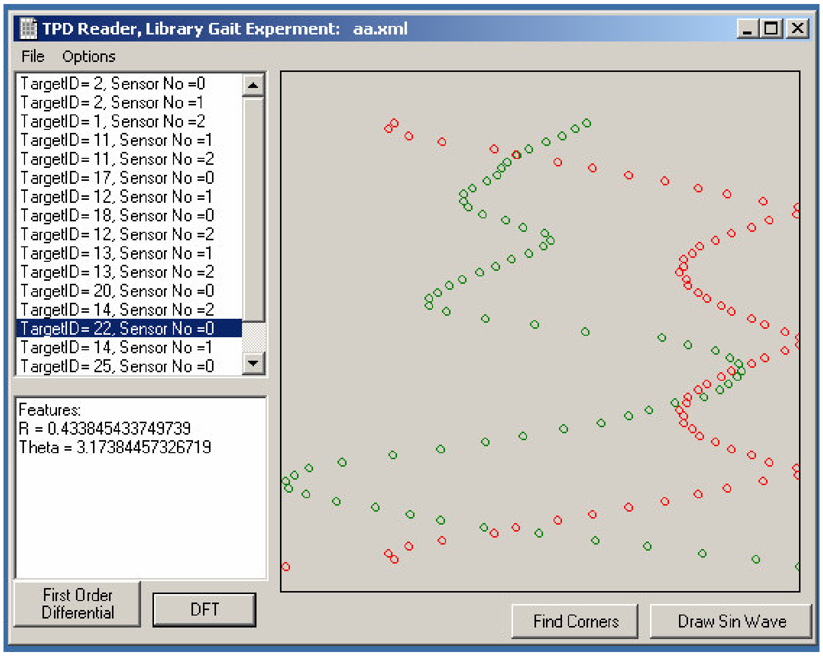

Figure 7: Screen shot of analysis tool

Future work

We plan to complete the software system shown above to include an automatic extracting of key frequency features pointing to the gait of the pedestrians. This will allow a further study to be carried out to establish to what extent this system can be used to identify or classify pedestrians. Initial examination suggests that some of the frequency information may well relate to the individual.

Conclusions

The study to date has presented a new and innovative method for obtaining information relating to human gait. This information can be easily collected in real time without the need for the pedestrians to even be aware they are being monitored. The detectors are reliable and robust for the detection and counting of pedestrians, but due to their low resolution and lens distortion had not been applied to further extraction of information. Our work shows that relevant information can be extracted, however we have yet to establish if this information can be used to identify and track pedestrians.

References

[1] Johanson ME. The Gait Laboratory: Structure and Data Gathering. In Human Walking 2nd Ed. Rose J and Gamble J (eds.) Williams and Wilkins, Baltimore, MD., 1994.

[2] BenAbdelkader C, Cutler R, Davis L *Person Identification using Automatic Height and Stride Estimation* IEEE International Conference on Pattern Recognition 2002, Québec, Canada.

[3] Phillips JP, Sarkar S, Robledo I, Grother P and Bowyer K. *Baseline Results for the Challenge Problem of Human ID Using Gait Analysis* Fifth IEEE International Conference on Automatic Face and Gesture Recognition, 2002, Washington D.C.

[4] www.irisys.co.uk (viewed 17th Nov 2005)

[5] http://homepages.inf.ed.ac.uk/rbf/HIPR2/hough.htm (viewed 17th Nov 2005)