We have started off by considering a simplified model where there is fishing art symmetry in the direction of the ship, the cable has no twist, the doors remain vertical and a stationary problem is considered with uniform current. For every part force and/or momentum equilibrium are imposed and the overall system is resolved numerically.

The input parameters in the physical system simulation are water density, velocity of the ship, depth and type of sea bed, the physical data of the cables and doors, the weight that the net trawls and its characteristics

Once the numerical simulation has finished, the length of cable, doors aperture and separation, net aperture and separation, tensions and special positions of the door and every cable point and net aperture will be known.

At present there is a graphical interface (based on OpenGL) where different kinds of fishing nets, doors, and cables present in the market can be selected and which also allows the results from the simulation to be monitored.

At the same time, the simulation obtained from the mathematical model using real data from fishing ships is under study.

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Hardware-Software Co-Design for Fingerprint Biometric Identification

Abstract.- This paper describes the design of a specific architecture for fingerprint identification based on a hardware-software co-design. This work summarizes the main stages involved in a classical fingerprint feature extraction algorithm. The paper proposes a hardware-software partitioning based on a profiler deduced from the execution of the whole algorithm running in a Pentium 1.7 GHz.

1. Introduction

Determining the identity of a person has become a critical task in a global and inter-connected society. Cash terminals, ATM machines, access control systems and internet transactions are some examples of security systems where the user's identity is fundamental information. Biometrics measures physiological or behavioural characteristics that allow reliable identification. Some well-known biometrics such as voice, fingerprint, iris, face or hand geometry are the basis of civilian and forensic identification systems today. Fingerprint identification is perhaps the most common biometrics method employed in the field of authentication [1]-[4] because it is cheap, the capture devices are small and it has a high algorithms recognition rate.

The identification accuracy of a biometric system is measured with the false (impostor) acceptance rate (FAR) and the false (genuine individual) reject rate (FRR). The FRR/FAR ratios depend, among other factors, on the type and difficulty of the algorithms used in the fingerprint feature extraction [1]. Usually, algorithms with high-medium complexity lead to acceptable low FRR/FAR. However, as it becomes more complex the computational cost increases which leads to undesirable high processing times. Thus, the overall performance of the identification system should be evaluated in terms of FRR/FAR, computational cost and others factors such as security, size and cost.

The hardware platform chosen to implement these algorithms must take into account all these parameters. A standard microprocessor solves (by software) the algorithms executing a set of functions written normally in a language such as C or C++. Typically, these functions employ high level primitives, as for example convolutions based on Gabor filters. This platform is neither quick nor cost efficient, even if an integer optimized code is used.

A digital processing signal (DSP) is a high performance microprocessor that internally incorporates a set of hardware specific blocks. In principle, DSP could be a suitable solution since these blocks solve complex primitives in real time (e.g., milliseconds) obtaining systems with very low FRR/FAR ratios. However, in order to achieve these performances the DSP cost is sometimes high, thus limiting this platform to a few applications where the cost is not a restrictive parameter.

The solution proposed in this work focuses on the development of a digital embedded system based on a hardware-software co-design. The basic idea of a co-design is to speed up the process by detecting the most critical parts of the code or the functions with higher computational cost. These tasks are solved by hardware by means of a specific coprocessor. The non critical parts and the control of the process are solved by software using a simple microprocessor. The final result is not only an important reduction in the overall processing time but also a more cost effective and efficient hardware implementation.

This paper is organised as follows. Section II summarizes the stages involved in the fingerprint feature extraction algorithm. Section III presents a software-hardware partitioning and it proposes the task that will be solved by software or hardware. Finally, conclusions and references are presented.

2. Fingerprint signature straction

The fingerprint image is characterized by a set of black and white lines called ridges and valleys, respectively. The aim of an identification fingerprint algorithm is to extract a set of singular points, known as minutiae, that allow one individual to be singled out. The minutiae correspond normally to the end or bifurcation of the ridge lines. The signature of a fingerprint is an array of vectors, where each vector is characterized by the coordinates, type (bifurcation or ending) and orientation of each minutia. The signature becomes the biometric identification code (template) associated to an individual.

2.1 Normalization

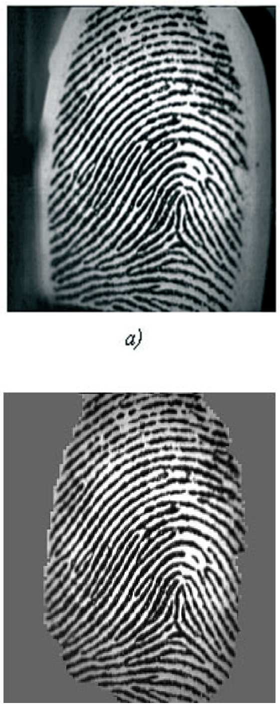
The first stage in the signature extraction is the normalization of the fingerprint image. In this way, the pixel intensity is standardised by adjusting the range of grey-level values to a determined mean and variance [3]. Normalization facilitates the processing of subsequent stages where a typical threshold that depends on the intensity and contrast of the image is used. Let I(x,y) the grey level value at pixel (x,y), and M_o and V_o the desired mean and variance. The normalized image I_N (x,y) is obtained as follows:

$$I_N(x,y) = \begin{cases} M_0 + \sqrt{\dfrac{V_0 \cdot (I(x,y) - M)^2}{V}} & \text{if } I(x,y) > M \\ M_0 - \sqrt{\dfrac{V_0 \cdot (I(x,y) - M)^2}{V}} & \text{if } I(x,y) < M \end{cases}$$

where M and V are the estimated mean and variance of I(x,y). Figure 1.a shows a fingerprint image after the normalization stage.

2.2 Segmentation

The aim of a segmentation is to separate the foreground areas from the background ones. The foreground is associated with the region that contains information of interest with ridges and valleys. The background area does not contain valid information and it corresponds to the region outside the borders of the fingerprint. As can be seen in figure 1.a the background presents a very low grey-scale variance, whereas, due to the presence of ridges and valleys, the foreground exhibits a high variance. The method based on variance thresholding is employed to perform the segmentation [3][6]. To achieve this, the image is divided into blocks of size 8 x 8 pixels. The grey-level variance of each block is calculated. If the result is lower than a threshold the block is segmented. Otherwise, the pixel corresponds to the foreground area. Figure 1.b shows the result of a segmented fingerprint image.



a)

b)

Figure 1.- Stages involved in the fingerprint signature extraction: a) Original fingerprint, b) Segmented fingerprint, c) Ridge extraction and d) Thinning and minutiae extraction

2.3 Ridge extraction and binarisation

The outcome of this stage is a binary image where the value of each pixel could be 0 or 1. Pixel set to 0 corresponds to a foreground ridge, whereas pixel set to 1 is associated to a background valley. The first step consists of an enhancement of the image by obtaining a better definition between the ridges and valleys. In order to achieve this, each pixel of the image is convolved with a Gabor filter. Gabor filters are employed because they have frequency and orientation selective properties. A two-dimensional Gabor filter consists of a sinusoidal wave with a particular orientation and frequency modulated by a Gaussian envelope:

$$G(x,y;\vartheta,f)=\exp\left\{\frac{-1}{2}\left[\frac{x_\vartheta^2}{\sigma_x^2}+\frac{y_\vartheta^2}{\sigma_y^2}\right]\right\}\cos(2\pi f x_\vartheta) \quad (2)$$

$$x_\vartheta = x\cos\vartheta + y\sin\vartheta \quad (3)$$

$$y_\vartheta = -x\sin\vartheta + y\cos\vartheta \quad (4)$$

By selecting a Gabor filter tuned at the spatial frequency of the ridges and a proper orientation its response can be optimized in order to maximise the ridge-valley structure by reducing the noise of the image. Before filtering, it is necessary to estimate the orientation θ of the ridges contained in the fingerprint. The orientation image is calculated with the improved Rao algorithm method described in [2]-[4]. In order to speed up the processing time the orientation is estimated in blocks of 8x8 pixels rather than at a pixel level. The result of the orientation is approximated by one of a set of 16 discrete angle values between -90º and 90º.

After filtering, the image is binarized by comparing the resulting grey-level value with a threshold. The outcome image is represented in figure 1.c.

2.4 Thinning

Thinning is performed prior to minutiae extraction. The thinning process consists of a set of iterative morphological operations which reduces the ridges until they are one pixel wide. The Zhang-Suen algorithm with removal stair-cases has been implemented to obtain the thinned image [5]. The result can be seen in figure 1.d.

2.5 Minutiae extraction

The minutiae extraction is a very simple task that can be carried out by examining the connectivity of the pixels in the thinned image. A pixel with a connectivity of 1 corresponds to an ending minutiae; a connectivity of 3 leads to a bifurcation, Figure 1.d shows the result of the minutiae extraction stage. It should be pointed out that a post-processing stage that eliminates false minutiae is necessary. For the sake of simplicity this stage has been omitted.

3. Hardware-Software Partitioning

The hardware-software partitioning consists of identifying the stages that will be implemented by hardware and the ones to be executed by software. To do this a profiler of the overall algorithm executed on a Pentium 1.7GHz has been obtained. The profiler indicates the stages with higher computational cost. Table I shows the processing time in millisecond for each stage and the percentage over the total executed time. As can be seen, normalization and minutiae extraction takes about 3.8% of the total time, which means a very low processing time. However, ridge extraction and thinning takes nearly 86% which clearly represents the most critical parts of the algorithm.

Taking these results into account, it is clear that ridge extraction and thinning should be implemented by a specific hardware. Normalization and minutiae extraction are the non critical parts that can be executed by software. The segmentation stage takes about 11% of the time and it can be implemented either by software or hardware.

Stage	Processing time ----	% time	Software/hardware
Normalization	*38,5 ms.*	*1,9%*	*Software*
Segmentation	*231,3 ms.*	*10,8%*	*Hardware/Software*
Ridge extraction	*1113,9 ms.*	*51,3%*	*Hardware*
Thinning	*735,8 ms.*	*34,1%*	*Hardware*
Minutiae extraction	*42,2 ms.*	*1,9%*	*Software*
Total time	*2161,7 ms.*		

Table 1.- Profiler of the overall algorithm and proposal for the software-hardware partitioning

4. Conclusions

A software-hardware partitioning proposal for designing an embedded digital system for fingerprint identification has been presented. The paper describes the most important stages involved in the minutiae extraction of a fingerprint image. The algorithm has been executed obtaining a profiler that allows the most critical parts with higher computational cost to be detected. Hardware is recommended to implement these stages and software to implement the others.

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Submarine Mapping using Multibeam Bathymetry and and Acoustic Backscatter: Illuminating the Seafloor

More than 70% of the surface of the Earth is covered by the oceans and its submarine topography is still poorly known, and as a consequence, oceanographers have constantly tried to improve their knowledge on the morphology and nature of the seafloor. Acoustic mapping systems have undergone a revolution during the last thirty years. From single-beam echo-sounders to the more sophisticated multibeam echo-sounders, seafloor mapping techniques and characterization has grown impressively. Multibeam echo-sounders are based on the principle of acoustic wave transmission and reception in the water. They represent the most significant advance in mapping large areas rapidly and accurately, and are essential for the study of geomorphology and seafloor facies. Combined with detailed positioning information (acquired through modern GPS navigation systems) and advanced computer graphics, multibeam systems provide us with a whole new view of the seafloor.

Multibeam echo-sounders: Overview

At first, multibeam echo-sounders consisted of an extension of single-beam echo-sounders. Arrays of sonar projectors produce soundings not only along the track, but also for significant distance across to the ship track.

Instead of lines of single soundings, new multibeam systems produce a swath of soundings (Fig. 1). In modern deep-water systems, the swath covered on the seafloor can be up to 7 times the water depth. This means that if we are working in an area of 3000 m water depth, the maximum width swept is of 21 km. To obtain a complete cartography of the seafloor, the vessel scans adjacent swaths at a speed of 8 to 12 knots, drawing up a mosaic of seafloor topography. Therefore, in «deep water» (> 3000 m), a zone of 400 km by 20 km (8000 km^2) could be surveyed in less than a day.

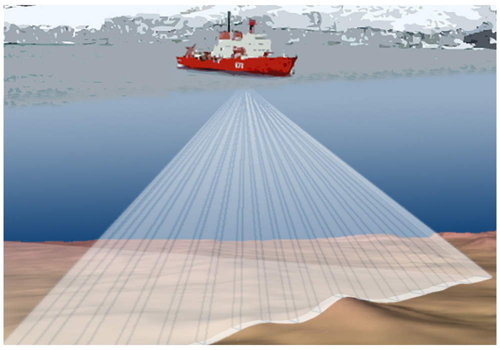

Fig.1. Sketch of how a multibeam echo-sounder surveys the seafloor.