

A Quality Approach To Biometric Imaging

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I invented or rather discovered vein patterns some years ago now and developed a very simple reader to obtain an Infra Red recording of the subcutaneous absorption pattern of an individual. The reader employed a number of IR LEDs and IR sensitive photo diodes in an array which when drawn across the surface of a subjects skin would provide a characteristic absorption pattern for the individual. Essentially a bar code reader for people. I assigned the rights in the invention to the British Technology Group (BTG) and anticipated the security industry and the Banks beating a path to the BTGs doors for access to this technology.

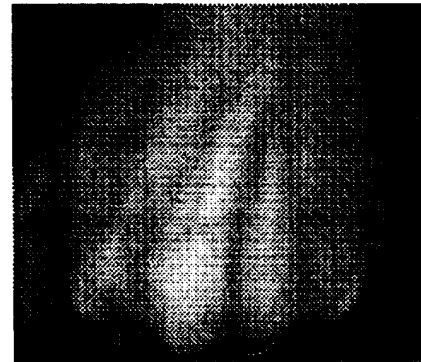
Alas like many inventors in Britain I was disappointed by the timidity of British Industry many wanted to market the system none wanted to develop it. I resolved in 1990 to develop this technology so that it couldn't be ignored. The BTG had undertaken some development work on Veincheck with David Claydon a former National Physical Laboratory scientist who had started testing the diversity and uniqueness of vein structures at the BTG. I had a brief chat with David on his methods and decided that a quality approach to biometric imaging essentially a Statistical Process Control (SPC) approach was required to provide a viable biometric identification system.

A Quality Approach First there was a requirement to define what is required of a biometric. Let me offer the following definition.

"A Biometric system should perform perfectly its function of identification or verification. Without any variability of performance, with zero failures and in a pleasant manner."

Infra Red Image. It maybe helpful at this juncture to show you what veins look like in the Infra red. This Picture (Video Image) shows the output of a low cost infra red imaging system that I constructed at home. Veins provide a very robust and repeatable pattern with virtually no difference from one year to the next. In this image the subjects hand is grabbing a handle presenting the dorsal surface to the camera. Veins can also be recorded in the wrist and palm of the hand. Although this unit provides adequate rendition of veins it was manufactured at home using readily available optical components. Optical consulting engineers who have looked at this prototype consider that the rendition can be improved by an order of magnitude in a commercially manufactured product.

Greyscale Dorsal Vein Image



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Product Family. The development started with a number of product concepts firmly established as goals.

Our first was to produce a biometric door handle that required no card or pin number that identified the doors user and provided access within 1 second.

Process Capability. In order to provide automatic identification within a product the process capability ie the minimization of variance becomes a paramount requirement. Our view is that the performance of a biometric is largely established this side of the lens. All biometric algorithms whether simple or based on advanced statistical techniques have in the end to determine if the trait measured corresponds to the subject being identified or not. **Minimising variance** in the location ,rendition and presentation of a trait simplifies,quickens and solidifies the whole biometric process. **This tenet holds for whatever image matching algorithm is subsequently applied.**

The first requirement was to establish a good process capability for the locator,the greyscale image grab and the binarisation process. A hand grab was constructed and illuminated via a ring array of IR Leds. The grab was constructed with an a cross section such that the hand (almost) intuitively grasped the handle in a repeatable manner.

All Images were used (no images were de-selected) the repeatability of Black/White pixel counts was established for each subject. The illumination and hand grab were refined until the results detailed below were obtained.

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Image Processing Our objective is to develop and manufacture low cost , accurate biometric identification systems. To provide the marketplace with high security Biometric access and Use systems at modest cost. For these systems to be affordable they need to be based upon low cost processors using simple yet effective identification algorithms. These algorithms should be fast and not computationally intensive. Looking at all the image sets by eye it was apparent that there was consistency and regularity with only minor differences due to the skew of the hand caused by the different stance of the subject in relation to the handle. ie. standing to the left or right of the handle as the image was taken. The second area of difference was rotational error. The subject sitting for some images and standing for others. Yaw the horizontal rotation of the hand was not encountered as all subjects tended to minimised this tendency in their grip.

Binary Image

Each image file was stored in a compressed form within a database of images. The image files included a short header which detailed the subjects initials, and other descrimonatory data. We decided on a simple initial approach that of bringing two different images into best registration and performing an exclusive OR of the images to determine identity. Additional image matching algorithms were developed that aligned the image on other features of the vein pattern,



Exclusive OR

The two images shown alongside illustrate the technique. The top image is a binary image of the vein structure within my left hand. The lower image is an exclusive OR of two binary images brought into best registration. The black pixels are regions of error between the top image and the underlying reference image. The delineation of the veins is clearly detailed as they run down towards the knuckles of the hand. Features within the vein pattern like the loops, circles and spurs are all aligned with only minor error pixels present at the extremities of these features.

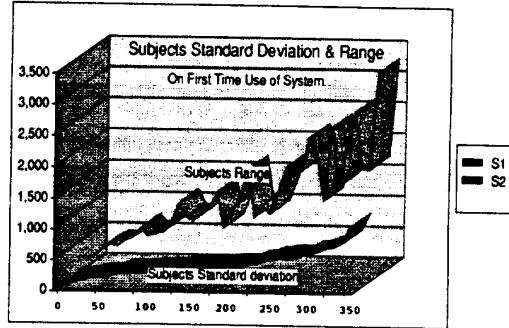


Algorithms. A PC based image matching algorithm calculates an error value for the amount of difference in the two aligned images, a score of zero is a perfect match. The image matching algorithm brings a reference image from storage decompresses it, aligns it with the subjects image, calculates the level of match, determines acceptance or rejection and writes the result to an archive file .

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Testing. Each Subject had a series of images taken from the dorsal surface of their hands . The greyscale image is cleaned of small surface artifacts via a pepper and salt algorithm and then binarized via a local contrast enhancement function The arithmetic ratio of white to black pixels was recorded for each individual. The chart opposite shows the standard deviation and range for subjects initial image sets. Many subjects provide consistent images with a good process capability from their first enrolment, Others provide more grouped image sets as their experience and familiarisation with the equipment grows..

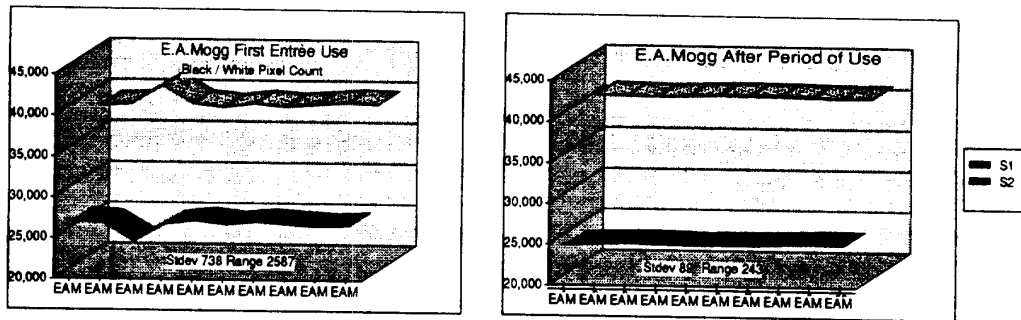
Standard Deviation and Range of Subjects Enrolment



Process Improvement Many subjects found their first two - three uses of the handle awkward but then settled down to provide a consistent set of images with good process capability. This can clearly be seen in Edwin Moggs results where his initial enrolment set had a high standard deviation whilst after a period of familiarisation Edwin regularly provides images with low standard deviations.

Having established a reasonably adequate process capability for the locator and initial image processing tasks ie. the ability to capture images and binarize them with a good

E.A.Moggs Process Improvement



all subject standard deviationon The image processing development started.

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Performance Testing. All images from all subjects within the image data base were compared via one image matching algorithm. The resultant archive file was sent to an independent statistician to calculate performance in terms of FRR and FAR. The results were encouraging.

Conclusion applying statistical process control techniques to the presentation ,capture,and digitisation of vein patterns minimizes the complexity and improves substantially the performance , accuracy and speed of a home produced biometric system. Manufactured products based on this technology will provide an order of magnitude improvement in rendition and process capability fulfilling the latent need for automatic biometric identification .