

Electronic Exchange of Fingerprint Images

WSQ Compression Review Group

(The following letter and report were received from Raymond T. Moore for possible publication. Since the subject is of vital interest to anyone engaged in any aspect of fingerprint identification, the material is presented. As explained below, Mr. Moore, and Latent Print Certification Board Chairman Norman Smith, are representing the IAI in this most important electronic image quality matter.)

At the March 4-6, 1992, Conference on the Electronic Exchange of Fingerprint Images, the conference participants agreed that the Wavelet Scaler Quantization (WSQ) algorithm would be used for the compression of fingerprint image data for transmission using the ANSI Standard that is being developed.

The implementation of the WSQ algorithm will require the selection of values for certain parameters which may affect various aspects of performance, including image quality. To ensure that the values that will eventually be selected will provide image quality that is satisfactory for forensic identification requirements, it was agreed that an image quality review group should be established. The motion specified that (the) "FBI shall sponsor an independent review group of no more than ten individuals which shall quarterly review the status of operational and proposed compression approaches. The group will include representatives from the FBI, IAI, academia, and private industry (to the extent that industry representation does not jeopardize procurement sensitivities). The quarterly report shall be public. Expenses will not be the responsibility of the FBI". The motion was amended to make the reviews quarterly for the first year only.

Subsequently, dates were established for the first four meetings and members of the group were designated. The dates that were established for the meetings of the WSQ Review Group are September 17, and December 11, 1992, and March 18, and June 3, 1993. IAI President Curtis Shane appointed Norman Smith and Raymond T. Moore as IAI representatives to the WSQ Compression Review Group. Other mem-

hers of the group are Tom Hopper and Stephen Meagher, FBI; Fred Preston, U.K. Home Office; and Norman D. Winarsky of the National Information Display Laboratory.

Meeting facilities for the group are being provided at the National Institute of Standards and Technology (NIST) with Dana Grubb serving as host and R. M. McCabe serving as recording secretary.

A summary of the minutes of the first (September 17, 1992) meeting of the WSQ Review Group is enclosed. This summary has been reviewed and accepted by all the members of the Review Group. If you feel that this is of sufficient general interest to the IAI membership, you are free to publish it in the *Journal*.

First Compression Review Group Summary

In compliance with Motion #1 of the NIST Workshop on the Electronic Exchange of Fingerprint Images held on March 4-6, 1992, the first meeting of the Compression Review Group was held at NIST. The meeting took place in Gaithersburg, MD on September 17, 1992. Organizations present were the FBI, IAI, NIDL, NIST, and the U.K. Home Office.

It was agreed upon that the group would review the status of operational and proposed gray-scale compression approaches to be used by the FBI in IAFIS at it applies to the law enforcement community. Focus shall be directed toward reviewing the development, testing, and implementation of gray-scale compression technique(s) within the scope of the standard. The group shall also develop recommendations for the FBI regarding improvements of the compression technique to be used.

Tom Hopper, from the FBI, announced that the WSQ algorithm is now ready to be released to the vendors for comments and suggestions. A technical specification document, describing the algorithm, is scheduled for release by December, 1992. Shortly after this document is released, a vendors' and implementors' conference shall be con-

ducted to discuss details, problems, and suggestions relating to the algorithm and technical specification.

The framework for the algorithm consists of three basic parts. The wavelet transform section splits the image into a sub-band structure. The scaler quantization section minimizes the number of unique coefficients resulting from the sub-band splitting. Finally, the coder section encodes each of the symbols from the quantization step. After investigating various combinations of these components, the FBI believes that the use of a custom transform, an adaptive scaler quantization, and the Huffman coder is the best combination for the WSQ framework. Within each of these components, vendor specific settings and adjustments can be used, provided they fall within the WSQ framework.

A prototype of the WSQ developed at the FBI provides for dynamic adjustment of six specific parameters which affect image quality. Currently the FBI is in the process of determining optimum settings for each of these parameters. Although there are still unresolved issues, such as image quality, Fred Preston, of the U. K., believes that the WSQ framework is stable and could be put into silicon. However, in order to allow for incremental improvement, the parameters should remain in software.

Hopper stated that for the next six months the FBI would be working with Los Alamos to improve the WSQ algorithm and, also, to investigate various approaches to segmenting fingerprint images. As image segmentation is a serious problem, resources are being devoted to aspects concerning the processing of the background, finger images which cross into the adjoining finger boxes, and the lines that form the finger boxes.

The group agreed to deal with both short- and long-term objectives. The short-term objective is to develop an acceptable compression algorithm to use in the IAFIS project. The long-term objective is to evaluate improvements to the compression algorithm.

The short-term goal of the group is the review progress of the current WSQ algorithm so as to ensure that an acceptable compression algorithm for use in the IAFIS project is developed. When satisfied with the image quality and operational levels of the WSQ approach, the review group will recommend to the FBI that the algorithm be inserted into the IAFIS environment. However, before this recommendation is

given, additional testing will be performed. Although each component of the image capture and compression process has received considerable testing in the past, additional end-to-end testing is planned. Norman Smith, one of the IAI's representatives, requested that fingerprint examiners from the IAI actively participate in the testing processes.

The basic long-term objective of the group will be to ensure that the quality of the images in the IAFIS is maintained and continues to improve. Periodic reports addressing the progress and quality of the WSQ approach shall be issued and forwarded to the FBI and other interested parties in support of the IAFIS development.

At this time only the FBI's implementation of the WSQ algorithm is under consideration. But this does not preclude other WSQ implementations from being considered. The WSQ structure allows for improvements to be made. Also, the possibility of better algorithms being developed in the future should not be ignored. The group will monitor and make recommendations, where appropriate, regarding the evaluation, testing, and implementation of future compression alternatives which may affect image quality and IAFIS operations. If, after evaluation by the group and thorough testing, any such future developments in image compression proved to be vastly superior to the current WSQ framework, they could be incorporated into IAFIS.

In order to take advantage of future improvements in fingerprint compression and other aspects of identification technology, the FBI will be recording scanned images to archival tape during their file conversion operation. These images will be recorded without any loss so that no degradation in image quality occurs. By maintaining such an archive of original images, the FBI will be able to use these archived images as input to superior processing algorithms without reconverting the existing fingerprint card file.

Image quality is not only an IAFIS issue but one that is inherent in the forensic discipline of the science of fingerprints. A proposal made by Steve Meagher of the FBI and accepted by the group proposed that the long-term objective of the review group be expanded to include all image quality issues. Examination of advanced techniques for image scanning, improving image quality, archiving, compression, matching, and image retrieval will be part of the long-term objective.

The topic of criteria to use for judging image quality was brought up by Ray Moore, who was also representing the IAI. It is his belief that although there is no universally accepted metric for image quality, resolution is one point which is measurable. Changes in image resolution resulting from compression and decompression should be determined with the use of suitable resolution targets, such as the NBS 10IOa (see *J. Forensic Ident.*, Vol. 41, No. 5- cd.) or circular resolution targets.

The point was brought out that the type of display device used to view fingerprint images affects the image quality. An inferior display will inhibit an examiner's ability to effect accurate identifications. The user should not be satisfied with an inferior display. However, Norman Winarsky added that the desired level of image quality is necessary before the image is stored in the database. Even a high quality display device will not reproduce that which was not originally present.

Another aspect of image quality that was addressed concerned the level of image quality that should be supported by electronic images. The main question was whether the electronic images replacing the fingerprint card should be defined as the finest level of fingerprint ridge detail possible. This would include specific requirements for the use of elements of the friction ridge itself, such as pores and ridge edges, to support the latent print comparison process.

Tom Hopper felt that monetary considerations may be a factor influencing image resolution and image quality. The master file of a fingerprint identification system is supported by ten-print operations. Images received by the FBI will originate from inked cards and live-scan equipment. At the state level, there may not be adequate funding to support systems that capture images at very high resolutions of perhaps 800-1000 ppi. The image quality of some of these systems may also not be adequate to support the use of the elements of the friction ridge in the comparison process. Steve Meagher agreed that cost is a consideration. According to Meagher, users of fingerprint automation equipment, such as an AFIS or live-scan equipment, also realize that the ten-print operations are needed to support the latent print operations. In order not to degrade latent operations, sufficient image quality must be present in the softcopy ten-print fingerprint images if there is to be no hardcopy fingerprint card.