NIST Special Database 24

Digital Video of Live-Scan Fingerprint Data

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1 Introduction

This document describes NIST Special Database 24, which contains MPEG-2 (Moving Picture Experts Group) compressed digital video of live-scan fingerprint data. The database is being distributed for use in developing and testing of fingerprint verification systems (see Section 2). There are two CD-ROM's (Compact Disc - Read Only Memory): the first contains 10 seconds (300 frames, 720x480 pixels) of fingerprint data with plastic distortions, and the second contains 10 seconds of fingerprints at various rotated angles. The database contains 10 random samples (5 male and 5 female) of all ten fingers, for a total of 100 MPEG-2 video files on each CD-ROM. Each MPEG-2 file is compressed at 5 million bits/sec producing files approximately 6.25 megabytes in size. Users need an MPEG-2 video player/decoder to use this database. A player/decoder is not included with the database, but a reference is given in section 4 as to where one can be obtained.

Previous results [1] show that FT (fourier transform) correlator matching of fingerprints does not work for two different images of the same print. The elasticity of the fingerprint and pressure differences when the two images are captured create enough plastic distortion so a correlator can not make a match between the two different images of the same prints. Figure 1 shows an example of plastic distortion between two prints. Initial tests show that tolerance to plastic distortions is achieved by using a composite matched filter of the fingerprint in the FT correlator. The matched filter is made by using a set of distorted fingerprints, for the desired finger, and combining all the distortion information into the matched filter to be used for verification. This database aids in determining how well a system can tolerate plastic distortions.

The MPEG-2 files can also be decoded into individual frames and used to test static minutia based matchers and determine how well each system tolerates significant plastic distortions.

[1] C.L. Wilson, C.I. Watson, E.G. Paek. Effect of Resolution and Image Quality on Combined Optical and Neural Network Fingerprint Matching, pages 2-4, NIST Internal Report 1998.

Figure 1: Correlation of two rollings of the same print. (Dark gray indicates correlated ridges, white and light gray indicate uncorrelated ridges.)

2 Fingerprint Verification

In this paper fingerprint verification is defined as the use of a subject's fingerprint as a "PIN/signature" to access or validate information. The fingerprint could be used similar to a "PIN" to validate ATM (Automatic Teller Machine) or credit card transactions. It could also be used to aid in building access security. As a digital signature, a fingerprint could be used to reduce forgery of written signatures. In all these potential applications, the fingerprint is used to verify the identity of a person and to detect fraudulent identification.

3 Data Collection

The data was collected using a DFR-90DF direct fingerprint reader from Identicator Technology.[2] The NTSC (National Television System Committee) video from the fingerprint reader was digitized in real-time using a Perception PVR-2500/3500 board (with the optional AD-2500/3500 capture board)[2] installed in a Pentium II 200Mhz computer.

The digital conversion from NTSC video by the Perception system combines two interleaved fields from the NTSC signal into one frame (30 frames per second) of digital video. The Perception software saves the digital video in motion JPEG (Joint Photographic Experts Group) format, where each frame is individually compressed using baseline JPEG compression. This file was saved into a sequence of individual frames that were compressed into MPEG-2 digital video using software[2] from the MPEG Software Simulation Group (www.mpeg.org, see section 5). MPEG compression was used because the images have a high amount of correlation between neighboring frames. MPEG compression was designed to take advantage of correlation between neighboring frames and compensate for the motion when compressing the data. [3]

The data on the first CD-ROM was captured with the test subject rolling and twisting their finger to create plastic distortions. Figures 2 and 3 show the same finger with plastic distortions. Users randomly moved and twisted their fingers to create many variations of the plastic distortions that can occur. Blurring can occur if subjects move their fingers on the scanning surface too fast, while capturing interlaced data (see Figure 4). Some blurring does occur on this database and can not be completely eliminated; it is something that systems using real-time video input will have to detect and tolerate or remove in order to capture good quality fingerprint data. This data is intended for use in creating the composite matched filters containing plastic distortions of the fingerprint.

Data on the second CD-ROM was captured with each person putting their finger on the scanner at different angles, starting rotated to the left extreme and working toward the right extreme. Movement between angles is done with the finger removed from the scanning surface to eliminate twisting plastic distortions. Figures 5 and 6 show fingers at the left and right extremes of rotation. The exact angle of the samples between these extremes was very difficult to fix, so the test subjects tried to create about five evenly spaced samples between the extremes. This data was intended to test against the composite matched filter for a verification. Data at various angles was captured because someone randomly placing a finger on the scanner is not going to place it at the exact same position and pressure every time.

The MPEG-2 digital video files on both CD-ROMs are 10 seconds (300 frames, 720x480 pixels) in length and compressed at 5 million bits/sec. Section 5 has more details on the software and parameters used to create the MPEG-2 digital video.

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[2]Certain equipment/software may be identified in order to adequately specify or describe the subject matter of this work. In no case does such identification imply recommendation or endorsement by the National Institute of Standards and Technology, nor does it imply that the equipment identified is necessarily the best available for the purpose.

[3]MPEG Video Compression Standard. J.L. Mitchell, W.B. Pennebaker, C.E. Fogg, D.J. Legall, Chapman & Hall, 1996.

Figure 2: Finger with minimal plastic distortion.

Figure 3: Finger with plastic distortion.

Figure 4: Blurring that occurs if finger is moved too fast.

Figure 5: Typical left maximum on rotation.

Figure 6: Typical right maximum on rotation.

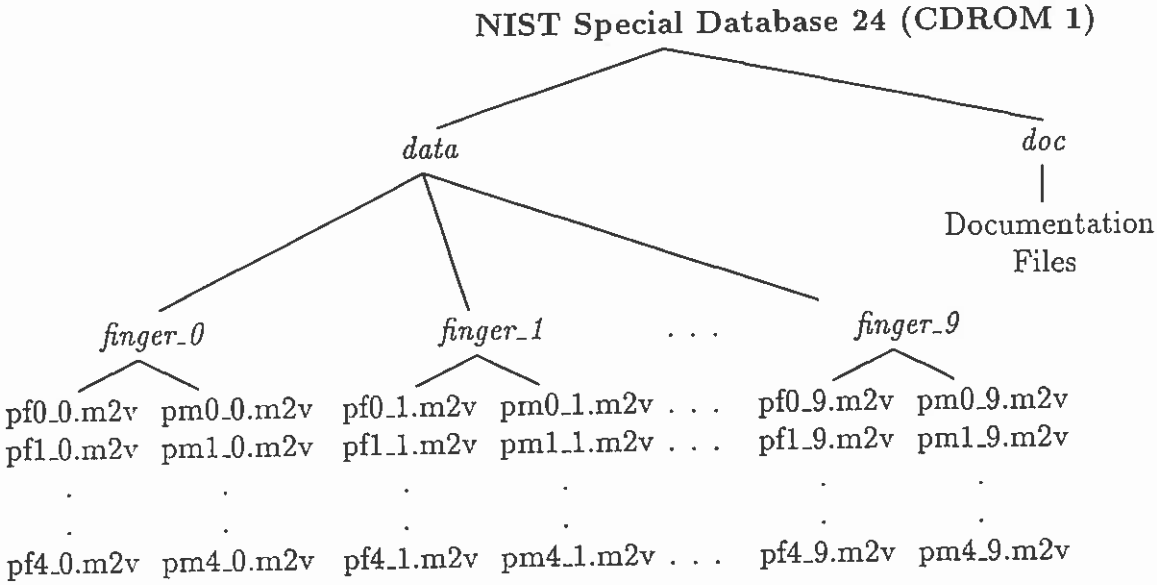

Figure 7: NIST Special Database 24 directory structure.

4 Database Content and Organization

NIST Special Database 24 contains live-scan data for 50 male and 50 female fingerprints. The live-scan data on the first CD-ROM contains plastic distortions of the fingerprint, and the second CD-ROM has various rotated angles of each print.

The top level file structure (see Figure 7) on both CD-ROMs has two directories: *doc* and *data*. The *doc* directory contains documentation, and *data* has 10 subdirectories *finger_0* - *finger_9* with each finger directory containing five male and five female samples for that finger number. The finger numbers and corresponding fingers are shown in Table1.

Number	Finger
0	Right Thumb
1	Right Index
2	Right Middle
3	Right Ring
4	Right Little
5	Left Thumb
6	Left Index
7	Left Middle
8	Left Ring
9	Left Little

Table 1: Finger numbers.

File names used are [p,a][f,m][0-4]_[0-9].m2v, where: [p,a] refer to plastic distortion data (on CD-ROM 1) and angular positioned data (on CD-ROM 2), [f,m] refer to female/male, [0-4] are the sample numbers, and [0-9] are the finger numbers. Sample numbers [0-4] are not correlated with finger numbers. These are NOT ten print sets from individuals; the database is a random selection of individual fingerprints.

5 MPEG-2 Digital Video Software

The software used to make the MPEG-2 files was obtained from the WWW (World Wide Web) site www.mpeg.org from the Mpeg Software Simulation Group (MSSG).[2] This software compressed the 300 digital frames, from the Perception software, into a MPEG-2 digital video file.

The software used a parameter file to set 54 different parameters when compressing the MPEG-2 digital video files. Appendix A shows the parameters used. Most of these parameters were defaults suggested for compressing images originating from NTSC video signals. A detailed description of each parameter and its function is included with the software on the MSSG web site.

The parameters that were changed from the default settings are described below. The "input picture file format" (10) did not allow for JPEG compressed input files, so the code was modified to read the JPEG compressed frames into the needed "YUV" (Y-Luminance, U,V-Color) color format.[3] The next three parameters provided information about the number of frames (300), starting frame number (1) and frame start time (00:00:00:00).

N and M (15, 3) were selected experimentally by testing an acceptable range of values and comparing the decompressed and original images. Comparisons were based on mean-squared error and visual analysis of artifacts created by the compression to determine the best settings. The final values were selected to give the least degradation over the set of images (files from 10 different indivuals) tested. Information to help in selecting the N and M parameters was obtained from MPEG compression text. [3] [4]

The size parameters (720, 480) are obviously dictated by the input image size. "Bit_rate" (5 MB/sec) was selected for the desired amount of compression and may not be the optimal setting for playing the images back real-time (30 frames/sec) on all systems.

The end user of this database will need a MPEG-2 player/decoder in order to use this data. The previously mentioned site (www.mpeg.org) is not the only source to get an MPEG-2 player/decoder. MSSG has a decoder that will save the video frames as individual images, which is useful for initial testing of simulation software before using the full video sequence as input. Individual images can also be used to test static minutia-based matching algorithms on a set of fingerprints with significant plastic distortions.

[4] Techniques & Standards for Image, Video & Audio Coding, K.R. Rao, J.J Hwang, Prentice Hall PTR, 1996.

A Parameter file for MPEG-2 encoder software.

```
MPEG-2 Test Sequence, 30 frames/sec
 r%04d          /* name of source files */
 rec%03d        /* name of reconstructed images ('-': don't store) */
 -              /* name of intra quant matrix file ('-': default matrix) */
 -              /* name of non intra quant matrix file ('-': default matrix) */
 stat_r.out     /* name of statistics file ('-': stdout ) */
 10             /* input picture file format: 0=*.Y,*.U,*.V, 1=*.yuv, 2=*.ppm */
 300            /* number of frames */
 1              /* number of first frame */
 00:00:00:00    /* timecode of first frame */
 15             /* N (# of frames in GOP) */
 3              /* M (I/P frame distance) */
 0              /* ISO/IEC 11172-2 stream */
 0              /* 0:frame pictures, 1:field pictures */
 720            /* horizontal_size */
 480            /* vertical_size */
 2              /* aspect_ratio_information 1=sqr pel, 2=4:3, 3=16:9, 4=2.11:1 */
 5              /* frame_rate_code 1=23.976, 2=24, 3=25, 4=29.97, 5=30 frms/sec. */
 5000000.0      /* bit_rate (bits/s) */
 112            /* vbv_buffer_size (in multiples of 16 kbit) */
 0              /* low_delay */
 0              /* constrained_parameters_flag */
 4              /* Profile ID: Simple =5, Main =4, SNR =3, Spatial =2, High =1 */
 8              /* Level ID: Low = 10, Main = 8, High 1440 = 6, High = 4 */
 0              /* progressive_sequence */
 1              /* chroma_format: 1=4:2:0, 2=4:2:2, 3=4:4:4 */
 2              /* video_format: 0=comp.,1=PAL,2=NTSC,3=SECAM,4=MAC,5=unspec. */
 5              /* color_primaries */
 5              /* transfer_characteristics */
 4              /* matrix_coefficients */
 720            /* display_horizontal_size */
 480            /* display_vertical_size */
 0              /* intra_dc_precision (0: 8 bit, 1: 9 bit, 2: 10 bit, 3: 11 bit */
 1              /* top_field_first */
 0 0 0          /* frame_pred_frame_dct (I P B) */
 0 0 0          /* concealment_motion_vectors (I P B) */
 1 1 1          /* q_scale_type (I P B) */
 1 0 0          /* intra_vlc_format (I P B)*/
 0 0 0          /* alternate_scan (I P B) */
 0              /* repeat_first_field */
 0              /* progressive_frame */
 0              /* P distance between complete intra slice refresh */
 0              /* rate control: r (reaction parameter) */
 0              /* rate control: avg_act (initial average activity) */
```

```
0          /* rate control: Xi (initial I frame global complexity measure) */
0          /* rate control: Xp (initial P frame global complexity measure) */
0          /* rate control: Xb (initial B frame global complexity measure) */
0          /* rate control: d0i (initial I frame virtual buffer fullness) */
0          /* rate control: d0p (initial P frame virtual buffer fullness) */
0          /* rate control: d0b (initial B frame virtual buffer fullness) */
3 2 30 15  /* P: forw_hor_f_code forw_vert_f_code search_width/height */
2 1 10 5   /* B1: forw_hor_f_code forw_vert_f_code search_width/height */
3 2 20 10  /* B1: back_hor_f_code back_vert_f_code search_width/height */
3 2 20 10  /* B2: forw_hor_f_code forw_vert_f_code search_width/height */
2 1 10 5   /* B2: forw_hor_f_code forw_vert_f_code search_width/height */
```