Workshop
• Forensic Image and Video Processing

• Dallas, AAFS, 17 February 2004.

Outline
08.30 – 09.00 Introduction by Zeno Geradts – Netherlands Forensic Institute
09.00 – 10.00 Photogrammetry by Richard Vorderbruegge PhD – FBI
10.00 – 10.20 Break
10.20 – 11.20 Image Processing by Lenny Rudin PhD - Cognitech
11.20 – 12.00 3D Techniques by Jurrien Bijhold PhD - NFI
12.00 – 12.30 Quality Assurance by Carrie Whitcomb NCFS
12.30 – 12.40 Closing remarks
Introduction
Image processing and Video processing

Zeno Geradts

AAFS, Dallas, 2004

Outline

• Background of this workshop
• Netherlands Forensic Institute - our group
• Investigation
• Image Restoration
• Image Comparison
• Integrity
• Image processing on fingerprints
Background

- 1994 Special conference by Scotland Yard on Forensic Image and Video Processing
  Lenny Rudin / Simon Bramble
- SPIE Investigative Image Processing
  www.spie.org conference from 1995
- 2000: establishing a working group within SPIE – chairmen Lenny Rudin / Zeno Geradts
- Several conferences until 2003

Mission

- Facilitating an open communication between scientists, industry and law enforcement in the field of forensic image processing and pattern recognition.
Outline

• Background of this workshop
• Netherlands Forensic Institute - our group
• Investigation
• Image Restoration
• Image Comparison
• Integrity
• Image processing on fingerprints

Netherlands Forensic Institute

• Arnout Ruifrok PhD, Ivo Alberink PhD, Jurrien Bijhold PhD, Mirelle Goos MS, Bart Hoogeboom MS, Derk Vrijdag BS, Zeno Geradts PhD

• Group Image Investigation and Biometrics of Digital Evidence Department
Group Image Investigation and Biometrics

- Image Integrity
- Camera identification
- Research on video techniques
- Image Restoration
- Interpretation in 3D-models
  - bullet trajectory analysis
  - Length measurement
  - 3D-visualisation
- Morphometric comparison with 3D images
- Face comparison
- FearID project
- Biometric systems
- Pattern Recognition from Forensic Image Databases

Outline

- Background of this workshop
- Netherlands Forensic Institute - our group
- Investigation
- Image Restoration
- Image Comparison
- Integrity
- Image processing on fingerprints
Investigation

- CCTV images (often time lapse)
  - Accidents, robberies
  - Typical problems: low quality

- Video from handycams
  - Accidents, disasters, snuff-movies, from the police
  - Typical problems: moving camera / zooming

- Photo material
  - From police, child pornography, identity-documents

Typical Questions

- Has there been tampered with the images
- Image enhancement
- Velocity of a car from video images
- Is the person on the CCTV-images the same as a suspect
Video of CCTV-systems

Many CCTV everywhere. 2000-2004: Explosive growth of number of camera’s sold. For example the Rijksmuseum and Van Gogh museum will have 700 cameras.

Outline

• Background of this workshop
• Netherlands Forensic Institute - our group
• Investigation
• Image Restoration
• Image Comparison
• Integrity
• Image processing on fingerprints
Example Image Processing

Original
Example

Example – bad results
Image Processing license plates ???

Surveillance video tapes characteristics
- View of large space or door, no close-ups
- Time-lapse, typical 4 images per second
- Multiplex recording, typical 4 to 12 cameras
- Digital Systems
Difference Day and Night

Digitization: equipment

• a number of high end and home video players
• Digital equipment
• Uncompressed digitizing for example with commercial software
  • or
• Media analysis
DVD / CD-recordable contains:

CD-recordable contains:
• processed image or small movie files
• instructions for viewing
• compressed movie-files for reference purposes (annotation of image sequence number)
• table of hash-codes
• a hash-code for the table is given in a written report

Outline
• Background of this workshop
• Netherlands Forensic Institute - our group
• Investigation
• Image Restoration
• Image Comparison
• Integrity
• Image processing on fingerprints
References of Images

Video overlays of reference points

Measuring the length

- lens distortion
  objects with straight edges in the image
- perspective projection
  point like objects in the image
- upper and lower limits for length
  propagation of estimation errors
  use of prior knowledge
Match of scene with image

Match of biped with a person
Surveillance video and animation

Gait parameters

Experiment by Menno Merlijn, student
Free university Amsterdam

• 12 persons walk 5 times with markers
• 3 camera’s: top view, frontal view and left view
• analysis of pixel positions of markers

Most characteristic parameters:
• angle between foot and walking direction
• step length
Methods

- (1) defects in CCDs
- (2) compensation for these errors in the camera’s
- (3) file formats that are used
- (4) noise introduced by the CCD
- (5) watermarking

Outline

- Background of this workshop
- Netherlands Forensic Institute - our group
- Investigation
- Image Restoration
- Image Comparison
- Integrity
- Image processing on fingerprints
**Authenticity**

- Research together with Naoki Saitoh from the National Research Institute of Police Science in Tokyo

**Defects**

- Cold pixel
- Hot pixel
- Column defect
Experiments with Trust Camera’s

• Dark images

Movie

Still Image

Average Number of Images
Camera Comparison (movies)

Camera 1

Camera 2

Temperature influence

0 C

20 C

40 C
Compression

CCD pixel defects
Other camera's tested

Sony Mavica
Sony Cybershot
Sony FD83
Sony DV Handycam

No visible pixel defects detected. For these camera's more sophisticated methods are needed.

Several times used in case work

- Child pornography images with pixel defects
- Determine if the defects are random!
File Headers

- JPEG
- JFIF
- EXIF
- CIFF
- SPIFF
- FLASPIX
- CAM
- APP12
- TIFF
- ..... Investigate serial numbers etc.

Media

- CompactFlash
- SmartMedia
- Miniature Cards
- PCMCIA-kaarten
- ...

Investigate the serial numbers in these cards
Conclusion

• Pixel defects can be found in images with camera’s
• It is important to know how random these defects are
• This method can be used for cheap camera’s.

Image Integrity

• Has there been tampered with this image?
Outline

• Background of this workshop
• Netherlands Forensic Institute - our group
• Investigation
• Image Restoration
• Image Comparison
• Integrity
• Image processing on fingerprints

Image Processing of fingerprints

Zeno Geradts, Arnout Ruifrok,
Jos van Wouw, Jitteke Struijk

Netherlands Forensic Institute
Validation of image processing

- Several publications in forensic journals and publications from 1988
- Actual work in fingerprints, documents, video image processing
- SPIE working group Investigative Image Processing
- US – Frye / Daubert


- “Often, the initial reaction is one of disapproval. The concern is that non-existent detail is added to the latent print. Image enhancement techniques are not designed to create detail but to improve images for human interpretation.”
continued

• Just as photographic techniques assist us in seeing various spectral ranges (such as infrared) and microscopes help us to see extremely small items, image enhancement techniques can help us to discern minute details within the image.”

Methods

• Contrast stretching / histogram equalization – low risk
• use of kernels - depending on kernel risk
• FFT – higher risk
• Dilation / erosion – high risk
• Wavelet – unknown risk
• Subtraction with registration (Improofs project EU) – depending on method used
Warnings

- 1994 S. Bramble: “We found that excessive cutting of the data can seriously degrade the image”. And in
- 1993 E. Berg: “However, one must be extremely careful when using the FFT spike boost so as not to cross the line between enhancement and restoration”.

FFT shoeprint
Feb. 1998 STATE v. HAYDEN 109 90

- “The evidence in the record supports the trial court's unchallenged findings that the technique utilised by Berg has a reliability factor of 100 percent and a zero percent margin of error and that the results are visually verifiable and could be easily duplicated by another expert using his or her own digital camera and appropriate computer software.”

Subtraction - Improofs

http://www.esat.kuleuven.ac.be/~konijn/improofs.html
New techniques

- Che-en Wen; Journal of Forensic Science
  September 2003 pp. 1-12.
- Tests on synthetic fingerprints
- AM-FM method - similar to wavelet filtering

Example from JOFS
Discussion

• Which new technique are admissible
• If critical reviewed, can the current techniques also lead to discussion in court?
• Know what the limits are of image processing
• Validation with same method as is used for the WSQ-compression? - test with different examiners (proficiency testing)
• Depending on the number of features that are visible
Questions?