Gait as evidence

Niels Lynnerup
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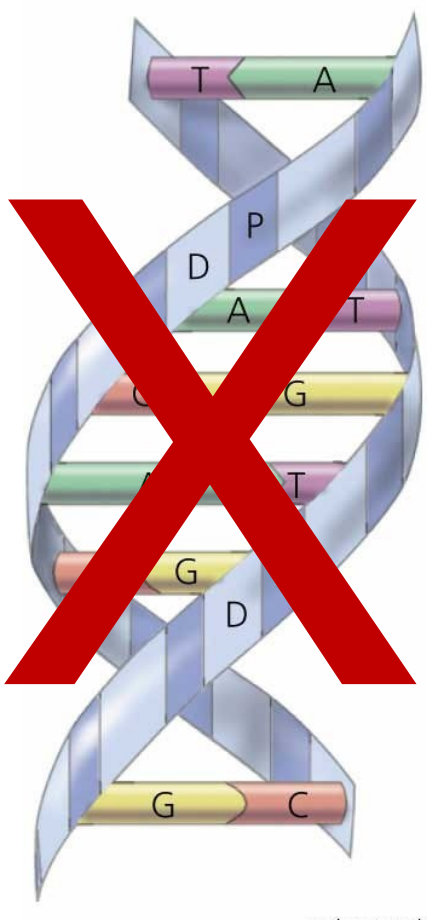
T
A
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Subject of study:

The entire human body

Specific features

Static – *In motion*

Evidence based

Judicial requirements

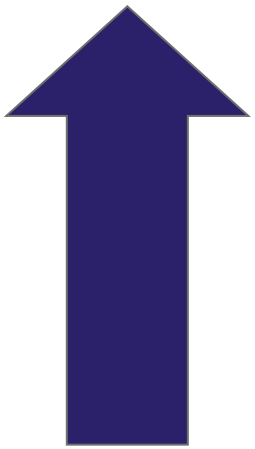
Scientific requirements

Evidence based

Judicial requirements

Scientific requirements

Hierarchy of evidence

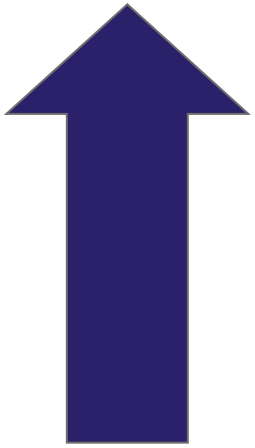


Systematic reviews and meta-analyses

Randomised, blind trials

Case reports

Hierarchy of evidence



Systematic reviews and meta-analyses

Randomised, blind trials

Case reports

Including biometric /biometric database based work

ELSEVIER

Legal Medicine 5 (2003) 156–160

LEGAL MEDICINE

www.elsevier.com/locate/legalmed

Brief communication

Facial image identification using Photomodeler®

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Received 15 January 2003; received in revised form 28 February 2003; accepted 12 March 2003

Abstract

We present the results of a preliminary study of the use of 3-D [illegible] photogrammetry. Perpetrators may be photographed or filmed by surveillance systems. The police may wish to have these images compared to photographs of suspects. The surveillance imagery will often consist of many images of the same person taken from different angles. We wanted to see if it was possible to combine such a suite of images in useful 3-D renderings of facial proportions.

Fifteen male adults were photographed from four different angles. Based on these photographs, a 3-D wireframe model was produced by Photomodeler®. The wireframe models were then rotated to full lateral and frontal views, and compared to like sets of photographs of the subjects. In blind trials, 9/15 of the wireframe models were assigned to the correct sets of photographs. In five/15 cases, the wireframe models were assigned to several sets, including the correct set. Only in one case was a wireframe model not assigned to a correct set of photographs at all.

Keywords: Facial image identification; [illegible]

1. Introduction

Surveillance cameras are by now ubiquitous as security devices in banks or such localities that are prone to robberies and theft. Often, perpetrators are thus 'captured' on video or photographic film during the robbery. Subsequently, the police may want to identify the perpetrator, most often by comparing the surveillance images with a suspect [1–3]. Due to different camera angles, distances and differences in the general position of head and body, a direct image-to-image comparison is often difficult [1–3]. However, the surveillance images will often consist of many images of the perpetrator, viewed from different angles, as several cameras are employed at locations such as banks.

We wanted to determine whether the computer program Photomodeler® [4] might be of assistance in these situations. Photomodeler® is a computer program that is able to construct a 3-D wireframe based on concordant image features as seen on at least three images of the same object. Therefore, simultaneous images of a perpetrator may be used to generate a wireframe model of the facial features of the perpetrator. This wireframe model may then be compared with photographs of an apprehended suspect. These latter photographs are often full frontal and lateral images, but by rotating and scaling the wireframe, the mapped facial features may be superimposed on the photographs of the suspect.

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Paper ID JFS2004054
Available online at: www.astm.org

TECHNICAL NOTE

Niels Lynnerup,[1] M.D., Ph.D. and Jens Vedel,[2] M.A.

Person Identification by Gait Analysis and Photogrammetry

ABSTRACT: [illegible] surveillance images from a bank robbery were analyzed and compared with images of a suspect. Based on general bodily features, gait [illegible] anthropometric measurements [illegible] resemblance to the suspect. Both exhibited a gait characterized by hyperextension [illegible] differed [illegible] than 6 mm on average. The latter was [illegible] by photogrammetry [illegible] of the [illegible] cameras. Using the computer software Photomodeler Pro®, synchronized images from different cameras were compared and concurrent body features were identified. The program could then render the perpetrator as a three dimensional, high precision, scalable and measurable object.

KEYWORDS: forensic science, forensic anthropology, image analysis, surveillance, identification

As part of our investigations of a bank robbery, which had involved murder, we carried out a forensic anthropological assessment of one of the two perpetrators involved. The assessments were based on surveillance [illegible] video [illegible] Photogrammetry literally means measuring by photography. As such, photogrammetry is a technique as old as photography. Photogrammetry is extensively used in surveying, mapping and architecture, but also more recently in forensic medicine, and may include measurement of unknown values by use of known values within single images (1–3). Another basic application for photogrammetry is measuring objects in a three dimensional space, using photographs of the object taken from different sides and angles. Similar points on the different photographs are identified and a computer program can then calculate the x, y, z coordinates of the points, thus creating a virtual model of the object. If the camera that took the photographs of the object has been calibrated, a true scale model is made. We used Photomodeler® Pro (4), a software package that allows the above operations. The basis for using photogrammetry in this case was the realization that the perpetrator moved around in the bank and was captured by two cameras simultaneously.

This paper presents the image material at our disposal, the results of our analyses with special emphasis on the use of photogrammetry, and how the results were interpreted and presented in court.

The Case History

On June 21th, 2002, a bank in the town of Aabygade, Denmark, was robbed. Two perpetrators, clad in dark clothes and wearing full face motorcycle helmets, ran into the bank and threatened the bank clerks to open the various safe boxes. One of the perpetrators remained standing in the front part of the bank as lookout, while [illegible] the bank, a gun was [illegible] bank, a man had noticed that a robbery was under way and decided to interfere and hinder the robbery. The perpetrators had parked a large motorcycle as their getaway vehicle just outside the entrance. Seeing this, the man tried to turn over the motorcycle using his car; he simply backed into the motorcycle. The perpetrator on lookout heard the noise of this attempt, and ran out of the bank, and fired a shot into the car. The bullet passed through the rear window killing the victim instantly. Seconds later the other perpetrator ran out the bank, and they made their getaway on the motorcycle, changing to a car in a nearby forest and then driving away at high speed.

The Case Image Material

We had the following imagery at disposal for our analyses.

Video Images from the Bank Surveillance System

The events of the bank robbery were recorded by multiple video cameras in the bank. In all, six cameras were mounted and in operation. Two of the cameras provided very useful images. One camera was placed just inside the porch pointing inwards, thus showing the front part of the bank clearly. This camera, CAM1, was b/w (Fig. 1a). The other camera was mounted at the very rear of the bank, pointing outwards, thus also showing the front area of the bank. This camera, CAM6, was a color camera (Fig. 1b). CAM1 was set to record four frames per second, while CAM6 was set to a lower rate of two frames per second. The cameras recorded to a digital system, Digi-Eye®, running on a PC-Windows platform. The software is proprietary, but enables export of still images in

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[2] 3D Photo, Aarhus, Denmark.
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No "Black Box" approach

Peer-reviewed publications

Evidence based

Judicial requirements

Scientific requirements

Expert Opinion Evidence

In Denmark:

Whatever the judge decides.

It is solely for the judge to decide if the witness is ”expert”, and whether the opinions expressed are ”expert”.

Expert Opinion Evidence

- The matter in question must be outside the experience of the factfinder.
- The witness must be appropriately qualified to give evidence on the matter.
- The evidence should meet a threshold of reliability

Forensic Science, Statistics & the Law

Commentary on news and publications at the intersections of scientific evidence, forensic science, and statistics.

SATURDAY, JUNE 4, 2011

R. v. Smith: Court of Appeal Rebukes Latent Fingerprint Identification in Britain for Being Out of Step with Modern Forensic Science

Displaying grave dissatisfaction with police-dominated latent fingerprint identification practices in England and Wales, the Court of Appeal in *R. v. Smith*, [2011] EWCA Crim 1296, quashed a homicide conviction. Hilda Owen, a 71-year-old woman, was found murdered in her home. The accused murderer was a neighbor, Peter Smith. He was in financial distress and stood to benefit from her will. A police fingerprint officer with more than 21 years experience and two colleagues who "independently" verified his work testified that they were certain that "a red blood-like substance" found on a door handle was Smith's.

ABOUT DHK

DH Kaye

Professor & Author

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POPULAR POSTS

R. v. Smith: Court of Appeal Rebukes Latent Fingerprint Identification in Britain for Being Out of Step with Modern Forensic Science

Displaying grave

PLACES TO VISIT, BOOKS TO READ

- DHK home page
- The New Wigmore: Expert Evidence
- The Douvle Helix and the Law of Evidence
- Double Helix Law

R. v. Smith [2011]

- For judge to decide who is a competent expert in a particular field.
- Essential for the proper administration of justice that there are independent expert.
- Competent scientist should keep detailed notes of his examination and the reasons for his conclusions.
- Modern methods of presentation of expert evidence should be used to make evidence accesible to jury and save court time.

R v Barnes and another

Source:	**All England Reporter**
Publisher Citation:	**[2012] All ER (D) 33 (Oct)**
Neutral Citation:	**[2012] EWCA Crim 1605**
Court:	**Court of Appeal, Criminal Division**
Judge:	**Pitchford LJ, Lloyd Jones J and the Recorder of Birmingham**
Representation	**Gareth Branston (assigned by the Registrar of Criminal Appeals) for the first defendant.**
	James Beck (assigned by the Registrar of Criminal Appeals) for the second defendant.
	Richard Thatcher (instructed by the Crown Prosecution Service) for the Crown.
Judgment Dates:	**27 June 2012**

Catchwords

Criminal Evidence - Evidence - Admissibility - First and second defendants being charged with conspiring to commit robbery and possession of firearm following incident at post office involving two men wearing bandanas covering faces - One of men holding shotgun - Judge allowing into evidence reverse projection evidence of CCTV manager for purpose of providing approximation of gunman's height - First defendant being convicted of both counts and second defendant being convicted of robbery offence - Defendants appealing - Whether judge erring in admitting reverse projection evidence - Whether judge erring in rejecting second defendant's submission of no case to answer - Whether convictions unsafe.

The Case

Criminal Evidence Evidence. The Court of Appeal, Criminal Division, in dismissing the defendants' appeals against conviction for conspiring to commit robbery and possession of a firearm whilst committing a Schedule 1 offence, contrary to s17(2) of the held that there was no sound basis for doubting the safety of the verdicts. In particular, the judge had not wrongly admitted evidence from a CCTV expert.

R. v. Barnes [2012]

”Reverse projection evidence”

- Evidence admissible.
- Not new science, but employed photographic techniques.
- Because the expert was applying techniques with which he was familiar, all that was required was the production of film which could provide a fair and accurate comparision with the crime scene recording.

Daubert

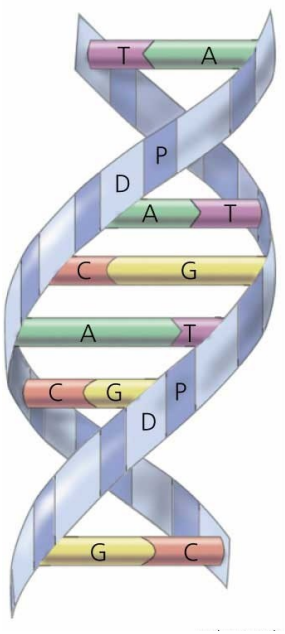
A non-exclusive four-part test:

(1) whether the expert's methodology can or has been tested;

(2) whether it has been subject to peer review and publication;

(3) its known or potential error rate and the existence and maintenance of standards controlling its operation; and

(4) whether it has attracted widespread acceptance within the relevant scientific community



Corroborative evidence

- Technical aspects:

  footage useful?

- Gait analysis:

  applying aforementioned guidelines.


DS2 12:Camera 12 10-08-2008 4:36:25 AM CEST


DB2 12:Camera 12 10-08-2008 4:36:25 AM CEST

- Direct comparison: ”1 to 1”

- *Not judged against laboratory data nor biometric databases*

Traits which indicate congruent identity

Traits which indicate non-congruent identity

Conclusion

Expert Working Group Marks

Expert Working Group Marks
ENFSI
EWGM Statute
EWGM Steering Committee
EWGM Projects »
Project Application Form
Conclusion Scale for Interpreting Findings within EWG Marks
Meetings »
IBSTE »
Library of Articles »
Wanted page
Feedback
Search

EWGM Projects

PROJECTS

The ENFSI Expert Working Group Marks has an aim to promote the area of marks examinations. To help to achieve our aim we are using a number of projects. The subject matter for these projects has normally been chosen because it is considered to be necessary and important to the marks area. The examiners of the mark area are invited to send your ideas for the topics of future projects with the Project Application Form (see the navigation).

Scale Committee

The idea of starting the Scale Committee of the ENFSI Working Group Marks occured after two proficiency tests arranged by shoeprint/toolmarks examiners of the National Bureau of Investigation, Finland (1995, 1997).
The Scale Committee was established in the 3rd European meeting for Shoeprint/Toolmark Examiners, arranged in Stockholm, Sweden 1999.

Members:
Dr. Horst Katterwe (chair)
Charles Belser
John Birkett
Alexandre Girod
Isaac Keereweer
Michel Moes
Gerrit Volckeryck
Yaron Shor
Anja Ytti

The main aim of the Conclusion Scale Committee of the ENFSI EWG Marks was to produce a conclusion scale that would enable practitioners to understand the meaning of conclusions formed by examiners across Europe. It takes into consideration the criminal justice systems that exist and provides a scale for communication. The harmonised conclusion scale (a level scale) is meant to be used with collaborative footwear tests of ENFSI EWG Marks.
The final result of the Scale Committee is an ENFSI Work Instruction Document *Conclusion Scale for Interpreting Findings in Proficiency Tests and Collaborative Exercises within the WG Marks* (see the navigation).

http://www.poliisi.fi/intermin/hankkeet/wgm/home.nsf/

"The opinion of the members of the Conclusion Scale Committee is that only the legal systems within the particular countries (and not a Standing Committee of ENFSI or not the Board of ENFSI) may decide on approval regarding interpreting evidence of the forensic scientific experts reports."

"The special requirement for the harmonised conclusion scale for interpreting findings in proficiency tests in marks cases is, that the proposed scale must allow to communicate results what ever method an examiner uses (Classical Approach, Likelihood-Ratio Approach, Full Bayes' Approach)."

HARMONISED CONCLUSION SCALE OF THE ENFSI WG MARKS

Level	Likelihood Ratio (partial Bayes' rule)	Probability (full Bayes' rule)
1	Identification	Identification
2	Very strong support for proposition A Strong support for proposition A	Very probably
3	Moderately strong support for proposition A Moderate support for proposition A Limited support for proposition A	Probably
4	Inconclusive	Inconclusive
5	Limited support for proposition ⊕ (⊕ = NotA) Moderate support for proposition ⊕ Moderately strong support for proposition ⊕ Strong support for proposition ⊕ Very strong support for proposition ⊕	Likely not
6	Elimination	Elimination

(A) = hypothesis: the questioned tool produced the mark;

(NotA) = alternative-hypothesis: the questioned tool didn't produce the mark.

(here assumed: even prior odds)

- Direct comparison: ”1 to 1”

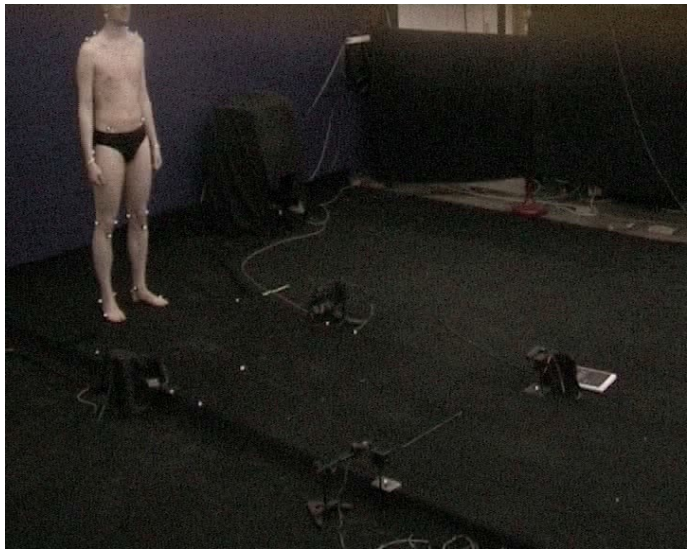
”Could it be someone else?”

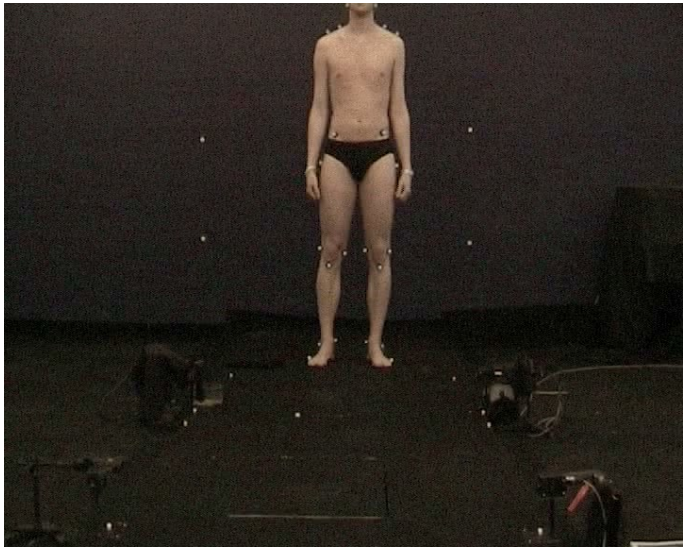
- Direct comparison: ”1 to 1”

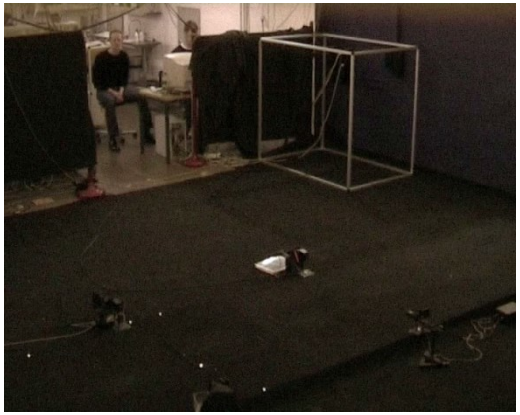
- *No judged against laboratory data nor biometric databases*

- But laboratory data or biometric data is gathered in order to better understand variation and test for error

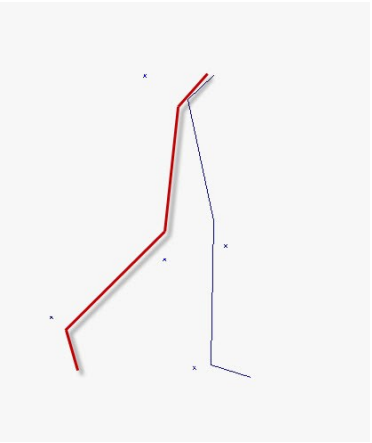
Method

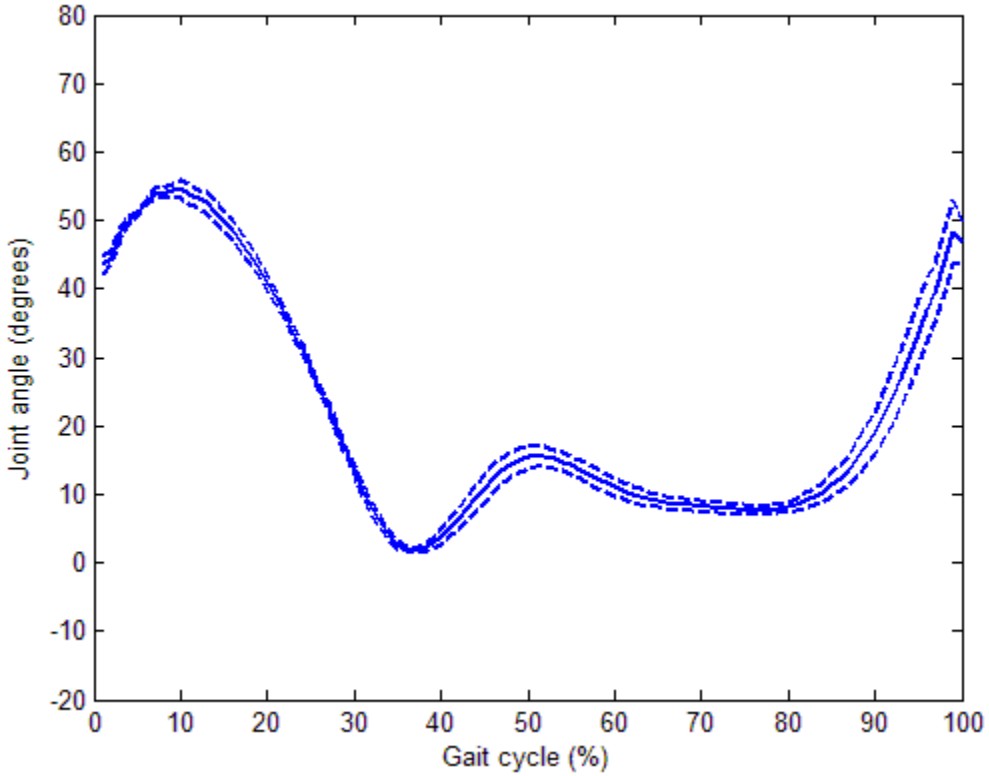


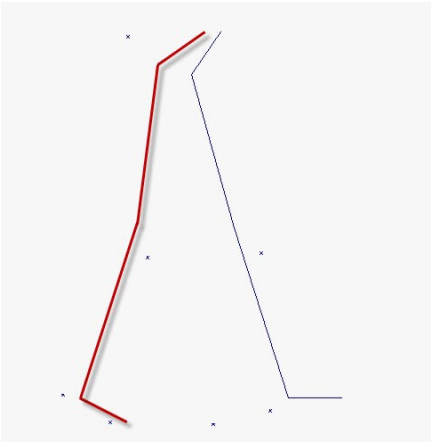


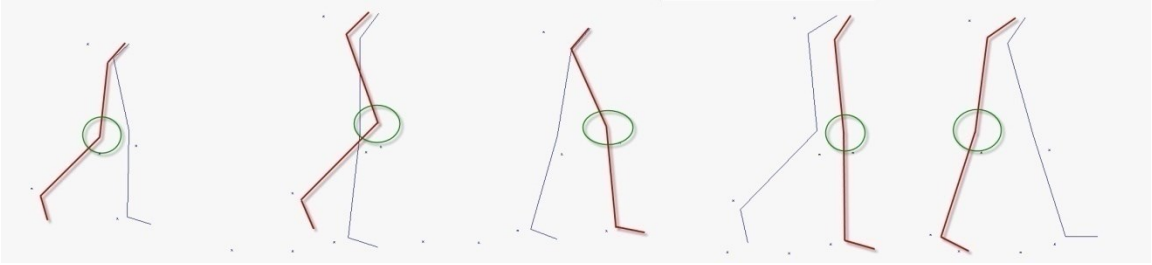


Method



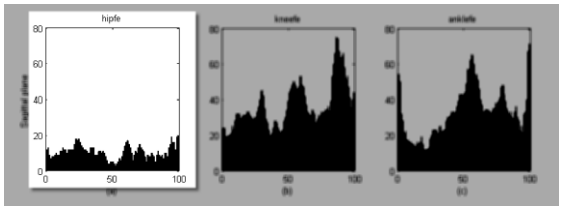

Joint angle (degrees)
Gait cycle (%)
80
70
60
50
40
30
20
10
0
-10
-20
0
10
20
30
40
50
60
70
80
90
100

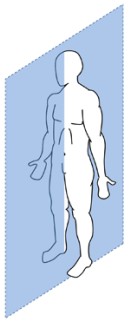


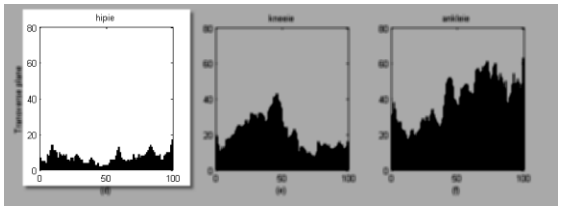


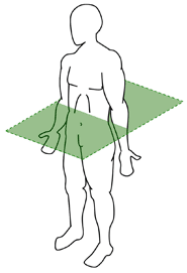
Conclusion

- The sagittal plane has the highest discriminatory power
- The hip flexion/extension angle has the highest discriminatory power



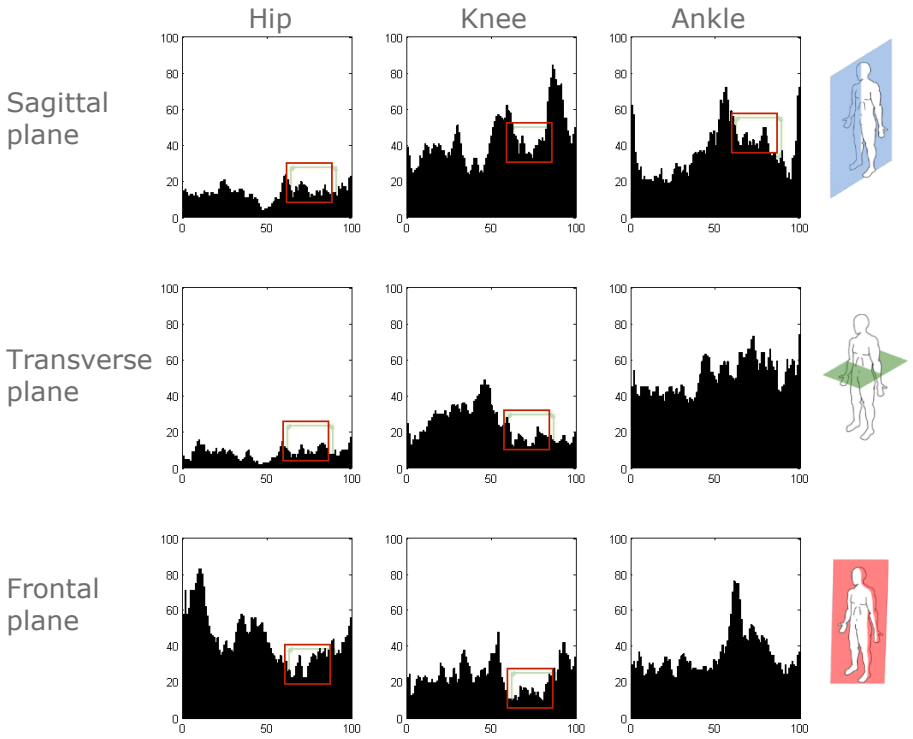




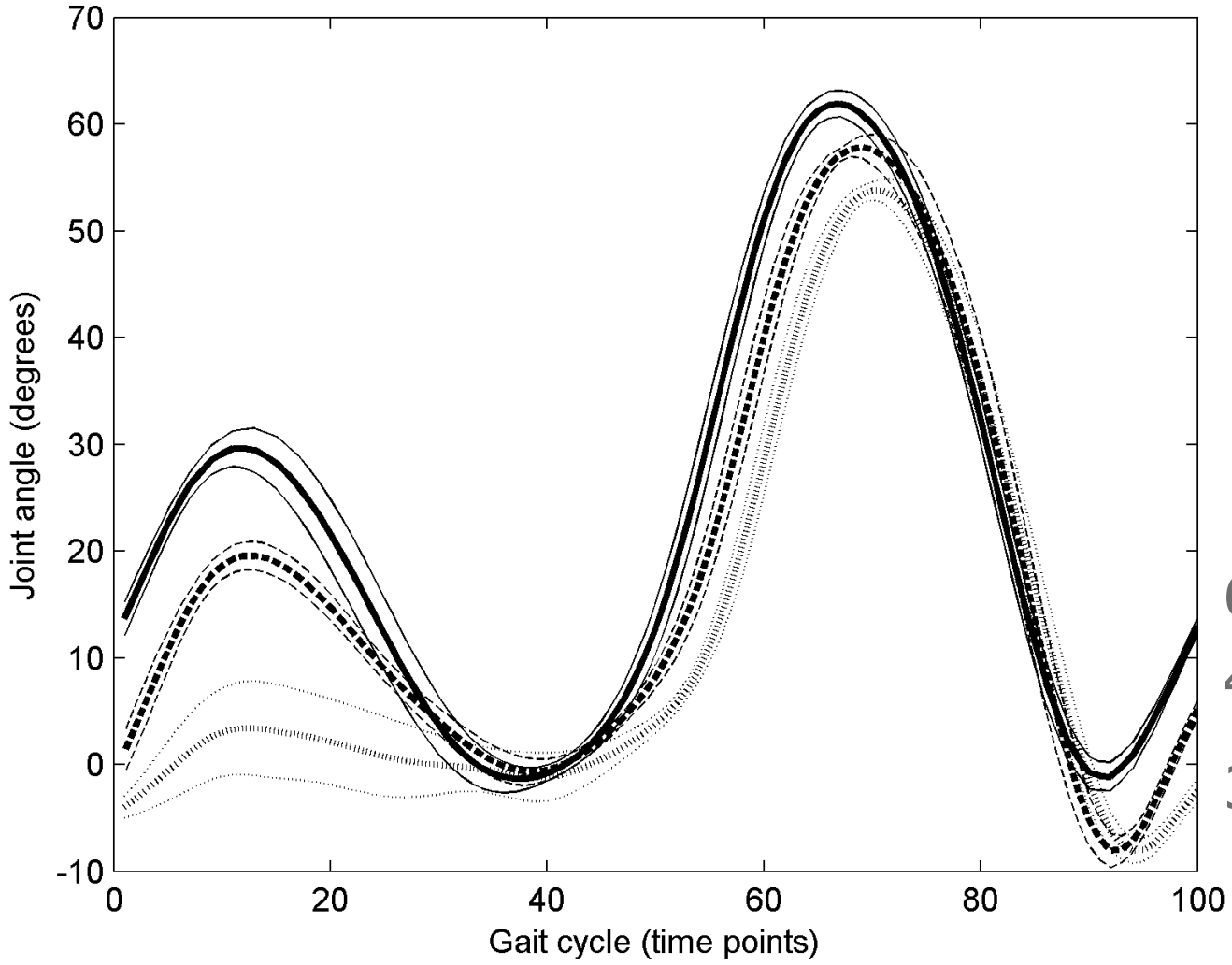


Conclusion

- Different angles have the peak discriminatory power at different places in the gait cycle



Gait for three velocities: Method

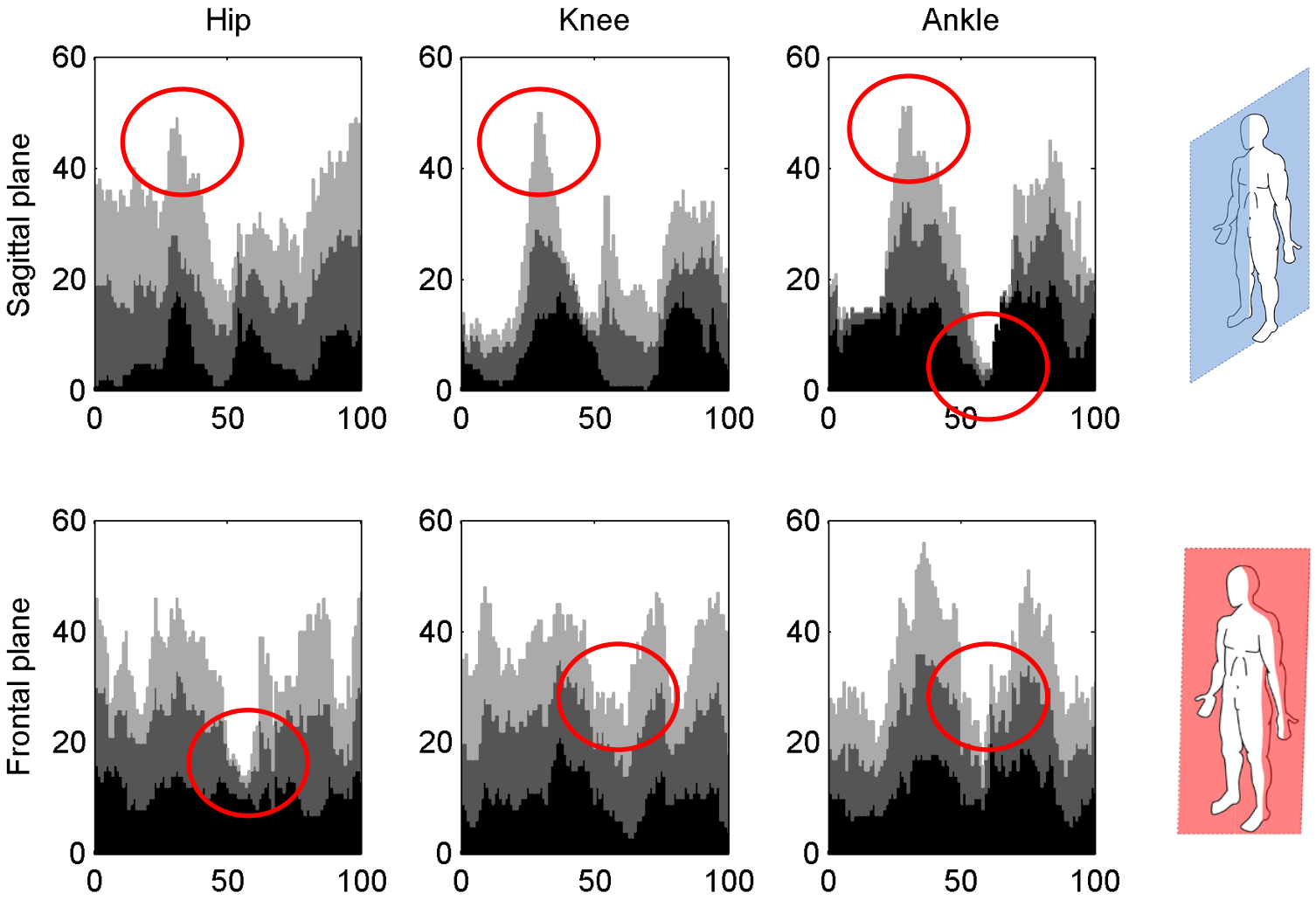


6 km/h

4.5 km/h

3 km/h

Gait for three velocities: Results



Future aspects

- Markerless systems
- More advanced statistical models
- Other parameters

Daubert

A non-exclusive four-part test:

(1) whether the expert's methodology can or has been tested;

(2) whether it has been subject to peer review and publication;

(3) its known or potential error rate and the existence and maintenance of standards controlling its operation; and

(4) whether it has attracted widespread acceptance within the relevant scientific community

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(A) = hypothesis: the questioned tool produced the mark;

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(here assumed: even prior odds)

Lynnerup N, Vedel J, 2005. **Person Identification by Gait Analysis and Photogrammetry**. Journal of Forensic Sciences, 50(1): 112-118.

Larsen PK, Simonsen EB, Lynnerup N, 2007. **Gait analysis in forensic medicine.** Proceedings of SPIE, the International Society of Optical Engineering 6491, 64910M (2007), DOI:10.1117/12.698512.

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Yang S, Larsen PK, Alkjær T, Simonsen EB, Lynnerup N. 2013. **Variability and similarity of gait as evaluated by joint angles: implications for forensic gait analysis. A**ccepted for publication in Journal of Forensic Sciences.

Thank you for your attention!

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