ACCV Human ID at a Distance HID 2020

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School of Electronics and Computer Science

Identifying people by their gait

A summary of progress

Mark Nixon

University of Southampton UK

UNIVERSITY OF Southampton
School of Electronics and Computer Science

Identifying people by their gait

A summary of progress

1. Where are we now?
2. How did we get here?
3. Where are we going?

Gait biometrics

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As a biometric, gait is available at a distance when other biometrics are obscured or at too low resolution

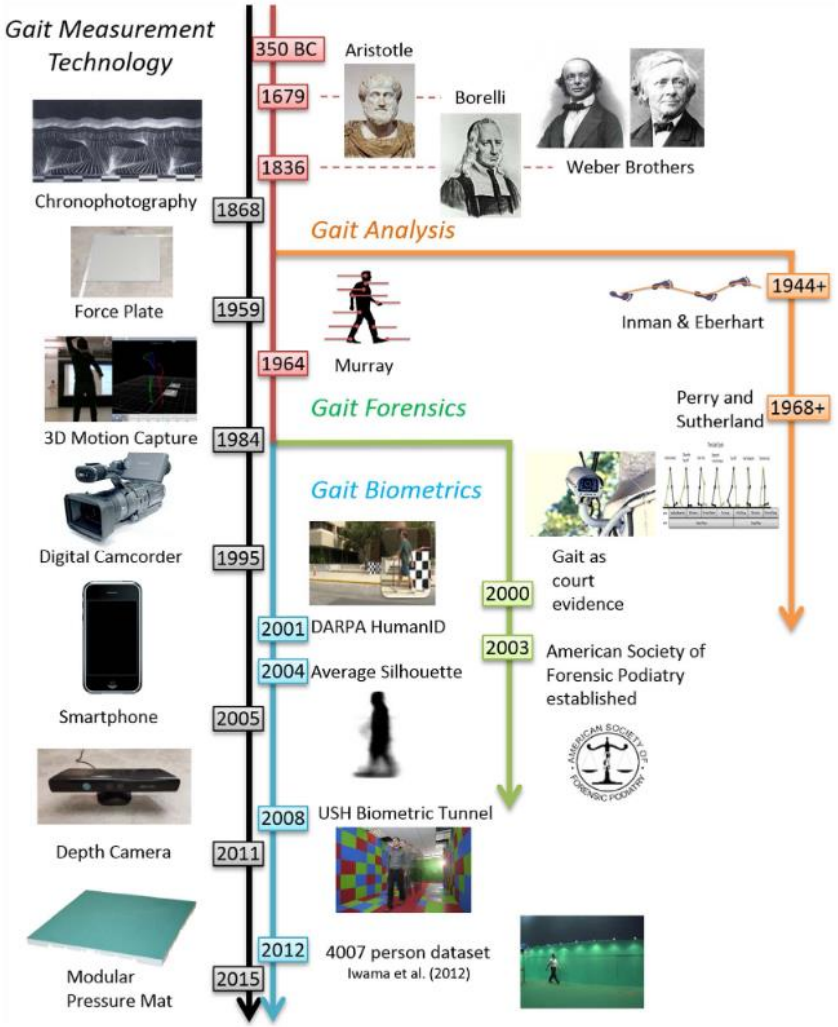
ABC News, July 13 2006

2000 years of progress

As a biometric, gait is available at a distance when other biometrics are obscured or at too low resolution

It is now widely accepted that people can be recognised by their gait

This is a consequence of desire, need and research, together with technological advance



Connor and Ross, Biometric recognition by gait, *CVIU* 2018

HiD competition, ACCV 2020

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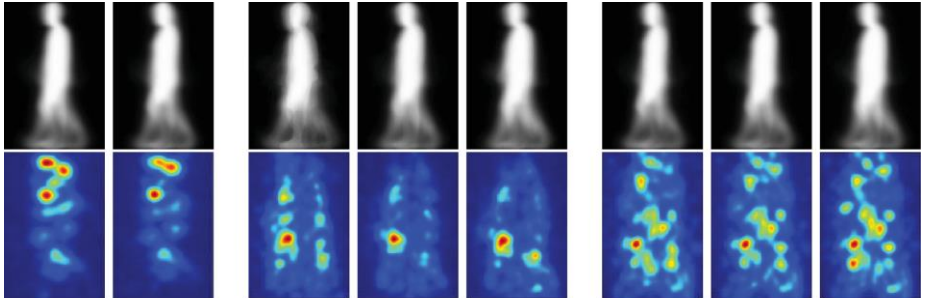
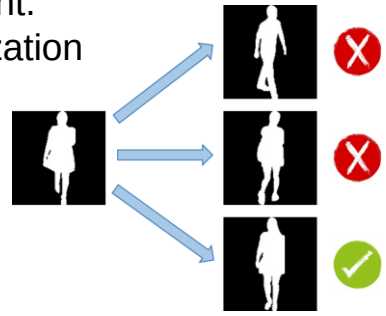
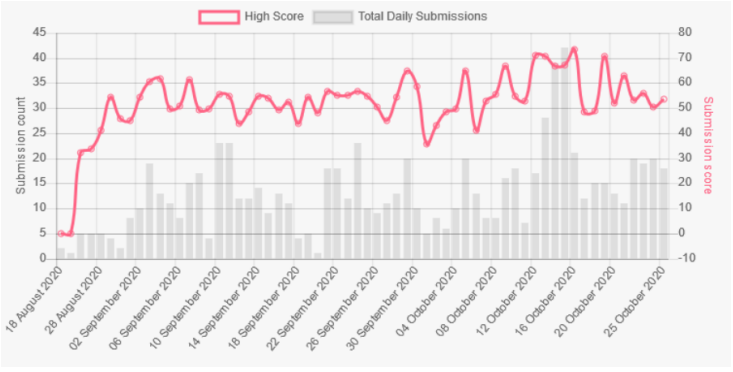


Top row: GEI for male, female, child, middle-aged, old, slim, medium and overweight.
Bottom row: corresponding visualization

CASIA E GEIs





https://competitions.codalab.org/competitions/26085#learn_the_details

What changes?

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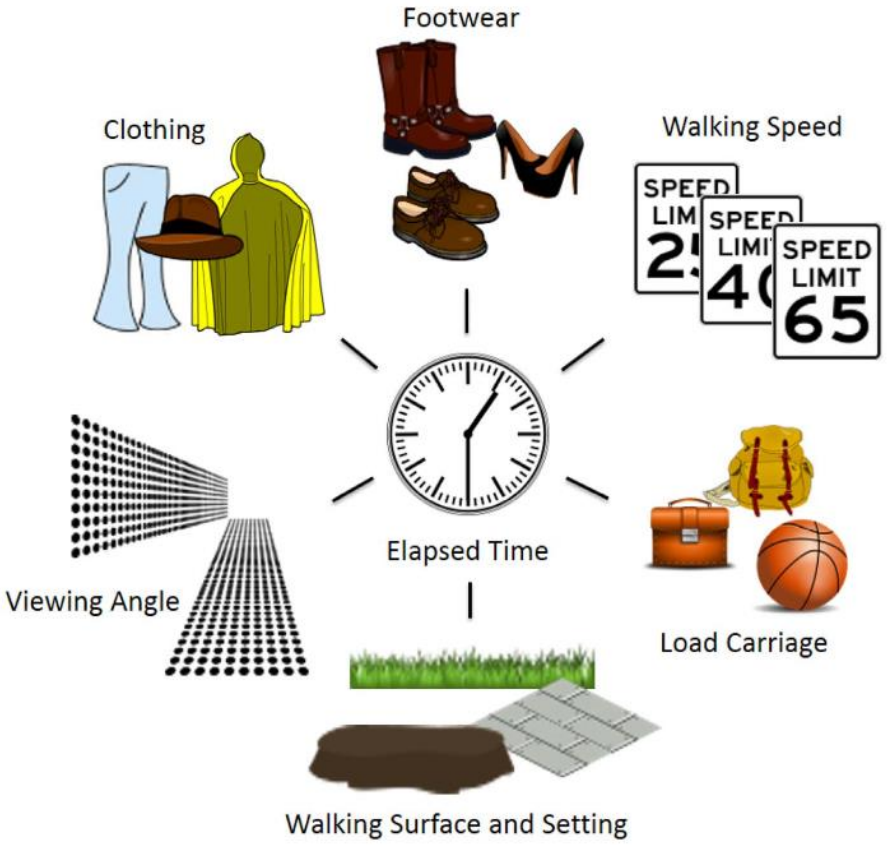
Many covariates can affect walking style

…. + health, drugs, mood,

…. but walking is a natural part of our daily lives



Biometrics and identity science

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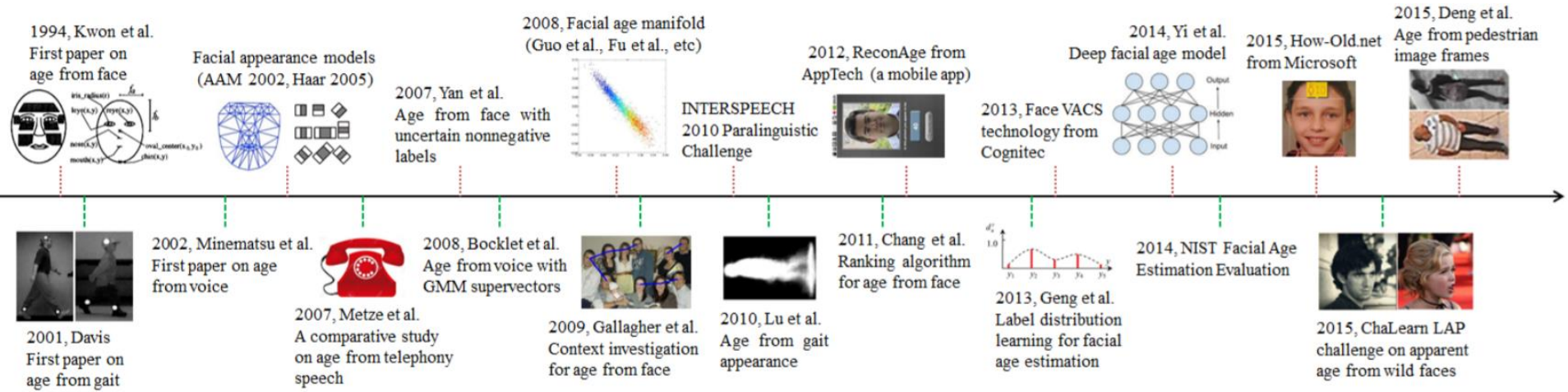

Major milestones in the history of automatic age estimation from biometric data

Sun, Zhang, Sun, Tan *IEEE TPAMI* 2018

Hand crafted then; deep learning now

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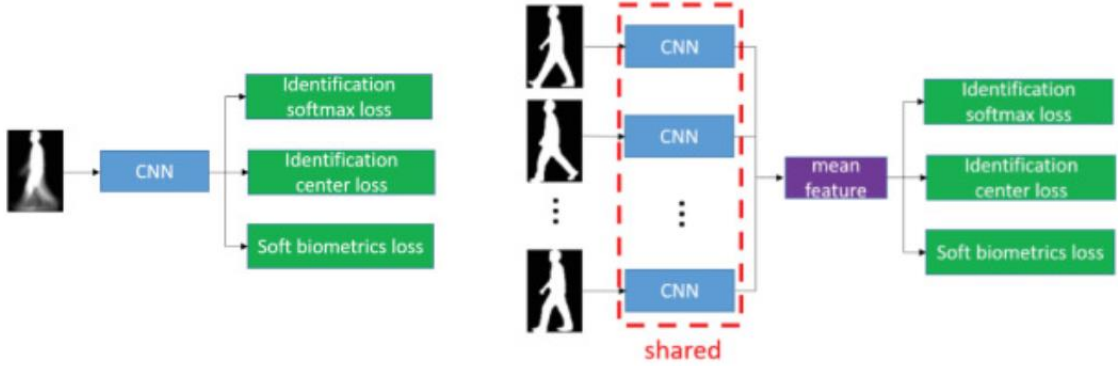

(a) Image level fusion (b) Feature level fusion

(c) Network architecture

Y Zhang, Y Huang, L Wang, S Yu, *Pattern Recognition*, 2019

Gait biometrics databases

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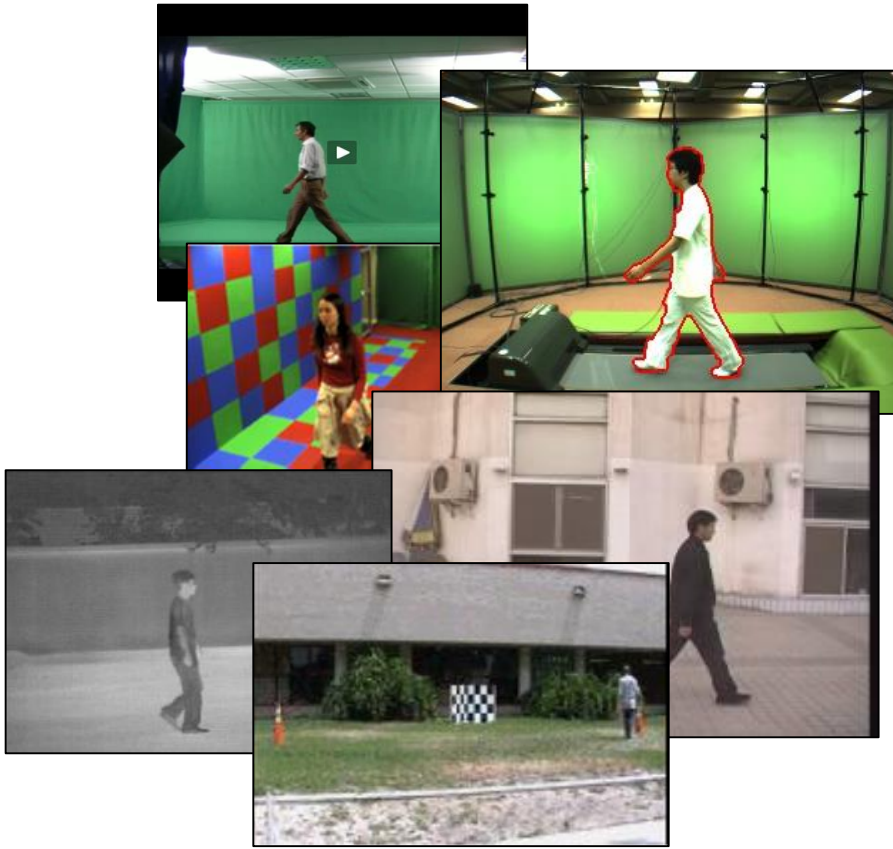
Laboratory

- Southampton 3D and 2D
- CASIA (+ multiview, thermal)
- Osaka OU-ISIR (+ multiview)

‘Real’ World

- HumanID
- Southampton
- CASIA

+ accelerometer, footfall, medical



M Okumura, Y Makihara, Y Yagi, IEEE TIFS 2012

Identifying people by their gait

A summary of progress

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1. Where are we now?
2. How did we get here?
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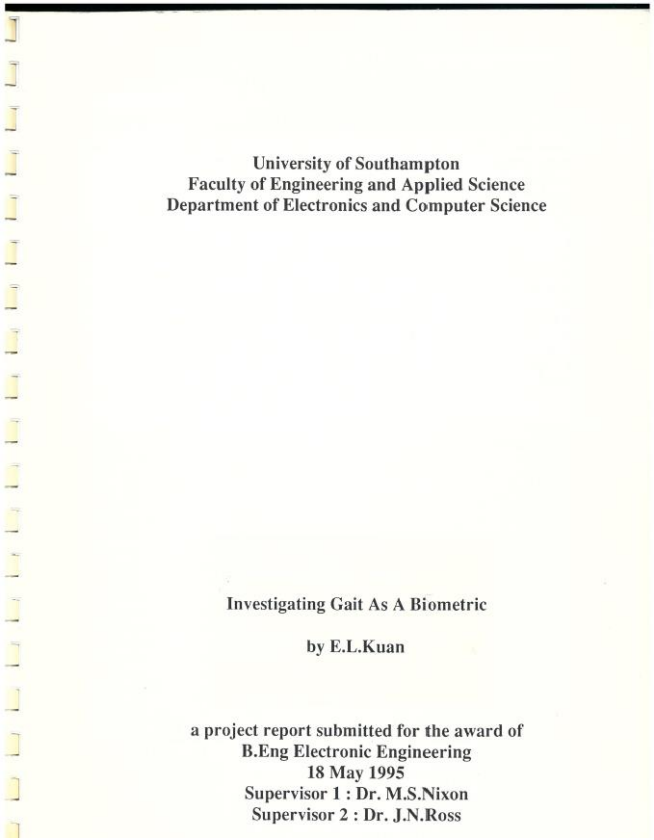

University of Southampton
Faculty of Engineering and Applied Science
Department of Electronics and Computer Science

Investigating Gait As A Biometric

by E.L.Kuan

a project report submitted for the award of
B.Eng Electronic Engineering
18 May 1995
Supervisor 1 : Dr. M.S.Nixon
Supervisor 2 : Dr. J.N.Ross

Technology in 1994

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Gait and literature

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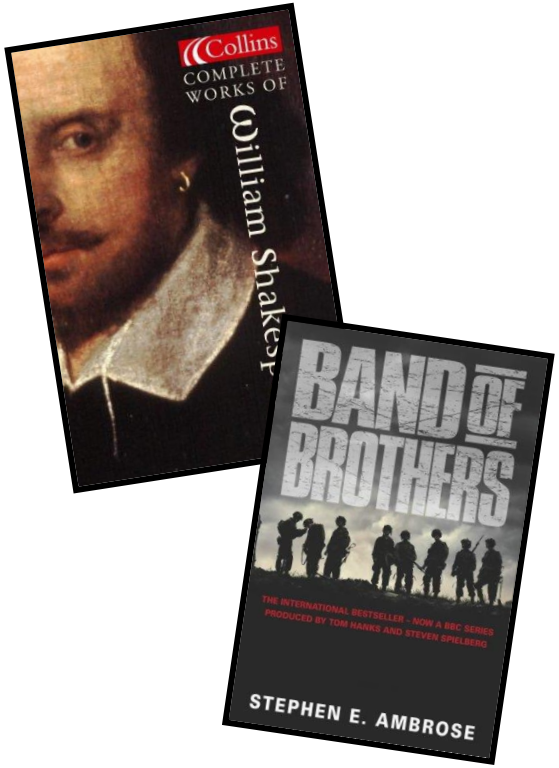
Dictionary: “manner of walking”

Shakespeare observed recognition:

> “High’st Queen of state; Great Juno comes; I know her by her gait” [The Tempest]
>
> “For that John Mortimer….in face, in gait in speech he doth resemble” [Henry IV/2]

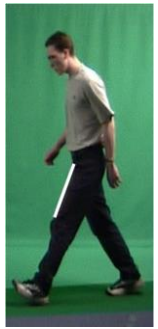
Other literature: e.g. Band of Brothers: “I noticed this figure coming, and I realized it was John Eubanks from the way he walked”

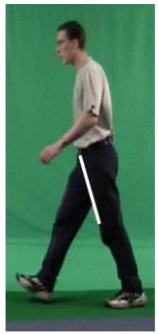


Early data

- 6 subjects; 7 sequences
- Sony Hi8 video camera
- Circular track ….exhausted subjects?

Little and Boyd, Videre, 1998





Model-based recognition

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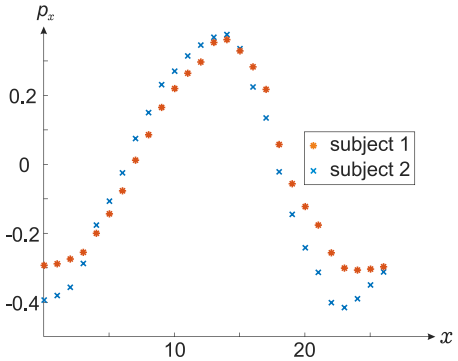
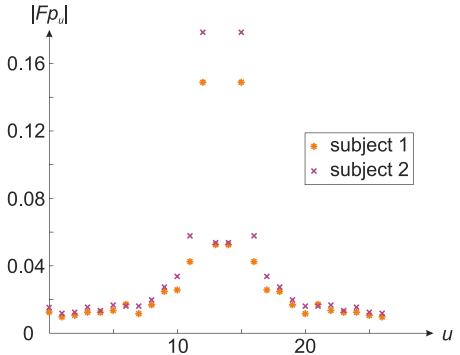
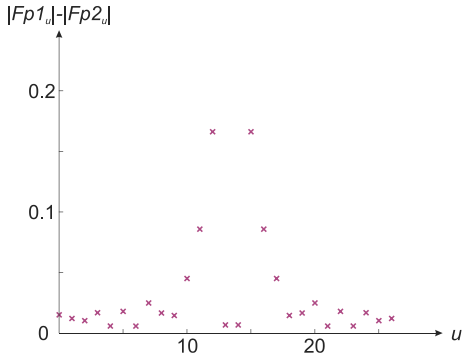


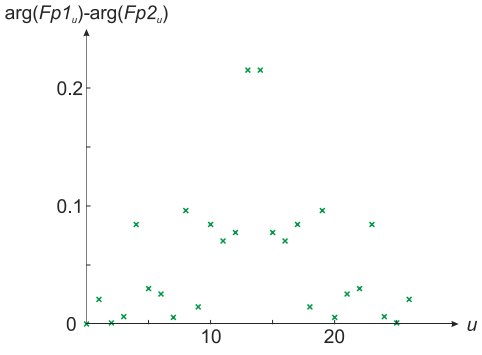
Inclination of thigh



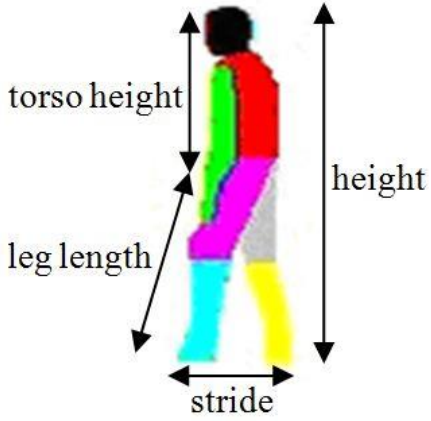
Magnitude of DFT



Difference between magnitude



Difference between phase



Other models are possible

D Cunado, MS Nixon, JN Carter, Proc. AVBPA, 1997

Using silhouettes

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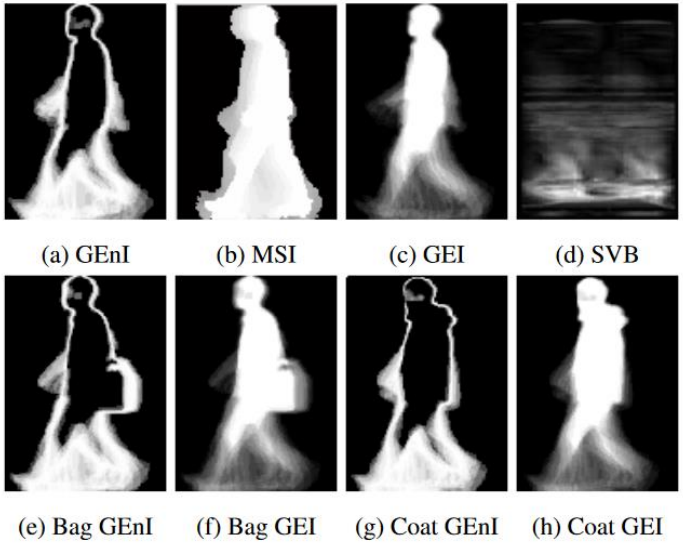
Some names: average silhouette, GEI

Gait Energy Image



Gait Entropy Image

J Han, B Bhanu, *IEEE TPAMI*, 2005

Many gait representations possible

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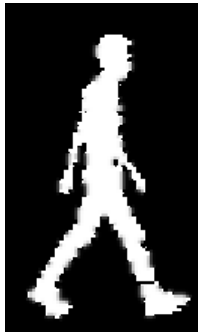
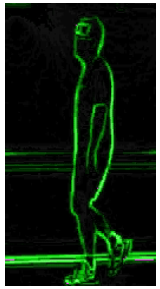
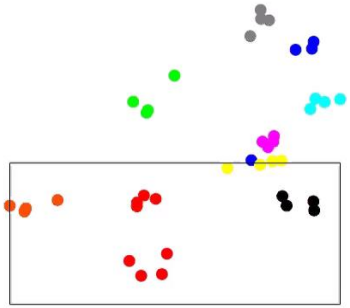
Recognising people from the motion of the whole body





silhouette flow edges symmetry acceleration feature space

MS Nixon, T Tan, R Chellappa, Springer, 2005

DARPA's Human ID at a Distance

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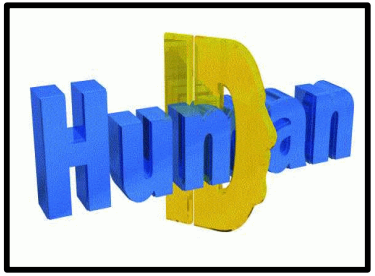

S Sarkar, PJ Phillips, Z Liu, IR Vega, P Grother, KW Bowyer, *IEEE TPAMI* 2005

Does gait biometrics really work?

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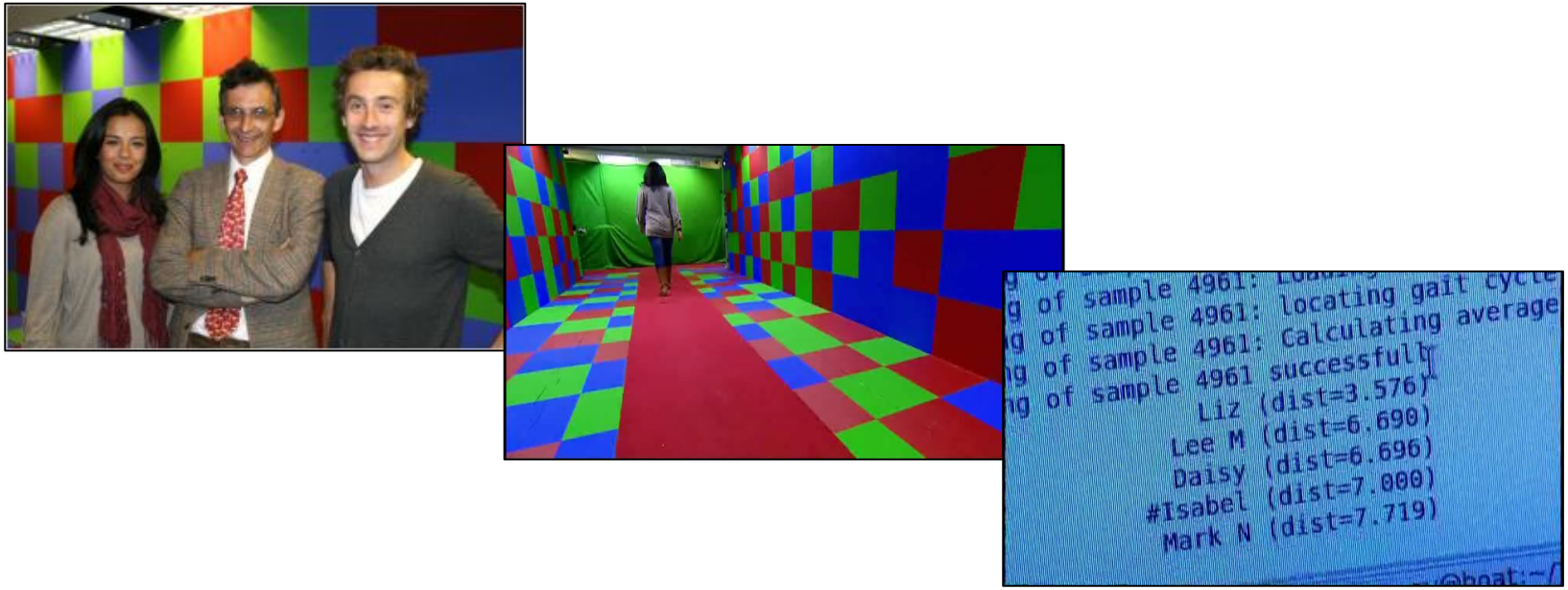
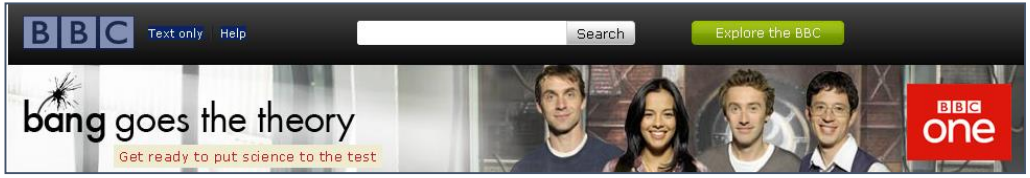


https://www.youtube.com/watch?v=PUwlNc0xAgQ

BBC1 Bang Goes the Theory
Episode 1, 2009



US demonstration ……

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Saturday Night Live 2002

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Identifying people by their gait

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Identity science

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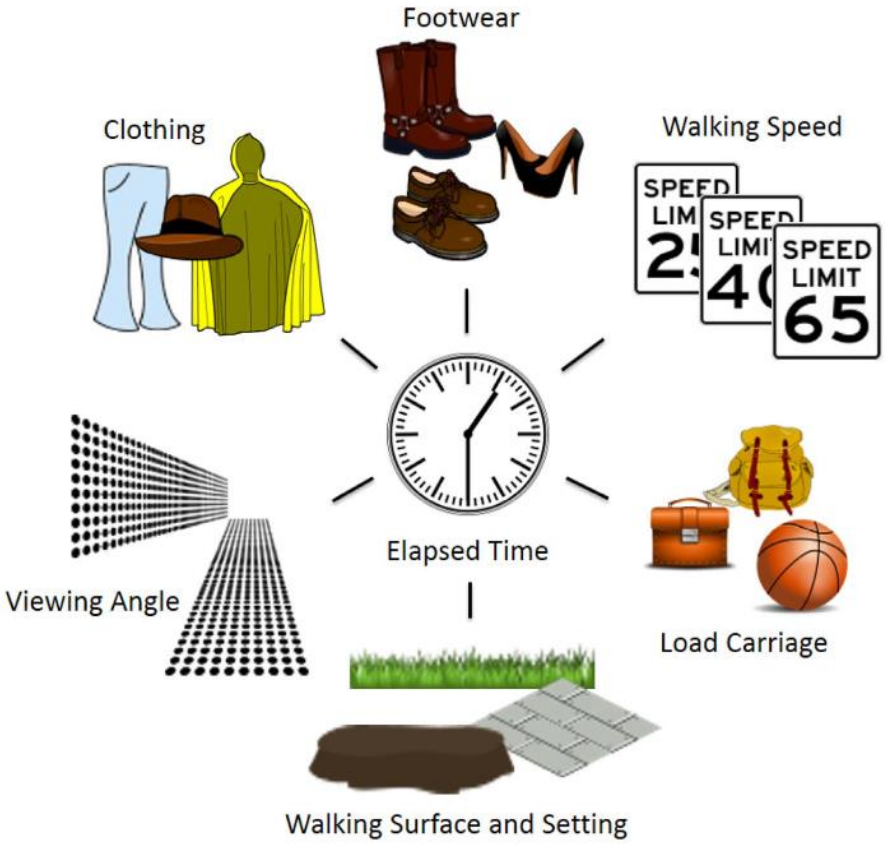
Science/ technology

- Covariates and exploratory variables
- Soft biometrics
- Spoofing
- Deep architectures

Applications

- Medicine (dementia, balance, falls)
- Sports
- Security
- Marketing



The first intelligent carpet

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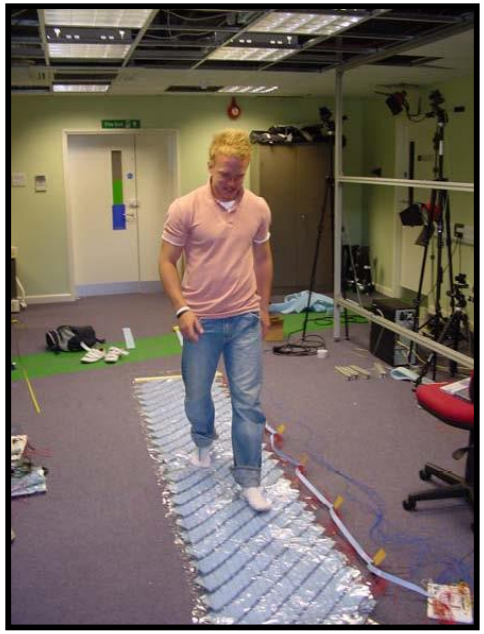
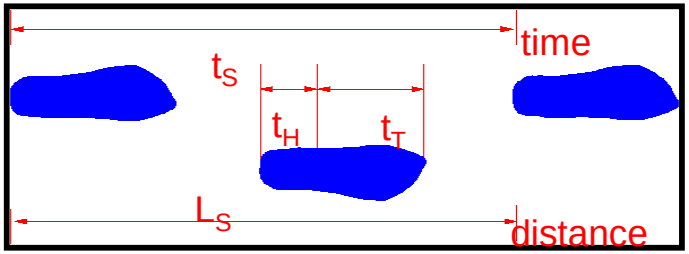
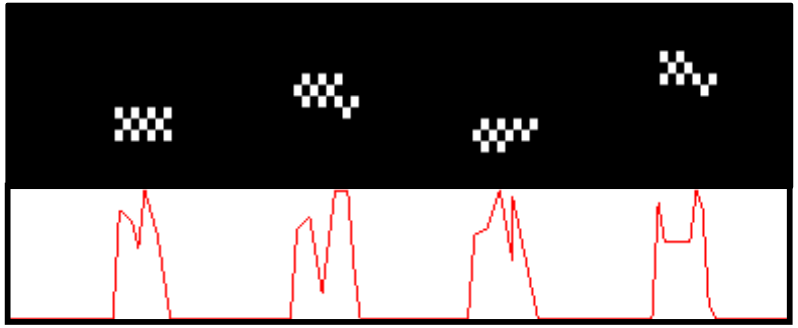
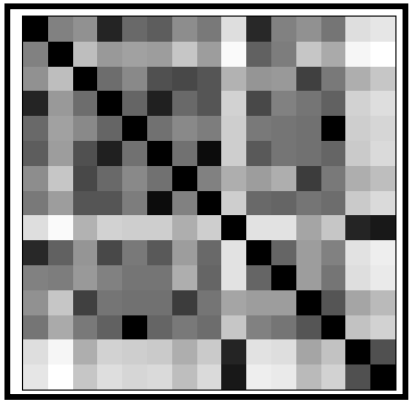


192×32 binary sensor array







Middleton, Buss and Nixon, *AutoID* 2005

3D recognition – marionette based

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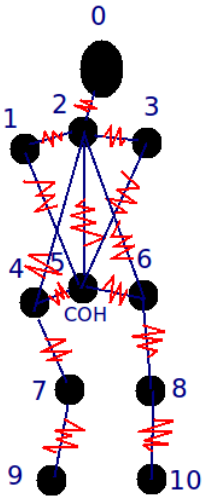

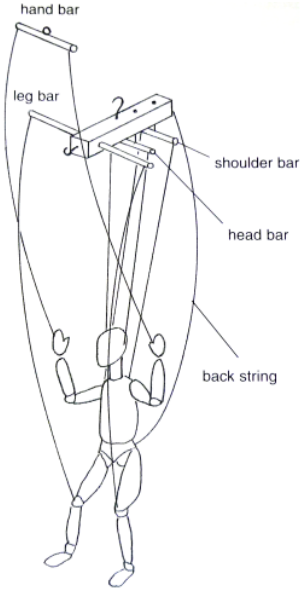

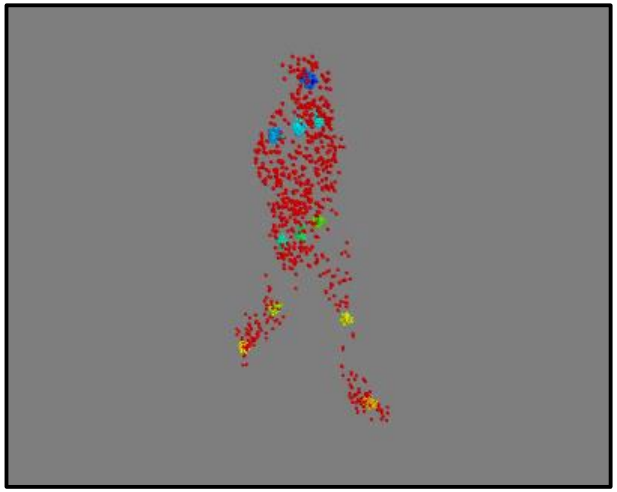

Ariyanto and Nixon, Proc. ICB 2013

Gait as evidence: murder case in Australia 2014

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Bouchrika, Nixon, Carter, *J. Forensic Science* 2011, and *Eusipco* 2010

https://www.youtube.com/watch?v=F1b_apXjjV0&feature=youtu.be

Descriptions and attributes for identification

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Eyewitness statement

"24 year old male average height wearing shirt"

Image of crime

Generate description

Subject	Gender	Age	Height	Nose W	Top
?	M	24	171	2.4	Shirt

Database of images

Generate descriptions

Subject	Gender	Age	Height	Nose W	Top
123456	M	25	172	2.3	Shirt
123457	F	36	156	2.2	Blouse
123458	M	58	182	1.2	T shirt

Database of descriptions

Martinho-Corbishley, Nixon and Carter, IEEE TPAMI 2019

Recent works

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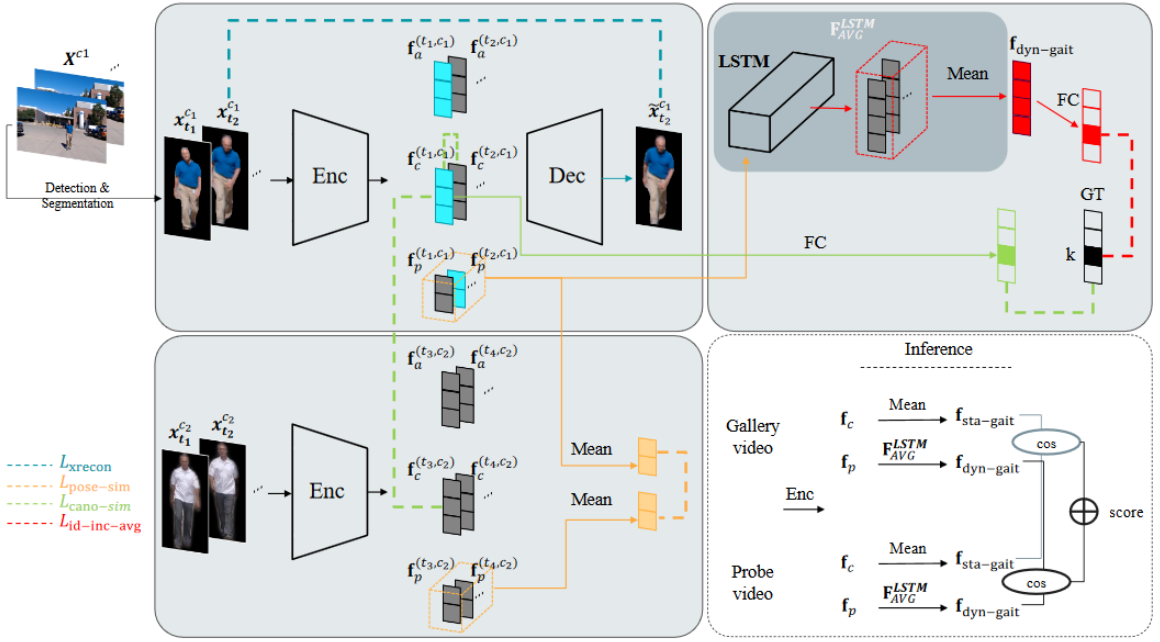
Fig. 1. Samples from the KinGaitWild dataset



SE Bekhouche, A Chergui, A Hadid…, ICIP 2020

Z Zhang, L Tran, F Liu , X Liu, IEEE TPAMI 2019

Conclusions

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Yes, gait works

Society will benefit more

The technology is grounded in science, literature, medicine + ….

We have more to learn

Congratulations to: Beijing Jiaotong University
Sichuan University
Harbin Engineering University
University of Science and Technology of China
and to all participants

Thanks to: Shiqi Yu and all organisers, CASIA (dataset), Watrix (sponsorship)

Selection of further reading

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1. Using gait as a biometric, via phase-weighted magnitude spectra, D Cunado, MS Nixon, JN Carter, *Proc. AVBPA*, 1997
2. The humanid gait challenge problem: Data sets, performance, and analysis, S Sarkar, PJ Phillips, Z Liu, IR Vega…, *IEEE TPAMI*, 2005
3. Individual recognition using gait energy image, J Han, B Bhanu, *IEEE TPAMI*, 2005
4. Human identification based on gait, MS Nixon, T Tan, R Chellappa, Springer, 2005
5. The OU-ISIR gait database comprising the large population dataset and performance evaluation of gait recognition, M Okumura, Y Makihara, Y Yagi, *IEEE TIFS* 2012
6. Biometric recognition by gait: A survey of modalities and features, P Connor, A Ross, *Computer Vision and Image Understanding*, 2018
7. Demographic analysis from biometric data: Achievements, challenges, and new frontiers Y Sun, M Zhang, Z Sun, T Tan, *IEEE TPAMI* 2018
8. A comprehensive study on gait biometrics using a joint CNN-based method, Y Zhang, Y Huang, L Wang, S Yu, *Pattern Recognition*, 2019
9. On learning disentangled representations for gait recognition, Z Zhang, L Tran, F Liu, X Liu… *IEEE TPAMI*, 2019
10. Kinship Verification From Gait?, SE Bekhouche, A Chergui, A Hadid… *Proc. IEEE ICIP*, 2020

Apologies if your own technique is missing, or your favourite. There are many more.

And thanks to ….

UNIVERSITY OF Southampton
School of Electronics and Computer Science

Dr John Carter, Dr Sasan Mahmoodi, Dr Jon Hare

Dr Hani Muammar, Dr Adrian Evans, Prof. Xiaoguang Jia, Prof Yan Chen, Prof Steve Gunn, Dr Colin Davies, Dr Mark Jones, Dr Alberto Aguado, Dr David Cunado, Dr Jason Nash, Prof Ping Huang, Dr David Benn, Dr Liang Ng, Dr Mark Toller, Dr John Manslow, Dr Mike Grant, Dr Jamie Shutler, Dr Karl Sharman, Prof Andrew Tatem, Layla Gordon, Dr Richard French, Dr Vijay Laxmi, Dr James Hayfron-Acquah, Dr Chew-Yean Yam, Dr Yalin Zheng, Dr Jeff Foster, Dr Jang Hee Yoo, Dr Nick Spencer, Dr Stuart Prismall, Wan Mohd.-Isa, Dr Peter Myerscough, Dr Richard Evans, Dr Stuart Mowbray, Dr Rob Boston, Dr Ahmad Al-Mazeed, Prof Peter Gething, Dr Dave Wagg, Dr Alex Bazin, Dr Mike Jewell, Dr Lee Middleton, Dr Galina Veres, Dr Imed Bouchrika, Dr Xin Liu, Dr Cem Direkoglu, Hidayah Rahmalan, Dr Banafshe Arbab-Zavar, Dr Baofeng Guo, Dr Sina Samangooei, Dr Michaela Goffredo , Dr Daniel Thorpe, Dr Richard Seely, Dr John Bustard, Dr Alastair Cummings, Dr Muayed Al-Huseiny, Dr Mina Ibrahim, Dr Darko Matovski, Dr Gunawan Ariyanto, Dr Sung-Uk Jung, Dr Richard Lowe, Dr Dan Reid, Dr George Cushen, Dr Ben Waller, Dr Nick Udell, Dr Anas Abuzaina, Dr Thamer Alathari, Dr Musab Sahrim, Dr Ah Reum Oh, Dr Tim Matthews, Dr Emad Jaha, Dr Peter Forrest, Dr Jaime Lomeli, Dr Dan Martinho-Corbishley, Dr Bingchen Guo, Dr Jung Sun, Dr Nawaf Almudhahka, Tom Ladyman, Dr Wenshu Zheng, Di Meng, Moneera Alnamnakani

Sponsors: EPSRC, Home Office, MoD (GD), DARPA, ARL, EU