KEYSTROKE DYNAMICS USE CASES

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KEYSTROKE PROFILING

UNIVERSITI MALAYSIA PERLIS

GREYC
Electronics and Computer Science Laboratory

Normandie Université

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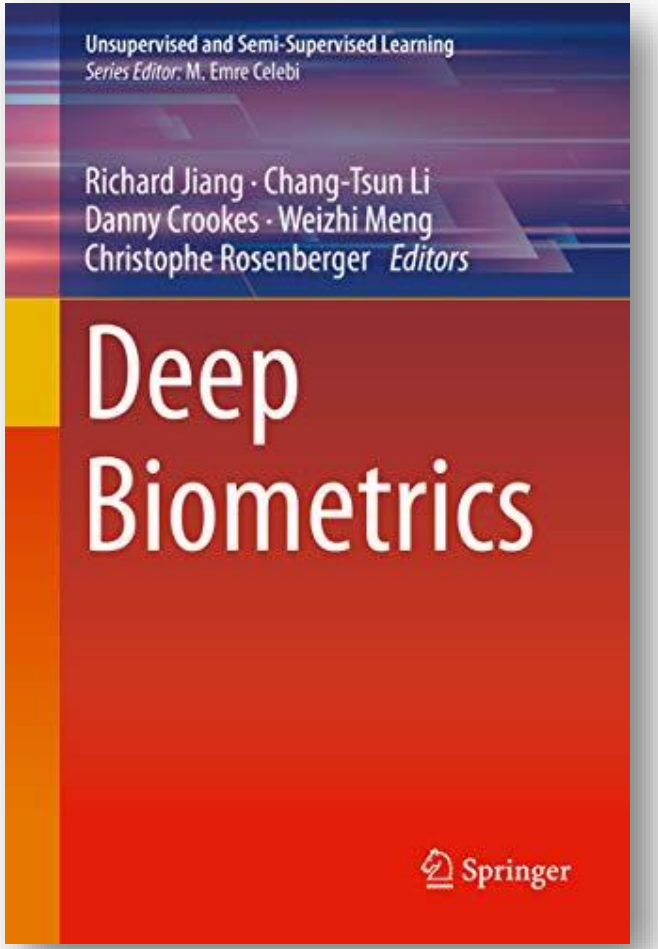
WHO AM I?

Christophe ROSENBERGER

- ❑ Full professor in Computer Science at ENSICAEN
- ❑ Cybersecurity researcher at the GREYC research lab (director)
  - ✓ Biometrics (since 2005)
  - ✓ Digital forensics (since 2021)
- ❑ Chairman of the evaluation and monitoring panel for the Italian Cybersecurity research strategy



https://rosenberger.ensicaen.fr/

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GREYC
Electronics and Computer Science Laboratory

ENSICAEN

School of Engineering in Normandy

Engineering diplomas: Computer science, Physical engineering and embedded systems, Materials science & chemistry

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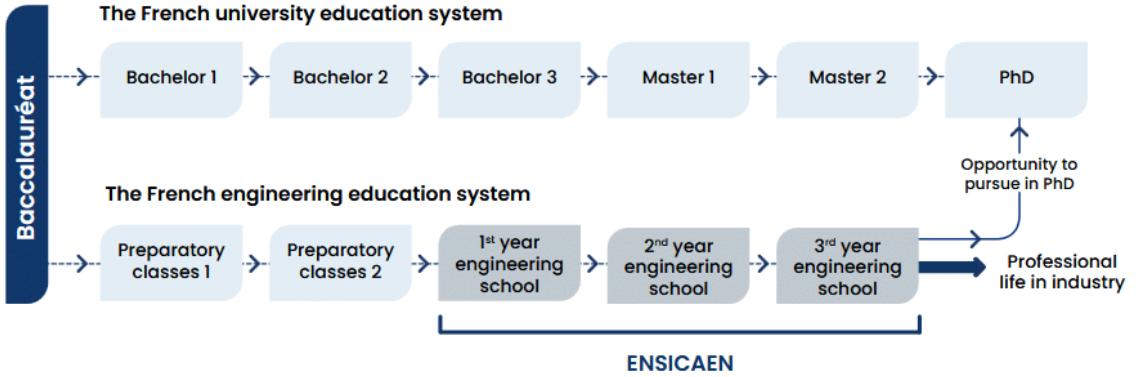
ENSICAEN SCHOOL OF ENGINEERING

National Graduate School of **Engineering** and **Research Center**



MSc Physical engineering and embedded systems

MSc Computer science

MSc Materials science & chemistry

Our laboratories

ENSICAEN research center includes **6 laboratories** supported by organisations such as the **CNRS**, the **CEA** and the **University of Caen**, including joint laboratory with **industry.**

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GREYC RESEARCH LAB

Research in Digital Sciences

Research topics: Image processing, artificial intelligence, data science, instrumentation, theoretical computer science, cybersecurity, natural language processing

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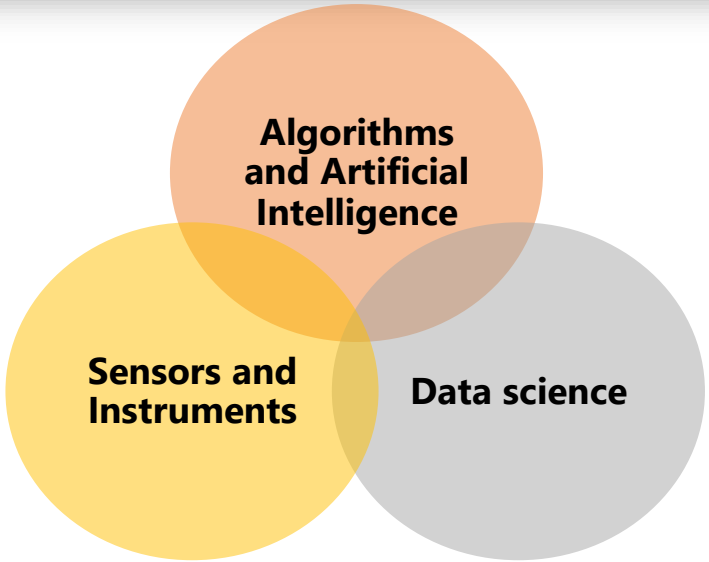
SUMMARY

~220 Members

- ❑ 7 full time CNRS researchers
- ❑ 29 full professors
- ❑ 49 associate professors (14 HDR)
- ❑ 68 PhD students (17 with a company)
- ❑ 18 permanent administrative and technical
- ❑ 10 post-doc and research engineers
- ❑ 19 associate members

Annual budget: 3000 K€ (without permanent salary)



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KEYSTROKE DYNAMICS

Real Use cases

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RESEARCH USE ONLY?

Analysis of Web services on Internet:

Use statistics from Alexa vocal assistant

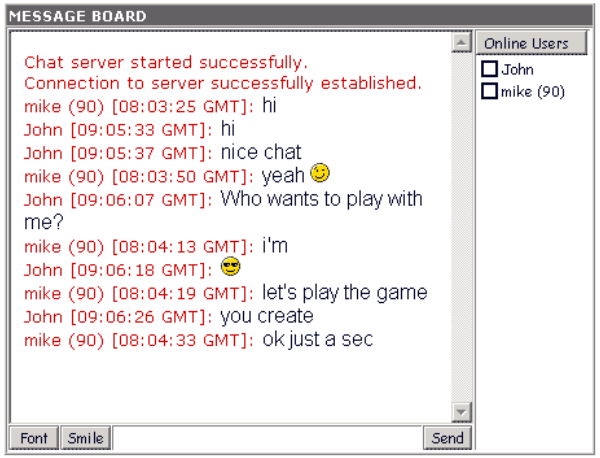
Analysis of TOP 200 websites:
1. Google
2. YouTube
3. Tmall
4. Baidu
5. Tencent QQ
6. Facebook
7. …

8% of websites collect keystroke dynamics data

Migdal, D. and Rosenberger C., “Don't listen to my Keystroke Dynamics!”, Summer school in biometrics 2019.

USE CASES

Two factors user authentication
Password + keystroke dynamics

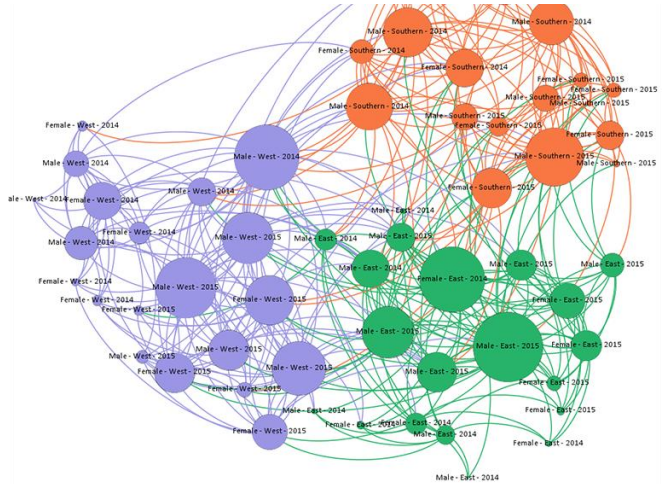


Chat analysis
Am I talking to the right person?

Personnalized advertisement on Internet

Emotion analysis

Physical intrusion detection



Trust between users in a social network

USE CASE - SOFT BIOMETRICS

Extracting soft biometric traits

Gender, Ethnicity, Skin Color, Hair color

http://anthro.palomar.edu/adapt/adapt_4.htm
© Corel Corporation, Ottawa, Canada

Eye color

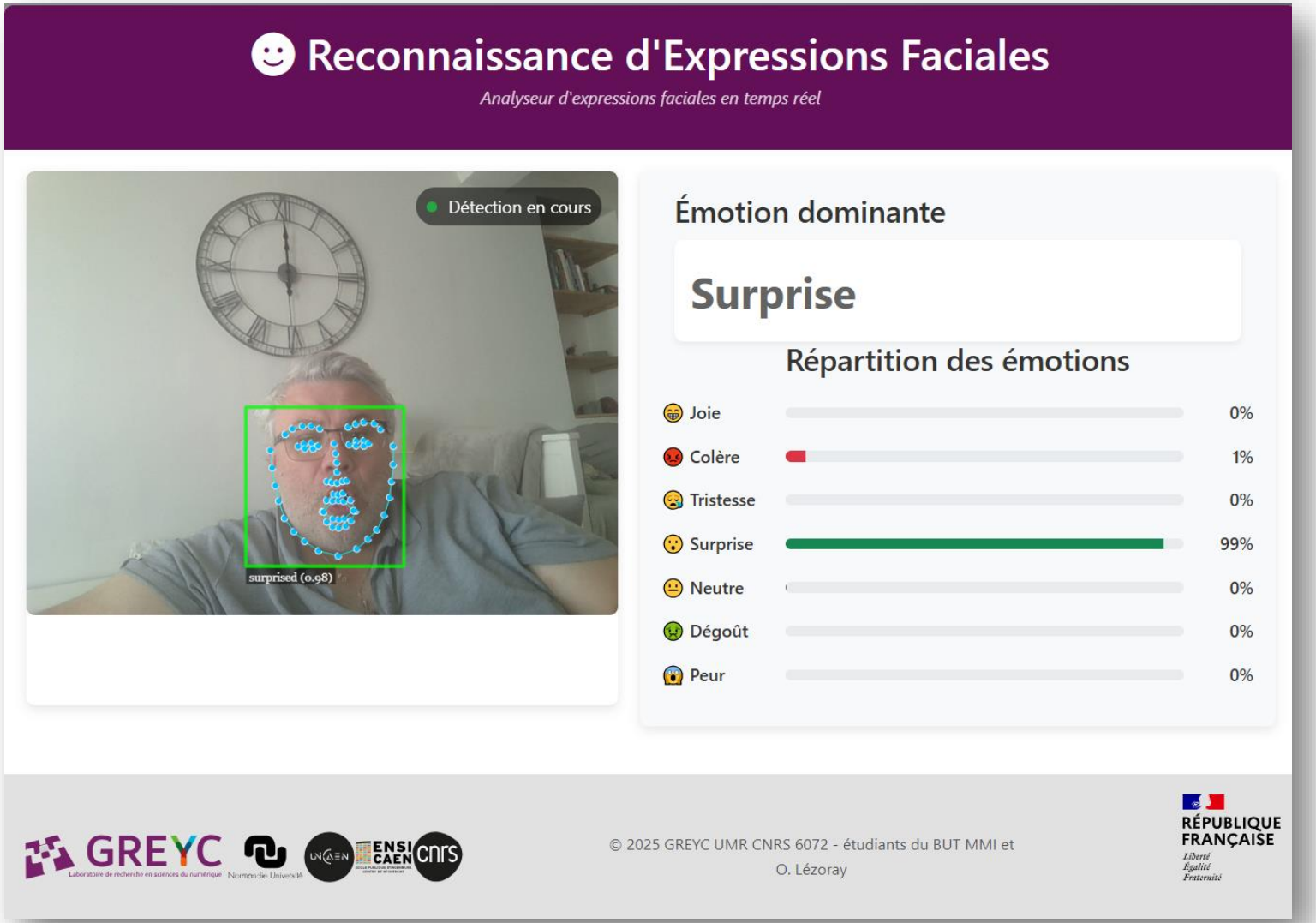
http://ology.amnh.org/genetics/longdefinition/index3.html
© American Museum of Natural History, 2001

Height

http://www.altonweb.com/history/wadlow/p2.html
© Alton Museum of History and Art

Weight

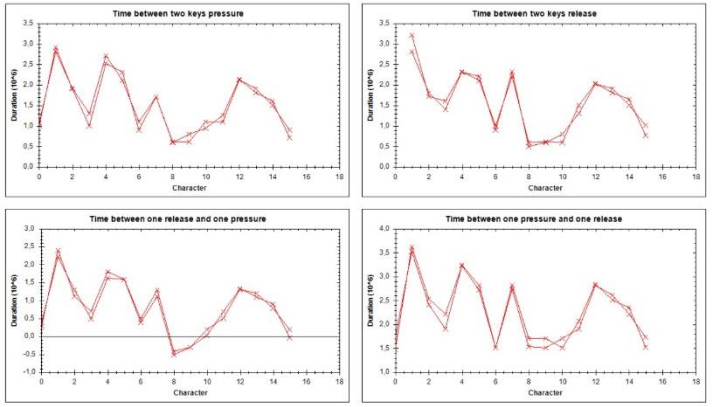
http://www.laurel-and-hardy.com/goodies/home6.html © CCA



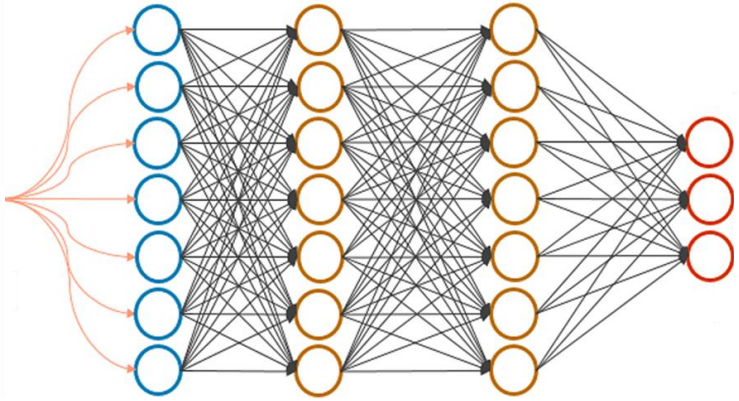
KEYSTROKE DYNAMICS PROFILING

Internet service

Data capture



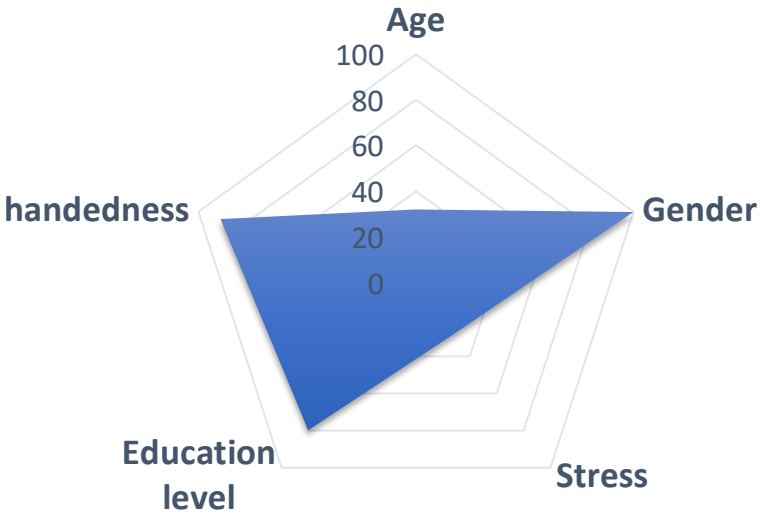
Keystroke dynamics data

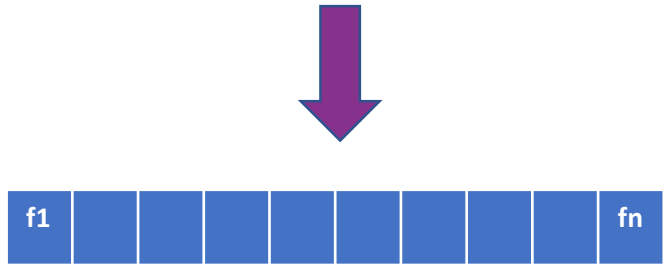


Feature generation

KEYSTROKE PROFILING

User's profile





User's signature

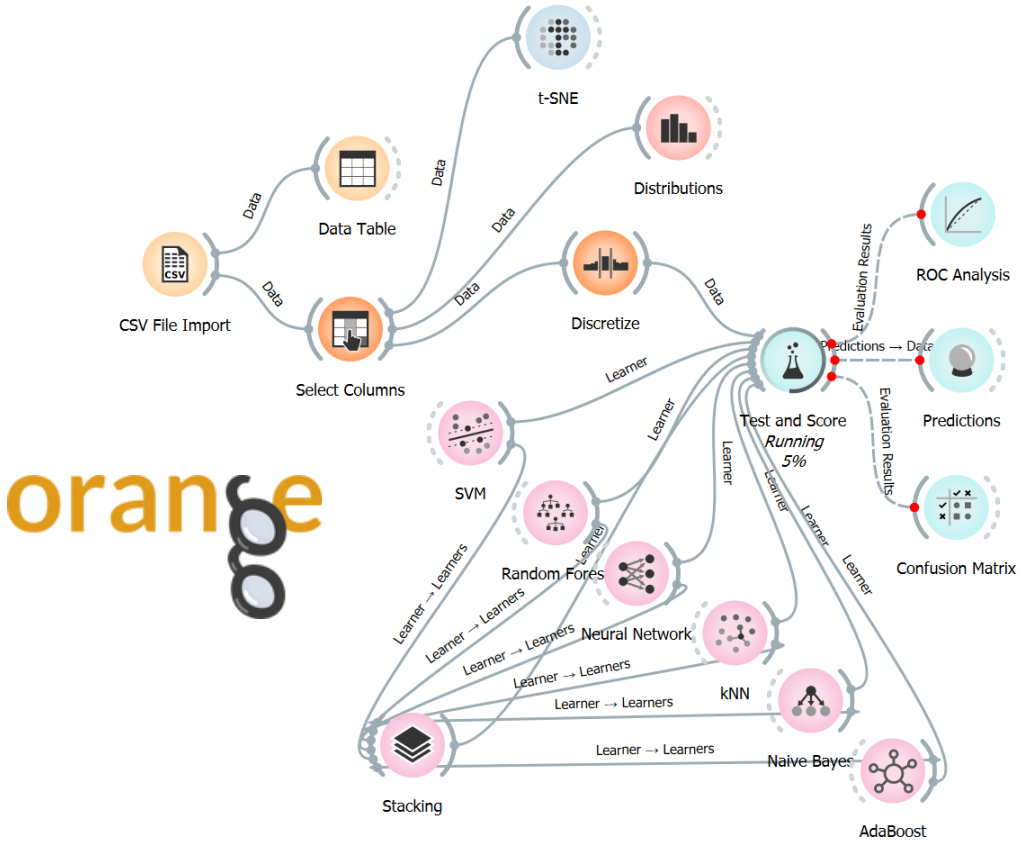
KEYSTROKE DYNAMICS PROFILING

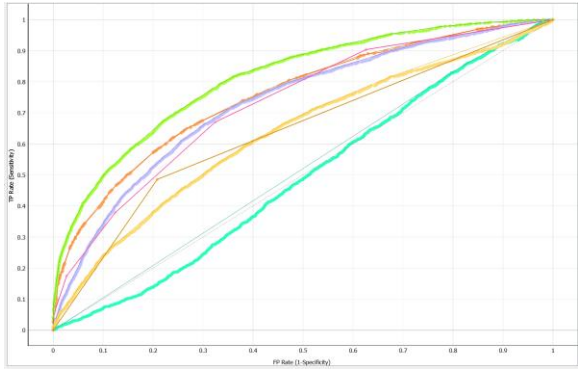
KEYSTROKE

PROFILING

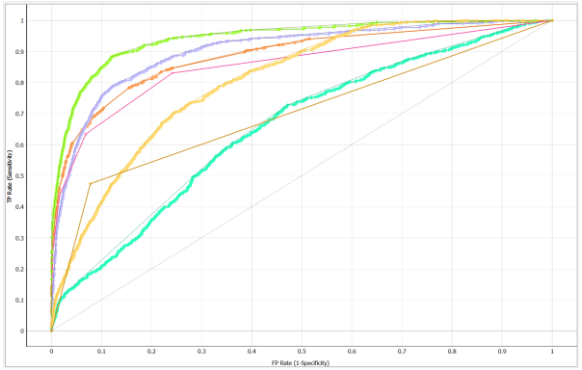
SOCIO DEMOGRAPHIC TRAITS

Profiling users with keystroke dynamics
Gender/Handedness/Age decade estimation

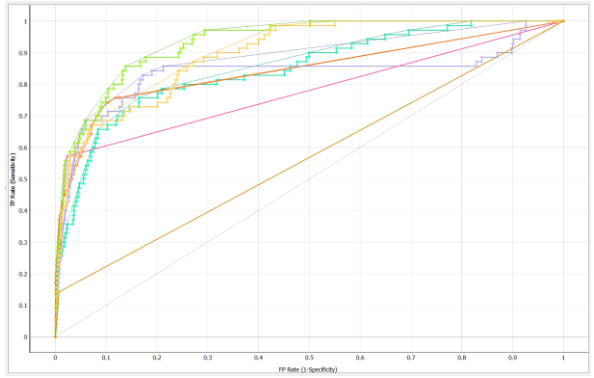




Gender (best 78%)



Handedness (best 93%)

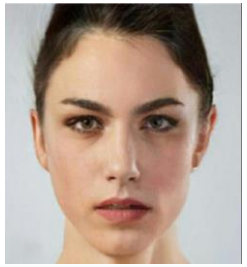


Age decade (best 53%)

Idrus, S. Z. S., Cherrier, E., Rosenberger, C., & Bours, P. (2014). Soft biometrics for keystroke dynamics: Profiling individuals while typing passwords. *Computers & Security*, *45*, 147-155.

SOCIO DEMOGRAPHIC TRAITS

Application: performance improvement
Combining decision functions considering the biometric data and the soft biometric information



X_1=(12.3 3 153 -3.2)
Biometric data

→ **Authentication score** → *Score*

X_1'=*Male*
A priori information

→ **Soft biometric method** → *Trait_confidence*
Soft_Similarity

Trait = score + (Trait_confidence)
Reward = score x (1 - Soft_Similarity)

Trait_confidence: difference between the real trait and the prediction
Soft_Similarity: percentage of similar biometric traits between the sample and the reference template

SOCIO DEMOGRAPHIC TRAITS

Application: performance improvement on keystroke dynamics

Classical biometric system

biometric system (Trait_confidence)

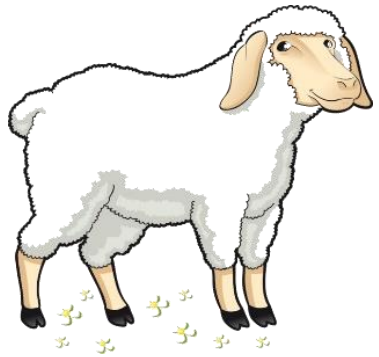
biometric system (Soft_similarity)

Password	Baseline	Gender	Age	Handedness	All soft biometric traits	Reward
Password 1	21.45%	**18.21%**	21.67%	19.64%	19.05%	10.27%
Password 2	18.38%	17.14%	17.14%	**16.67%**	18.45%	7.45%
Password 3	19.26%	19.64%	**16.19%**	19.05%	19.05%	9.59%
Password 4	19.84%	**14.29%**	19.52%	18.45%	17.86%	7.34%
Password 5	15.56%	13.93%	14.76%	**13.10%**	14.88%	14.09%
Fusion of 5 passwords	10.63%	10.36%	10.71%	12.50%	**8.33%**	5.41%

- ❑ EER value nearly divided by 2
- ❑ Processing of the same biometric data
- ❑ Taking into account a priori information

Syed Zulkarnain Syed Idrus, Estelle Cherrier, Christophe Rosenberger, Soumik Mondal and Patrick Bours, “Keystroke Dynamics Performance Enhancement With Soft Biometrics”. The IEEE International Conference on Identity, Security and Behavior Analysis (ISBA 2015) Hong Kong.

KEYSTROKE DYNAMICS PROFILING



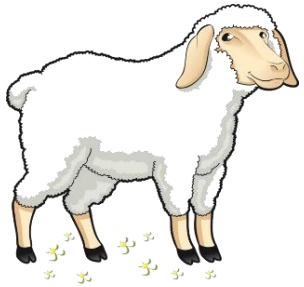
KEYSTROKE

PROFILING

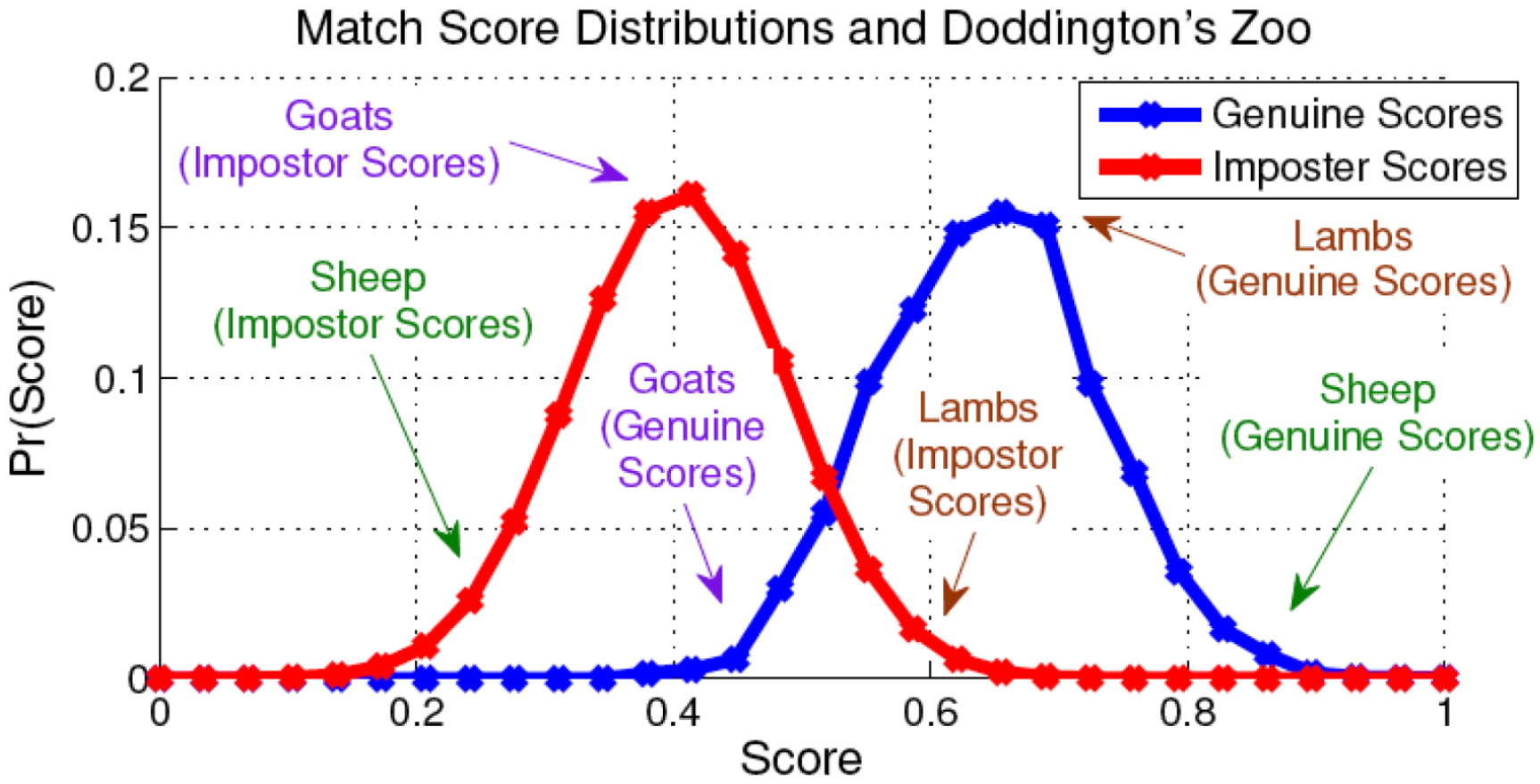
USERS RECOGNITION

Doddington zoo: different behaviours when using a biometric system

Sheep	Goats	Lambs	Wolves
Users who can easily be recognized	Users who are particularly difficult to recognize	Users who are easy to imitate	Users who can easily imitate others



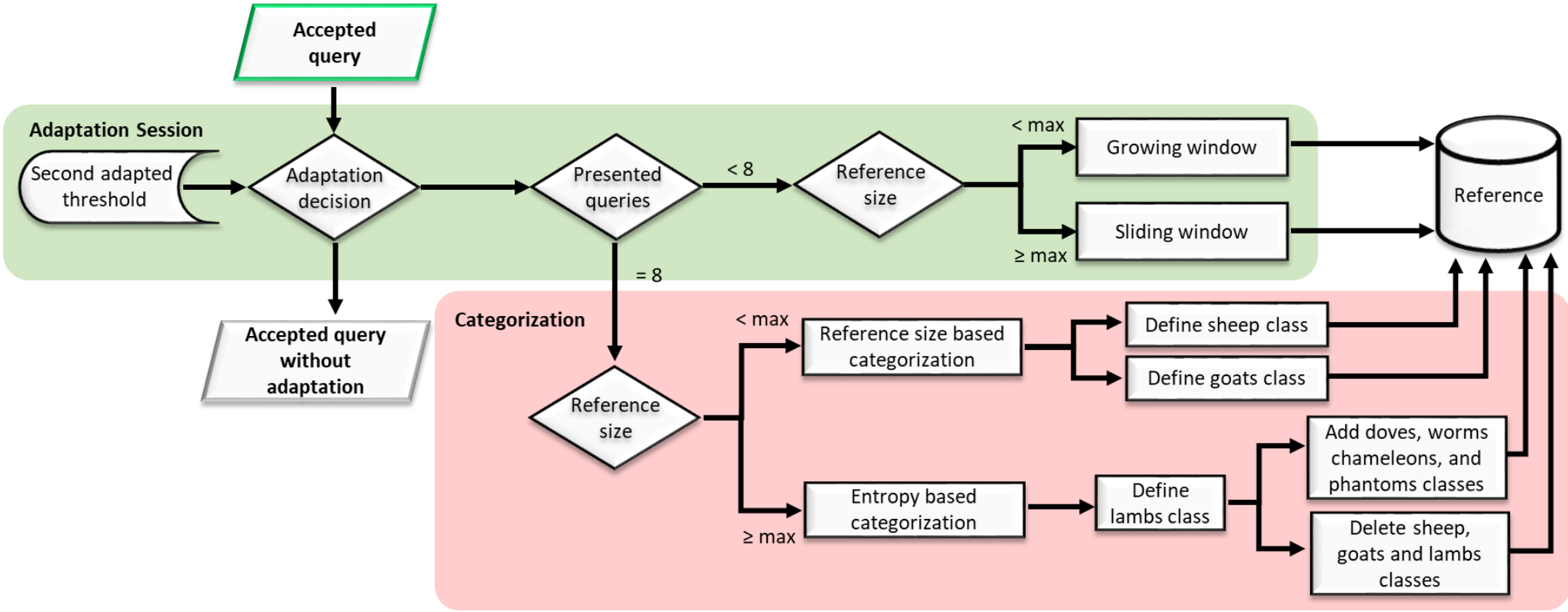
USERS RECOGNITION



DeCann, B., & Ross, A. (2013, September). Relating roc and cmc curves via the biometric menagerie. In *2013 IEEE Sixth International Conference on Biometrics: Theory, Applications and Systems (BTAS)* (pp. 1-8). IEEE.

USERS RECOGNITION

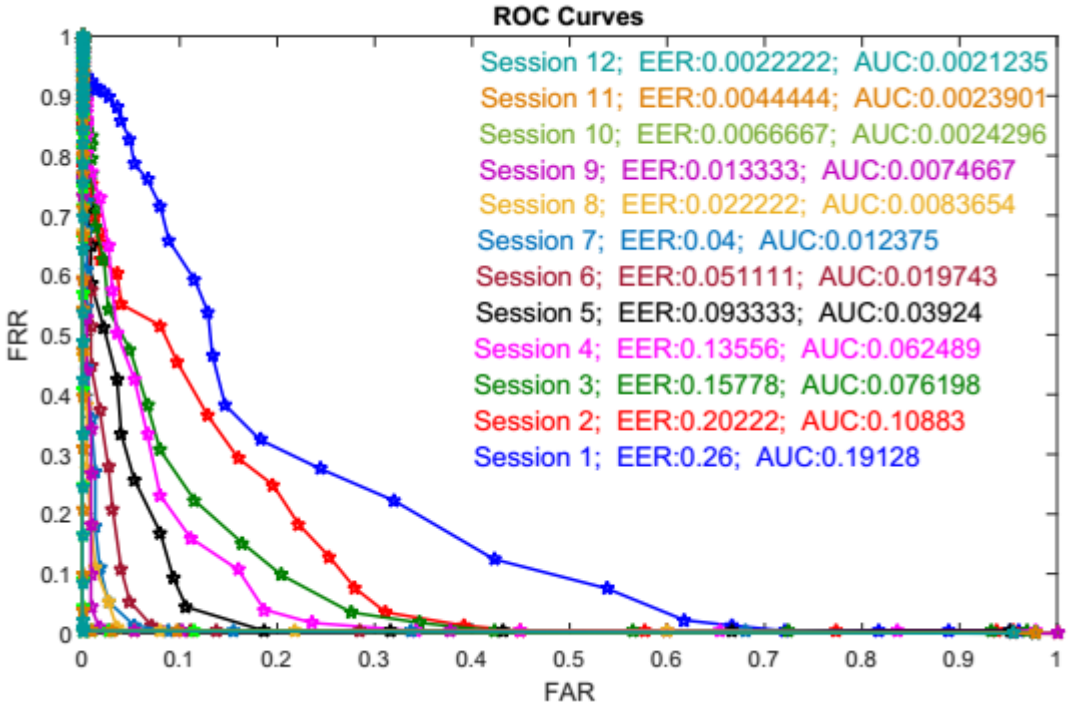
Evolution of keystroke dynamics: Template update approach



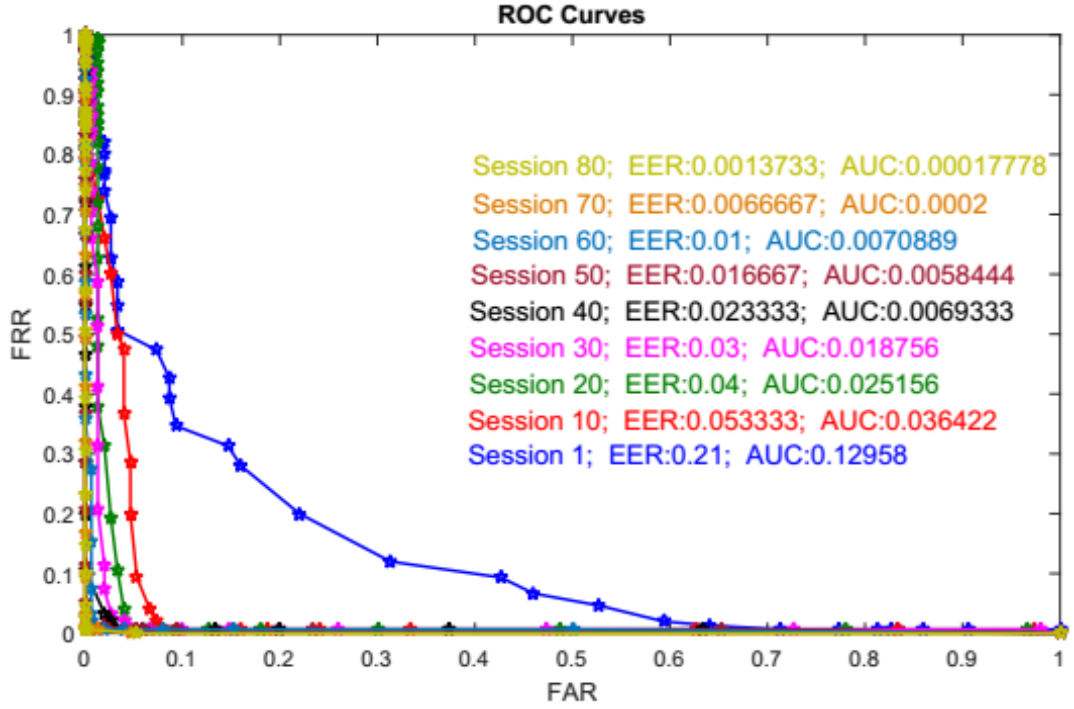
Mhenni, A., Cherrier, E., Rosenberger, C., & Amara, N. E. B. (2018, October). User dependent template update for keystroke dynamics recognition. In *2018 International Conference on Cyberworlds (CW)* (pp. 324-330). IEEE.

USERS RECOGNITION

Impact on performance: deacreasing errors with time



WEBGREYC database



CMU database

Illustration of ROC curves and the associated EER and AUC performances of each adaptation session.

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INDUSTRIAL APPLICATIONS

Distant exam monitoring
Protection of children on Internet

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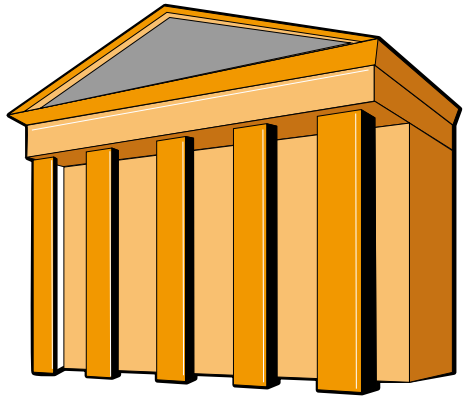
DISTANT EXAM MONITORING

Fraud during a distant exam
- ❑ Using keystroke dynamics to identify user impersonation
- ❑ Joint PhD thesis with TestWe company



Trust evolution

Fraud detection
Face & Keystroke
dynamics analysis

testwe
Security beyond simplicity

Les Sous-Doués (Claude Zidi 1980)

Haytom, M. A., Rosenberger, C., Charrier, C., Zhu, C., & Régnier, C. (2020, July). Identity Verification and Fraud Detection During Online Exams with a Privacy Compliant Biometric System. In *ICETE (2)* (pp. 451-458).

PROTECTION OF CHILDREN ON INTERNET

Behavior analysis on Internet

- ❑ Using keystroke dynamics to very users profile when chatting on Internet
- ❑ Startup created in 2018 in Norway with Pr. Patrick Bours (NTNU) as co-founder & Lead Researcher at Aiba

https://aiba.ai/

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CONCLUSION

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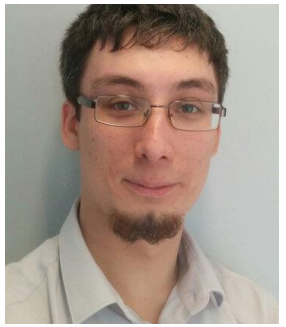
PHD STUDENTS

2008-2011
Data collection
Evaluation

2010-2014
User profiling



2016-2019
Anonymization

2020-2023
Deep learning feature extraction
Synthetic data generation

2010-2012
User profiling
Multibiometrics

2014-2019
Adaptive systems

2017-2021
Application to e-learning

2020
Challenge based
keystroke dynamics

2024
Fairness of
keystroke dynamics

CONCLUSION

Many uses cases of keystroke dynamics for real applications:

Demos

- **Identity verification**: Keystroke dynamics data can be used to verify a user's identity by comparing the extracted signature to the real one.
- **Profile verification**: we can check if the user has the correct profile (detecting a fake young girl of 14 years old as for example).
- **Authorship attribution**: In a digital world, users collaborate while editing documents. We believe the proposed framework could be used to determine/verify co-authors of a document.
- **Emotion detection**: can be used for health applications (depression) or mood estimation

"On the Internet, nobody knows you're a dog."

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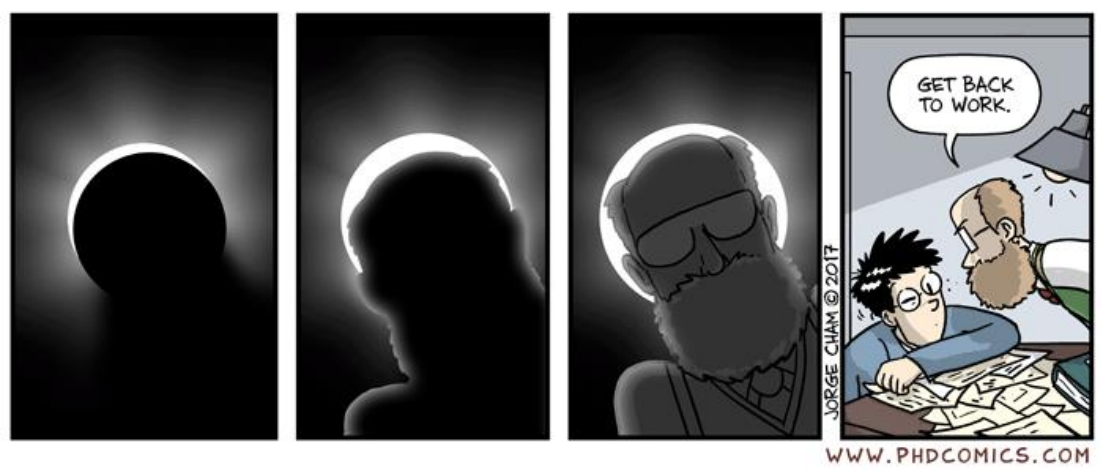

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