



# The landscape of facial processing applications and the challenges for the development of trustworthy systems

Isabelle Hupont Torres on behalf of the HUMAIN team  
European Commission - Joint Research Centre

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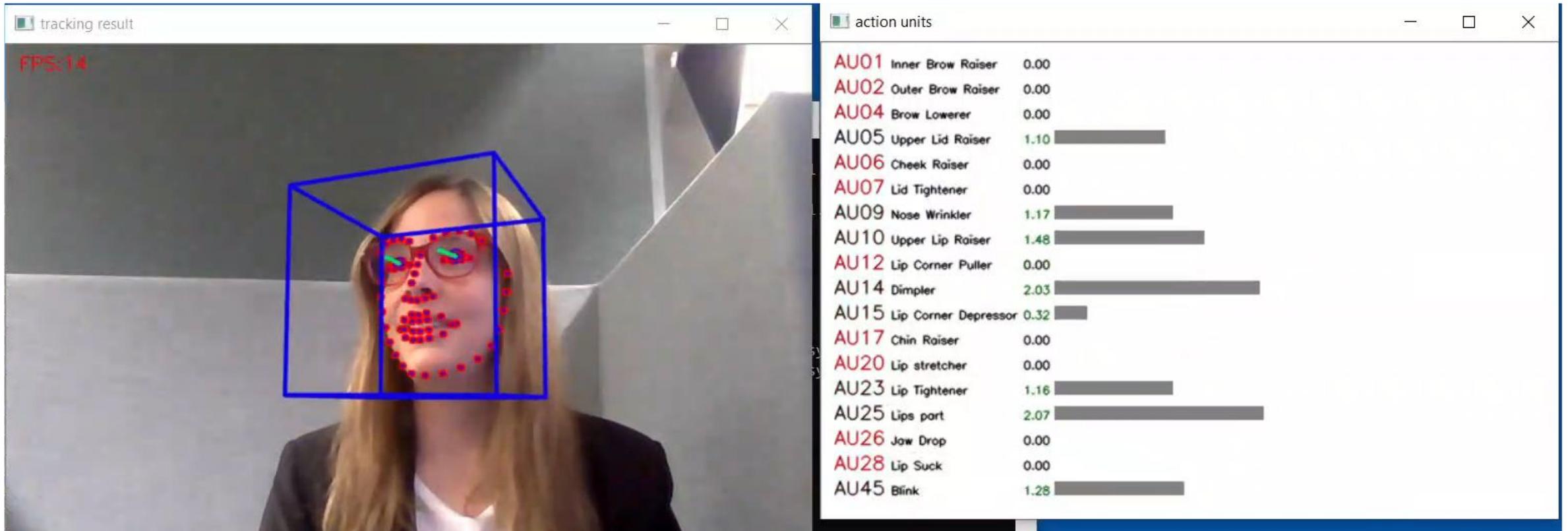


# HUMAINT

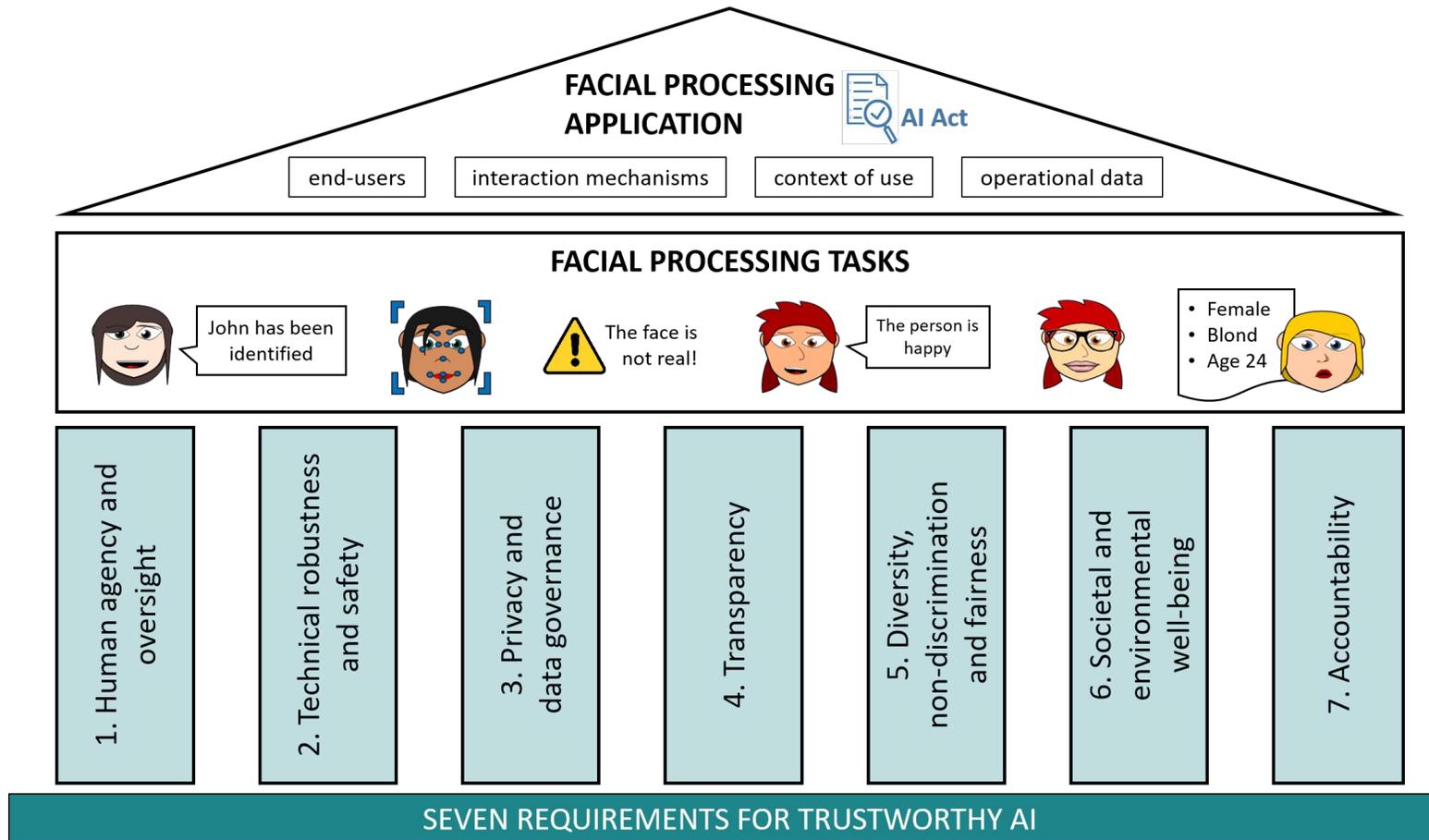
## Understanding the impact of Artificial Intelligence on human behaviour

1. Study **risks** and **opportunities** of current AI systems:
  - **Opportunities:** cognitive assistance, automation, personalization, support.
  - **Risks:** safety and fundamental rights.
2. Develop methodologies for **trustworthy AI**:
  - Diversity and **non-discrimination**
  - **Transparency**
  - Human **oversight**
3. Focus on scenarios with **strong social impact**:
  - Criminal justice, children, education, driving systems, affective computing...

# This is a facial processing algorithm



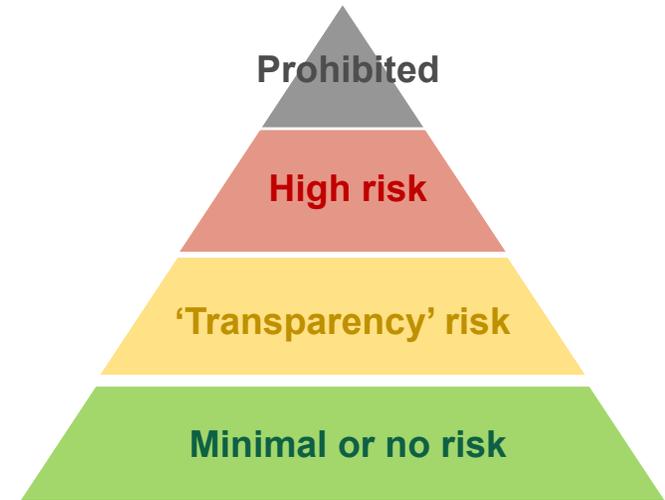
# Trustworthy facial processing: from algorithms to systems



Hupont, I., Tolan, S., Gunes, H., & Gómez, E. (2022). The Landscape of Facial Processing Applications in the Context of the European AI Act and the Development of Trustworthy Systems. Nature Scientific Reports.

# Establishing the landscape of facial processing

- We reviewed > 37K scientific publications.
- We identified 183 companies.
- We compiled 60 real-world applications.
- For each, we assessed **application areas**, **risk level** (according to the AI Act), **academic references** and **key companies**.



# Main limitations and challenges identified

- Facial processing systems are **not well-documented**, which causes **disinformation**.
- The cause of **fairness** problems relies on **datasets**:
  - ❑ Demographically imbalanced.
  - ❑ Big Techs vs SMEs (e.g. Google & Facebook > 12x public datasets, SMEs limited by research-only licenses).
- Software architectures tend to be increasingly **distributed**:
  - ❑ Security and privacy issues.
  - ❑ More research is needed on federated learning, visual cryptography, data minimisation...
- Need for **evaluation benchmarks** beyond accuracy and considering **operational** settings:
  - ❑ Important factors are neglected: energy consumption, fairness, explainability, human oversight.

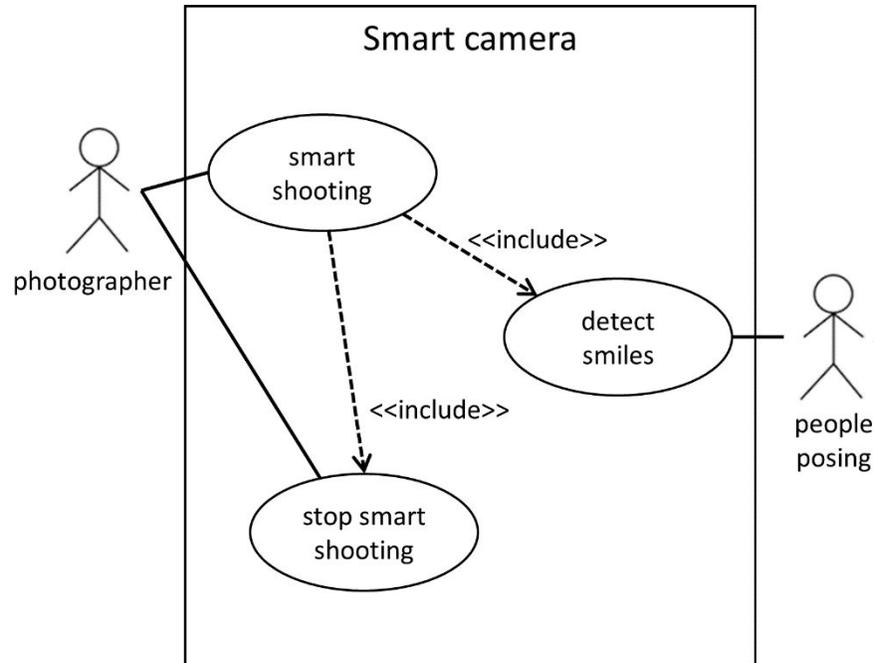
# Facial processing applications

ID	Risk	Application	Computational tasks	Areas	# Companies	
					SME	Large
BI1	●●	Access control	FD + FI (+FSD)	BIC, MCI, EDU, EMP, <u>LE</u> , VSU, TRA, ENT, CLI, TOU, FIN, IND	33	20
BI2	●●	Access control with masks	FD (+FAM) + FI (+FSD)	idem	4	6
BI3	●	Border control*	FD + FV + FSD	BIC, MIG, LE	6	10
BI4	●	Banking authentication*	FD + FV + FSD	BIC, FIN, MKT	11	13
BI5	●●	Sousveillance (video surveillance at human level using, e.g., bodycams)	FD (+FT) + FI	BIC, <u>LE</u> , MCI, VSU	9	1
BI6	●	Devices, machines and data unlocking*	FD + FV + FSD	BIC, MCI, ENT, IND, TRA, CLI	13	14
BI7	●	Face authentication for e-Government*	FD + FV	BIC, SER, JUS, EMP, POL, CLI	1	5
BI8	●●	Unconstrained face identification	FD (+FT) + FI	BIC, <u>LE</u> , MIG, MCI, VSU	33	14
BI9	●●	Person re-identification	FD + FT + FI	BIC, <u>LE</u> , MCI, VSU	3	3
BI10	●	Person search by identity <sup>†</sup>	FD (+FT) + FV	BIC, LE, VSU, ENT	23	8
BI11	●●	Contact tracing <sup>†</sup>	FD + FT + FI	BIC, <u>LE</u> , CLI	4	0
BI12	●●	Person tracking with drones	FD + FT + FI	BIC, <u>LE</u> , VSU	2	0
BI13	●●	Perimeter protection	FD + FT + FI	BIC, <u>LE</u> , MCI, VSU	5	3
BI14	●	Control of attendance	FD + FV/FI	BIC, EMP, EDU	17	9
BI15	●	VIP recognition	FD (+FT) + FI	BIC, MKT, ENT, TOU, FIN	14	1
BI16	●	Face tagging in personal pictures and videos	FD + FI	BIC, ENT	3	9
BI17	●	Assistance for people with visual impairments	FD (+FT) + FI (+FER)	BIC, SOC, CLI	0	1
BI18	●●	Person search in social networks <sup>†</sup>	FD + FV	BIC, <u>LE</u> , EMP, SER, MKT, POL	1	0
BI19	●●	Mobile surveillance robots	FD (+FT) + FI	BIC, <u>LE</u> , MCI, VSU, IND	2	0
BI20	●	Product personalisation	FD (+FT) + FI	BIC, ENT, TRA, MKT	2	3
BC1	●	Demographic analysis	FD + FT + FAE	BIC, MKT, TOU	21	9
BC2	●●	Person search by facial appearance	FD (+FT) + FAE	BIC, <u>LE</u> , VSU, ENT	1	1
BC3	●●	Face mask detection	FD (+FT) + FAE	BIC, <u>LE</u> , CLI, VSU, TOU, MKT, TRA	13	6
BC4	●	Decision-making based on detected personal attributes	FAE	BIC, EDU, EMP, SER, MIG, JUST, SOC, FIN	0	0
BC5	●	Personalisation of advertising content	FD + FAE	BIC, MKT	4	0
BC6	●	Verification for age-restricted goods	FD + FAE	BIC, MKT, ENT	2	1
BC7	●	Clinical syndrome assessment	FD (+FT) + AU/FAE/FER	BIC, CLI	1	0

# Facial processing applications

ID	Risk	Application	Computational tasks	Areas	# Companies	
					SME	Large
ER1	●	Smile detection	FD + FAE/FER/AU	ENT	0	8
ER2	●	In-lab user experience testing	FD + FER (+AU)	MKT, ENT	12	3
ER3	●	Crowdsourced user experience testing	FD + FER (+AU)	MKT, ENT	6	1
ER4	●	Measure of consumer satisfaction	FD (+FT) + FER (+AU)	MKT, ENT, TOU, CLI	4	3
ER5	●	Student proctoring and tutoring	FD + FER (+AU)	EDU	4	3
ER6	●	Job interviews	FD + AU (+FER)	EMP	2	1
ER7	●	Audience affect monitoring	FD + FER (+AU)	EDU, ENT, POL, CUL	4	1
ER8	●	Emotional gaming experience	FD + FER (+AU)	ENT	0	0
ER9	●	Interactive emotional art	FD (+FT) + FER	ENT, CUL	3	2
ER10	●	Emotional recommendation system	FD (+FT) + FER	ENT, CUL, MKT	0	0
ER11	●	Driver monitoring and warning	FD + FER (+AU)	TRA	7	6
ER12	●	Driver monitoring for autonomous vehicles	FD + FER (+AU)	TRA	2	3
ER13	●	Affective interaction with agents	FD + FER (+AU)	ENT, MKT	12	3
ER14	●	Affective robots as companions for elderly	FD + FER (+AU)	CLI, SOC	4	3
ER15	●	Social robots for children with autism	FD + FER (+AU)	EDU, CLI, SOC	4	1
ER16	●	Pain detection	FD + AU (+FER)	CLI	2	0
ER17	●	Police interrogations	FD + AU (+FER)	LE, MIG, JUS	4	0
ER18	●	Emotion estimation in groups or crowds	FD + FER	LE, VSU, ENT	0	0
OT1	●	Pandemic control	FD + FT	LE, VSU, CLI	6	1
OT2	●	Occupancy control	FD + FT	MCI, VSU, MKT, TOU, ENT, CLI	15	4
OT3	●	People counting in crowds	FD (+FT)	LE, VSU	3	3
OT4	●	Photo-sketch matching	(FAM+) FV	LE, JUS	0	0
OT5	●	Interactive facial attribute manipulation	FAM	LE, JUS, ENT, CLI	4	2
OT6	●	Facial augmented reality	FD + FLE	ENT	7	2
OT7	●	Image and video anonymisation	FD (+FAM)	LE, VSU, ENT	5	0
OT8	●	Visual lifelogging as memory aid	FD + FT (+FI)	SOC, CLI, ENT	2	2
OT9	●	Video summarization	FD (+FT + FER)	LE, VSU, ENT	2	1
OT10	●	Generation of deepfake videos	FD (+FT) + FAM (+FER)	ENT, POL, MKT, CUL	2	1
OT11	●	Facial motion capture for virtual character animation	FD + FLE (+AU + ALR)	ENT	6	5
OT12	●	Evidence for parentage and kinship	FD (+FAM + FER) + KV	LE, JUS, SOC, CLI	1	0
OT13	●	Automatic transcription or enhancement of speech	FD (+FLE) + ALR	LE, VSU, CLI, ENT	2	0
OT14	●	Speech recognition for voice impaired	FD (+FLE) + ALR	CLI	2	0
OT15	●	Face-guided communication and interaction	FD + FT (+AU +FER)	CLI, ENT	2	1

# Towards a unified documentation of use cases



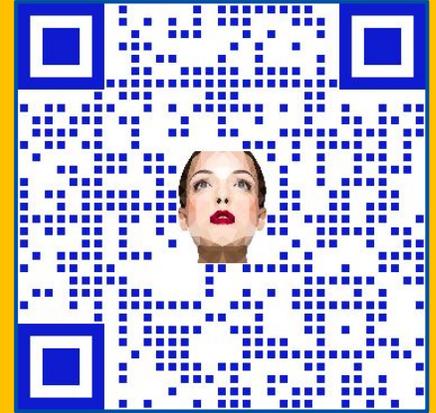
USE CASE	Smart shooting	
Context of use	A group of people (min. 1 – max. 10 persons) wishes to take a picture ensuring that they all appear smiling on it. They use a smart camera hardware with an embedded smile detection algorithm for that purpose.	
Intended purpose	Automatically take a picture of the person or group of persons posing facing the camera when everyone is smiling.	
Application areas	Entertainment and leisure	
User	Photographer	
Target persons	Person	Description
	People posing	Persons posing facing the camera.
Success end condition	A picture is recorded in the camera internal storage, in which all people shot are smiling.	
Failure protection	If the picture is not taken, the “smart shooting” mode is turned off and a message pops up to the user.	
Trigger	The photographer presses the “smart shooting” button.	
Main course	Step	Action
	1	The camera turns on the “smart shooting” mode.
	2	The smile detection algorithm detects faces and smiles, until all detected faces are smiling.
	3	The picture is taken.
	4	The picture is saved in the camera’s internal storage.
Extensions	Step	Branching action
	2a	No smile is detected for more than 5 minutes.
	4a	The picture cannot be saved.
Misuses	The system is not intended to monitor or manipulate persons’ emotions by forcing them to smile, e.g. in working environments.	

# Conclusions: key steps towards trustworthy AI

- Put the **focus on systems**, not just on algorithms.
- Facial analysis has **risks** that need to be carefully assessed...
- ... but also offers many **opportunities**. Some applications for social good are being **developed by SMEs** and/or still not in the market.
- **Incentivize data sharing** practices.
- Create for a **unified documentation of use cases**.
- Develop **operational benchmarks** for systems' evaluation.

# Thank you!

Contact: [isabelle.HUPONT-TORRES@ec.europa.eu](mailto:isabelle.HUPONT-TORRES@ec.europa.eu)



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