Horus: AI-Driven Solutions for Synthetic Realities in the Digital Age

Prof. Anderson Rocha
IEEE Fellow
Institute of Computing, Unicamp
arrocha@unicamp.br

Unicamp Professor for almost 15 years
Expert in **Artificial Intelligence** and **Complex Data** (23+ years)
Research in both theoretical and applied aspects of Artificial Intelligence

Reasoning for Complex Data (**Recod.ai**) Lab. Coordinator
> Recod.ai counts with ~350 collaborators worldwide
> One of the largest and most productive in Latin America (LATAM)

IEEE Fellow
Microsoft, Google e Tan-Chin Tuan Foundation **Fellow**
Asia Pacific Association AI Fellow

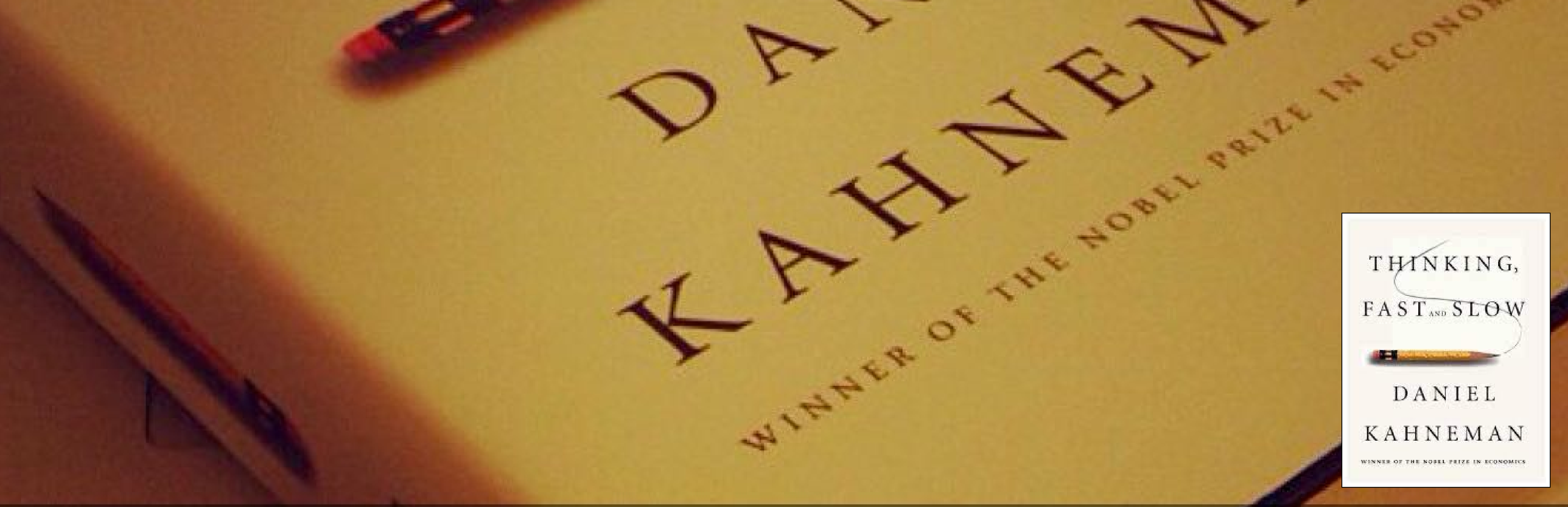
Listed among the **TOP-2% Scientists** worldwide (According to Stanford/PlosOne Study)

Visiting Professor to multiple institutions over the years

Tag me

Univ. of Colorado, Colorado Springs

recod.ai
reasoning for complex data



WYSIATI

DANIEL KAHNEMAN & DAVID MCRANEY

Historically, we've always relied on **artifacts**

Artifacts

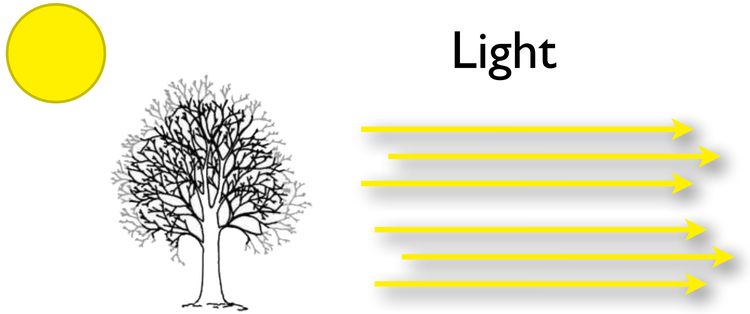
Acquisition

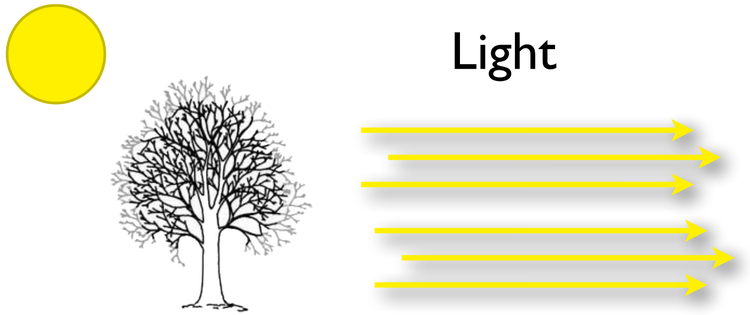
Illumination + Shadows

File structures

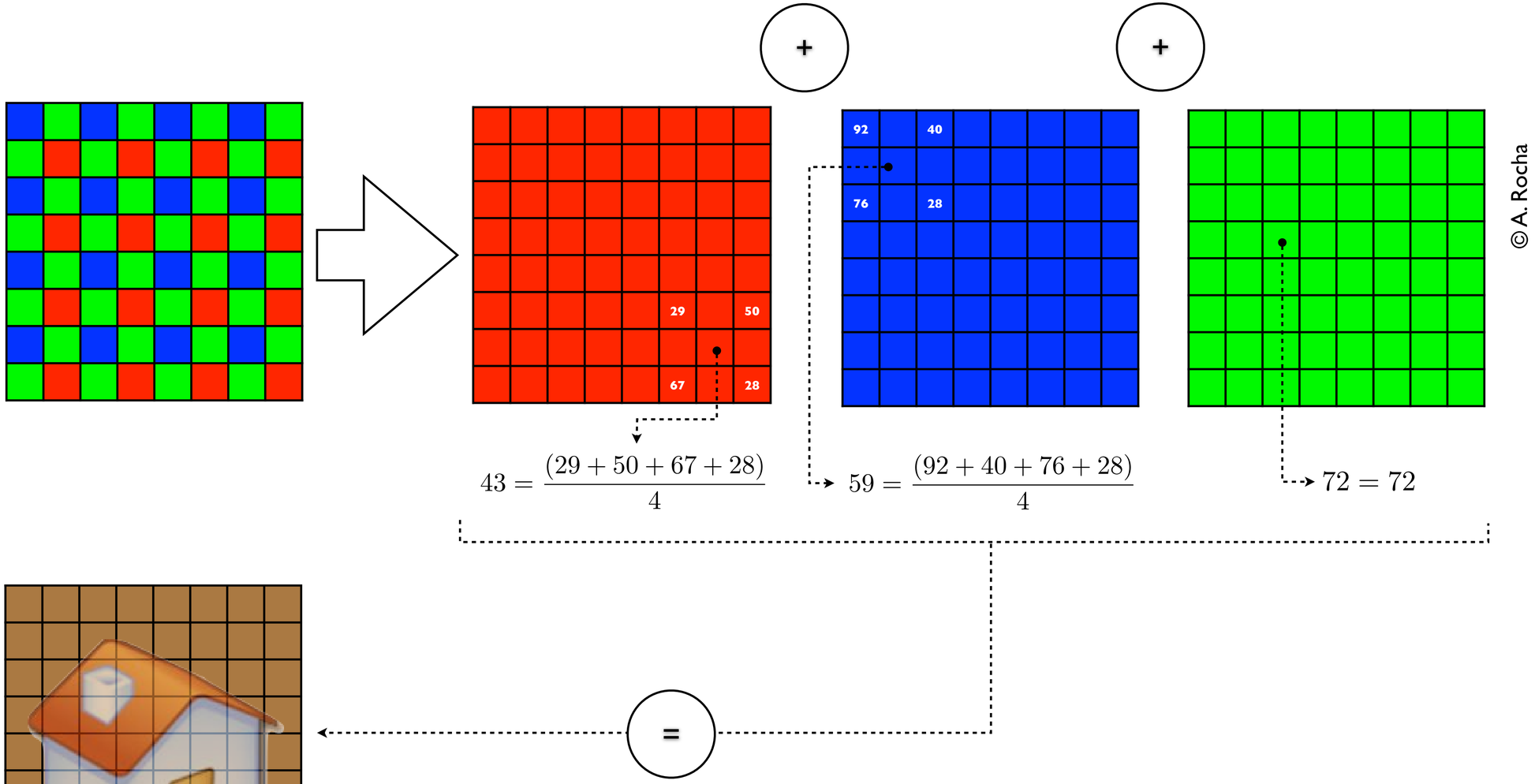
Structural Properties (pixel, semantics, neighbors)

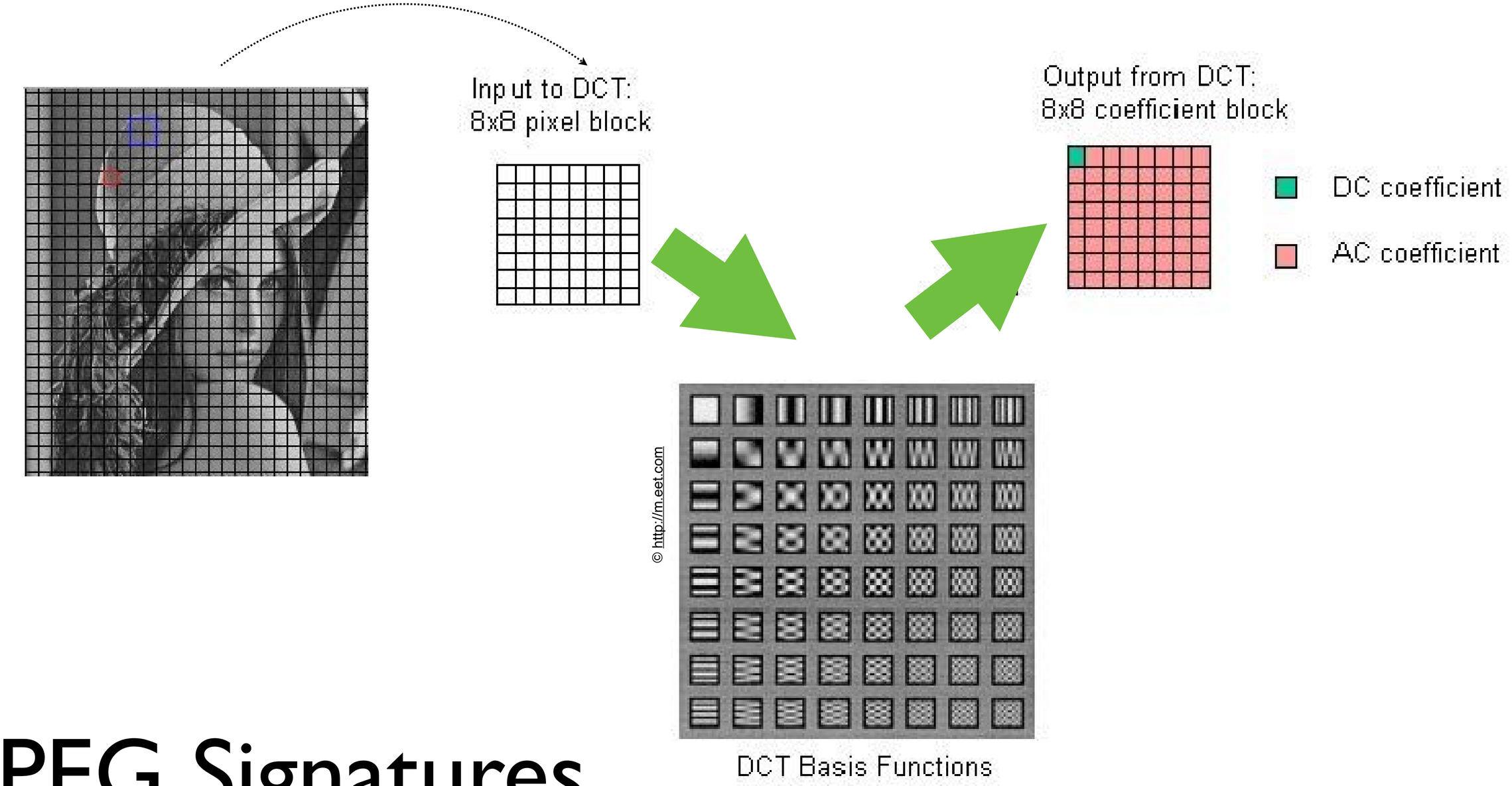
Compression


Light
Lenses
Filters
Exposition, Focus,
Stabilization
Infra-red
Anti-aliasing
Quality Enhancement
Image Processing Unit
Imaging Sensors
• Demosaicing
• White correction
• Sharpening
• Aperture and Gamma correction
• Compression
• …
CCD, CMOS...
Resulting Photography
Mosaic
Color Filter Arrays (CFA)...


Light
Lenses
Exposition, Focus,
Stabilization
Filters
Infra-red
Anti-aliasing
Quality Enhancement
Imaging Sensors
CCD, CMOS...
Mosaic
Color Filter Arrays (CFA)...
Image Processing Unit
• Demosaicing
• White correction
• Sharpening
• Aperture and Gamma correction
• Compression
• …
Resulting Photography

Mosaicing


+
+
92
40
76
28
29
50
67
28
$43 = \frac{(29+50+67+28)}{4}$
$59 = \frac{(92+40+76+28)}{4}$
$72 = 72$
=
©A. Rocha



JPEG Signatures

Structural Artifacts

Challenges

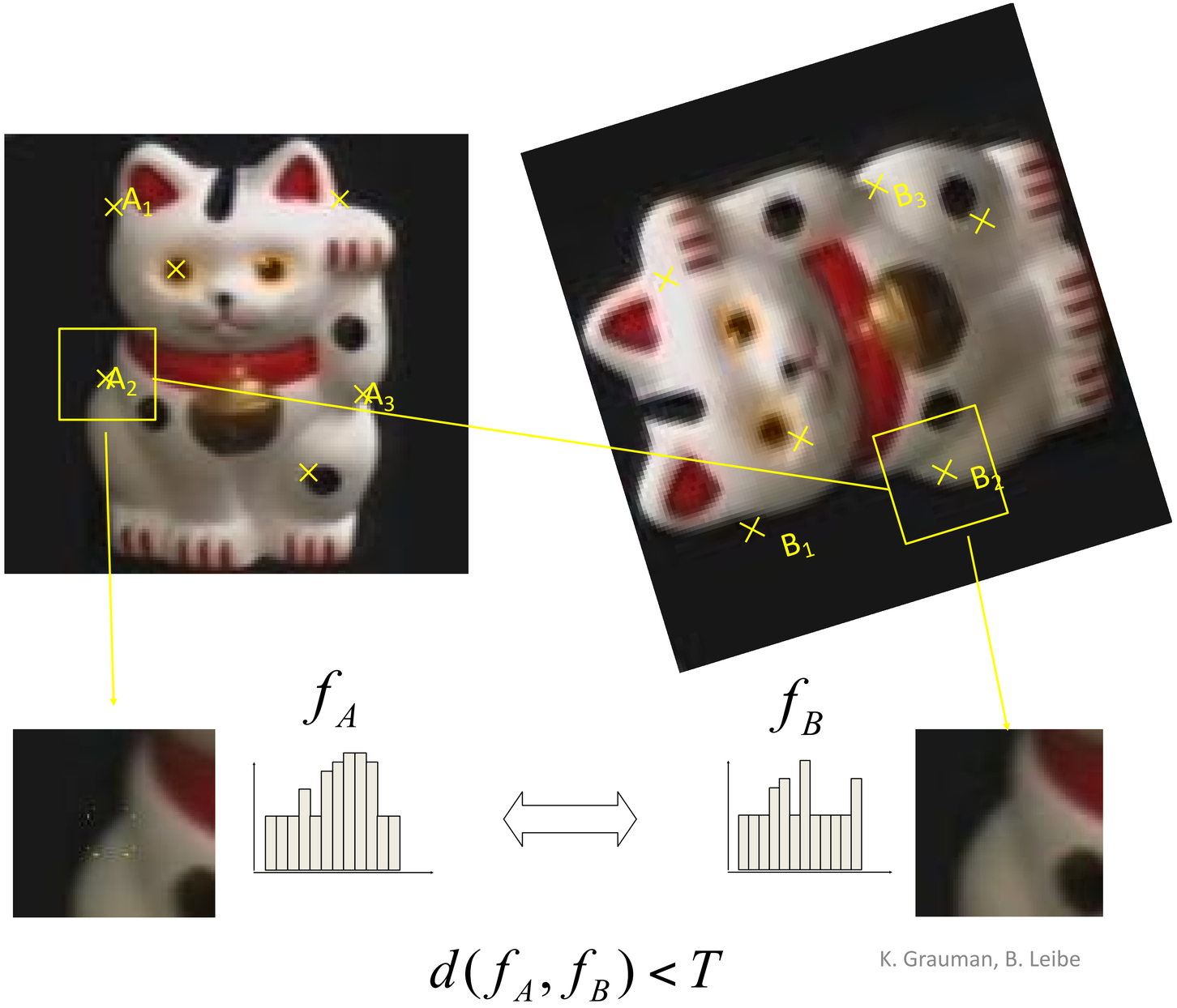
Compression

Scale

Rotation

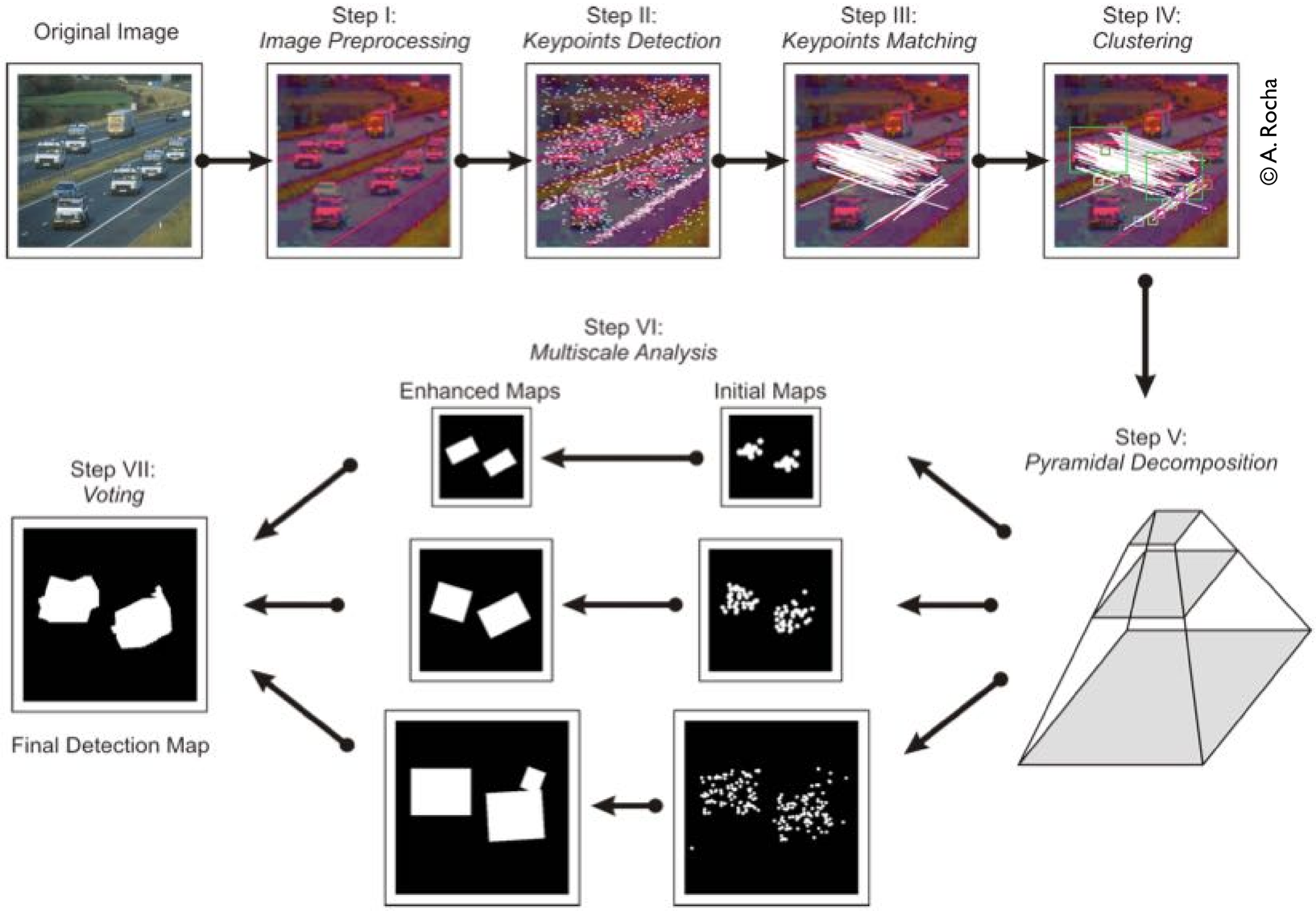
Illumination

Way out?



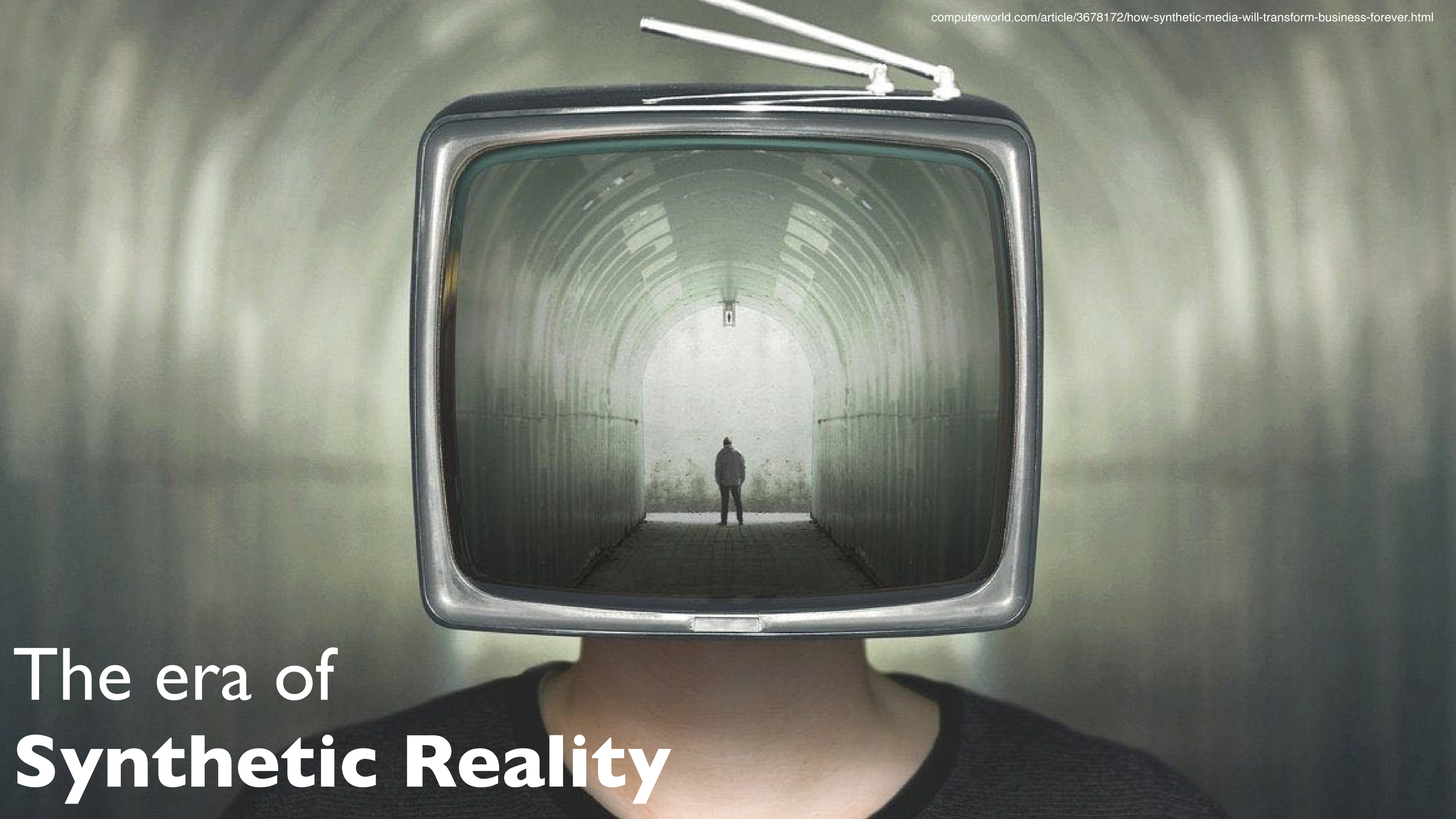
K. Grauman, B. Leibe

Multi-scaling



Going deeper into copy-move forgery detection: exploring image telltales via multi-scale analysis and voting processes.
E. Silva, T. Carvalho, A. Ferreira, and A. Rocha. Elsevier Journal of Visual Communication and Image Representation (JVCI). *Best Paper*

Then… **everything** changed



The era of **Synthetic Reality**

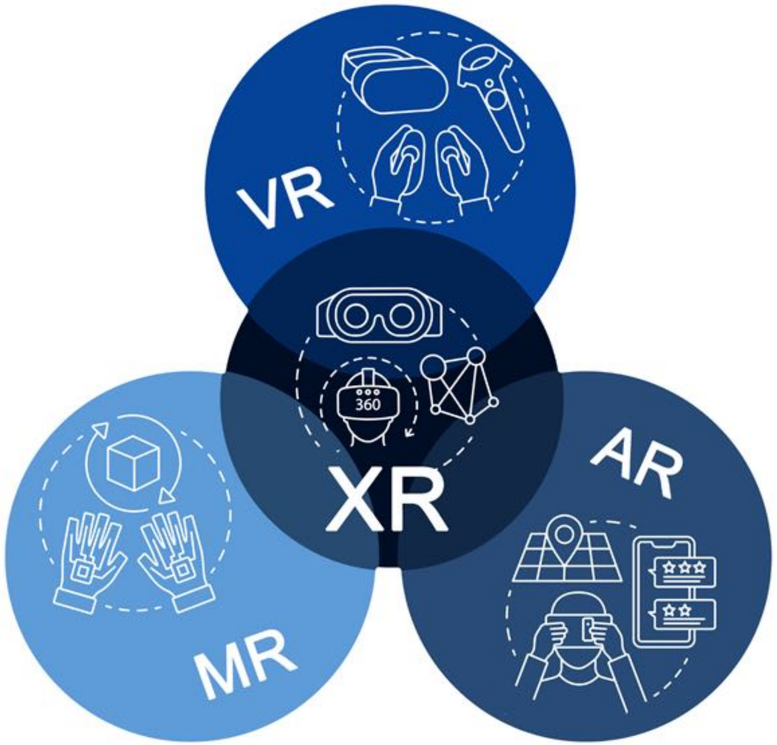
Synthetic Reality

AI-driven synthetic media

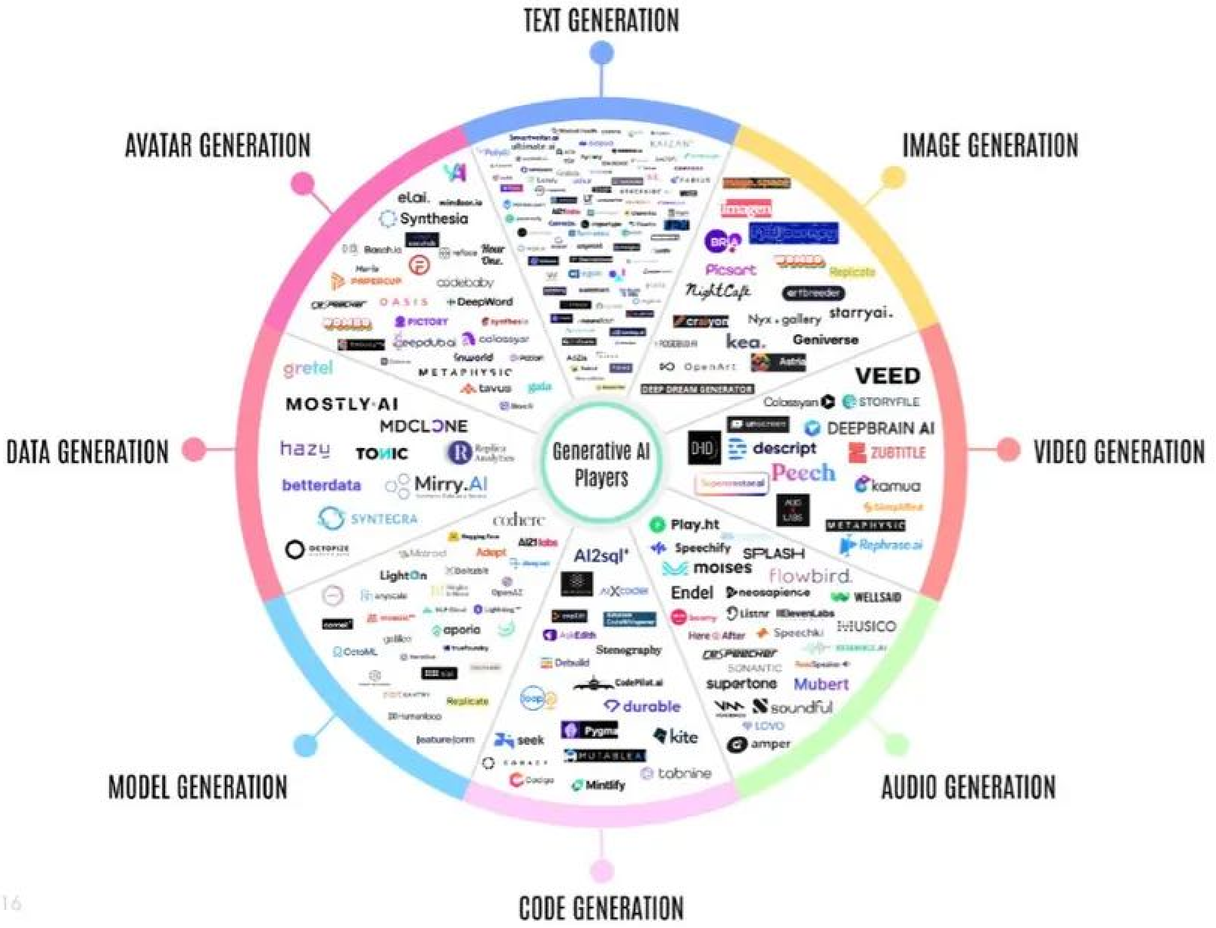
Context

Narratives

VISION OF THE FUTURE



NEW REALITY



Number of AI-Created Images*

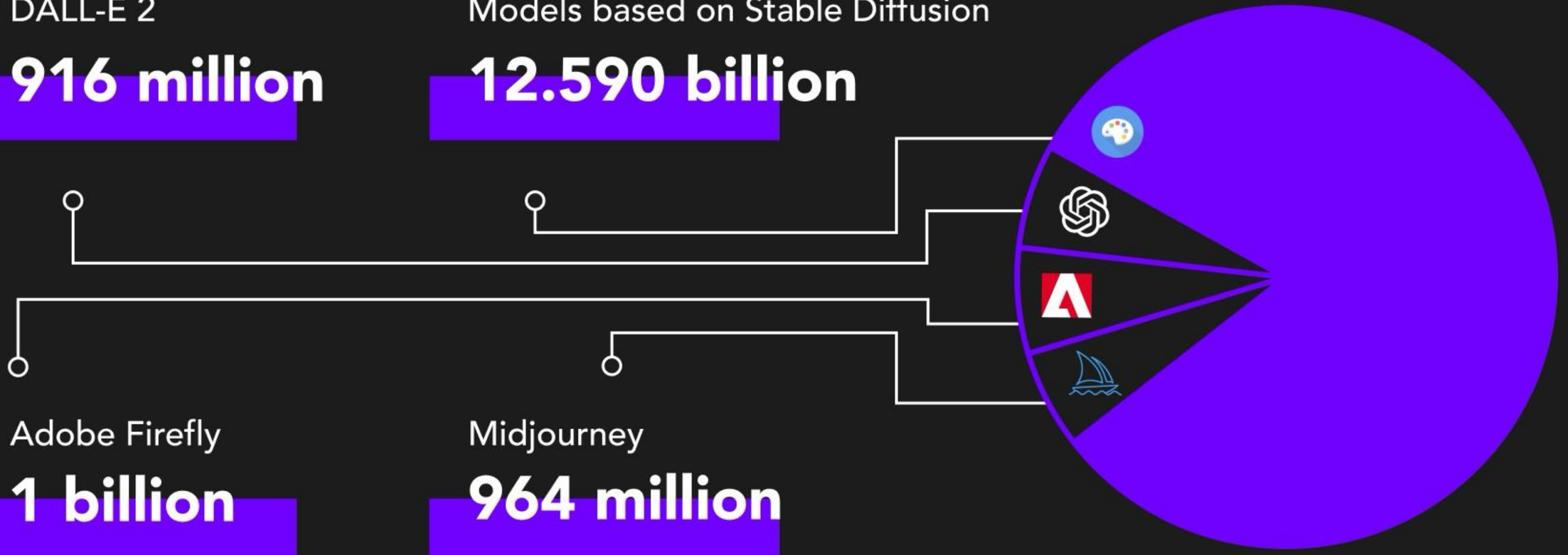
EVERYPIXEL

DALL-E 2

916 million

Models based on Stable Diffusion

12.590 billion



Adobe Firefly

1 billion

Midjourney

964 million

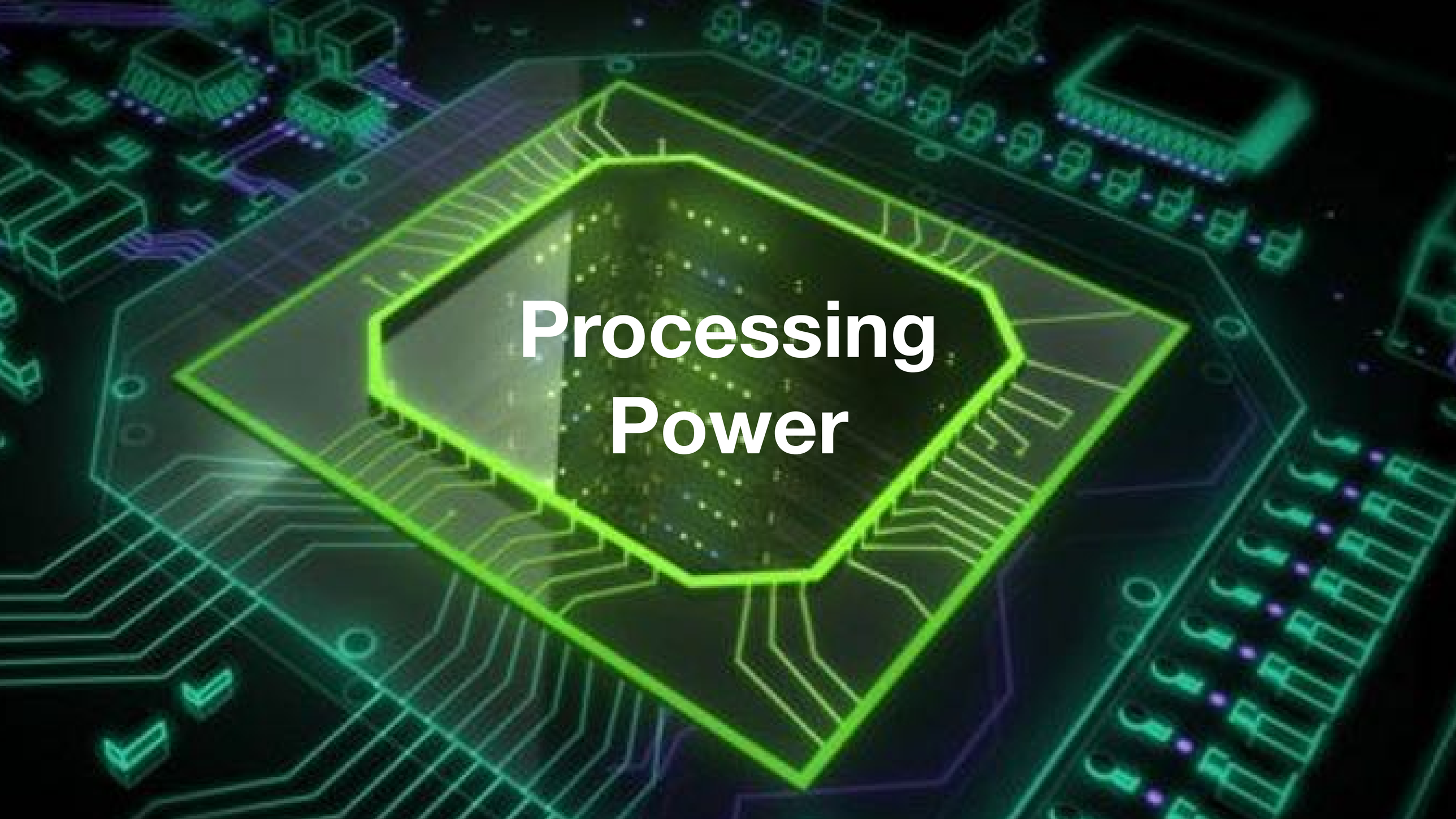
15.470 billion

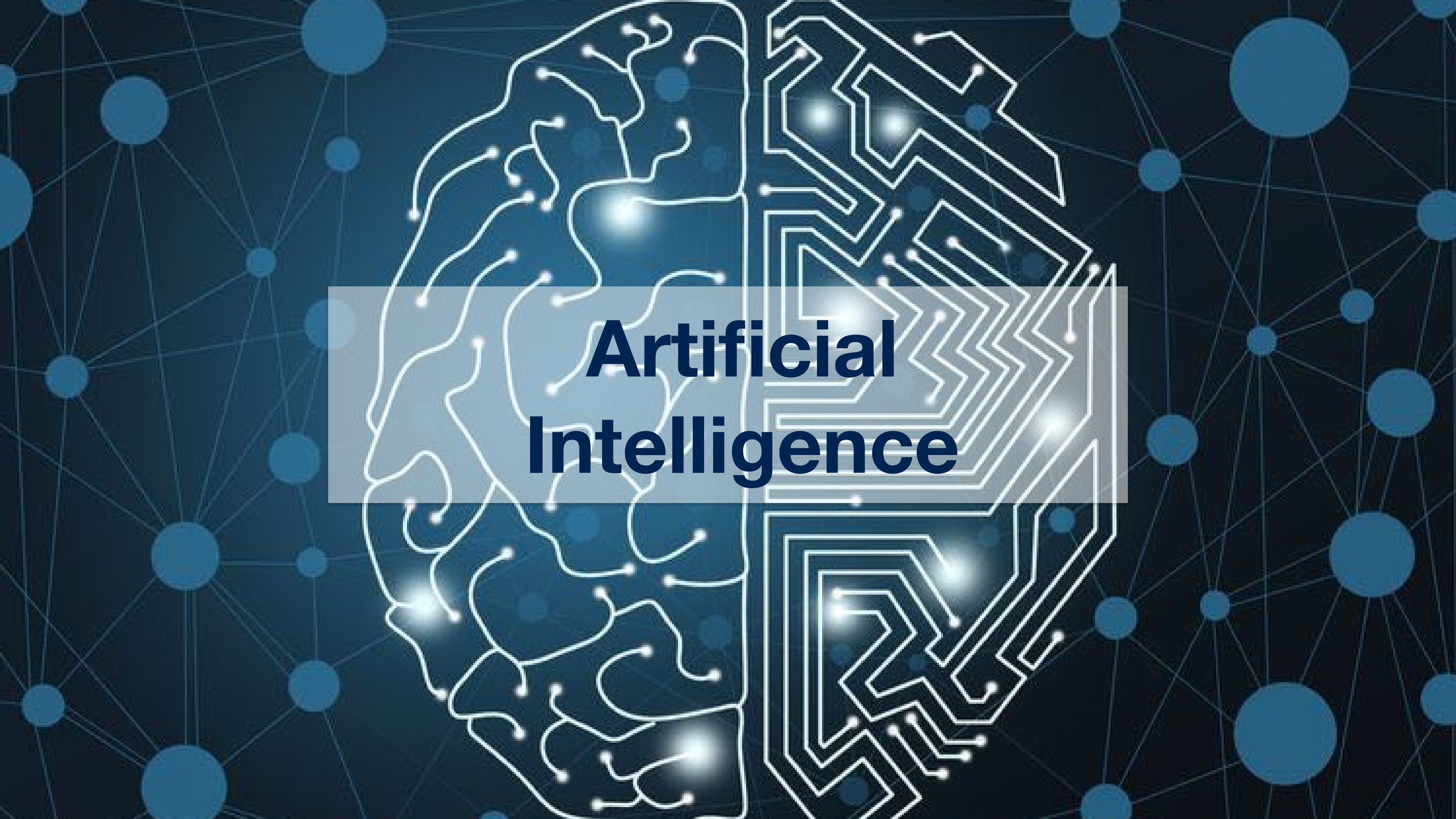
Sources: Adobe;
our estimates, based on Photutorial, OpenAI, Civitai

*As of August 2023

> Data and Image from EveryPixel


Data!
(as never before)


Processing
Power


Artificial
Intelligence


Théâtre d'Opéra Spatial by Jason M. Allen

https://www.cpr.org/2023/09/06/jason-allens-ai-art-won-colorado-fair-feds-deny-copyright-protection/

Jason Allen at his Atelier, Colorado, U.S.









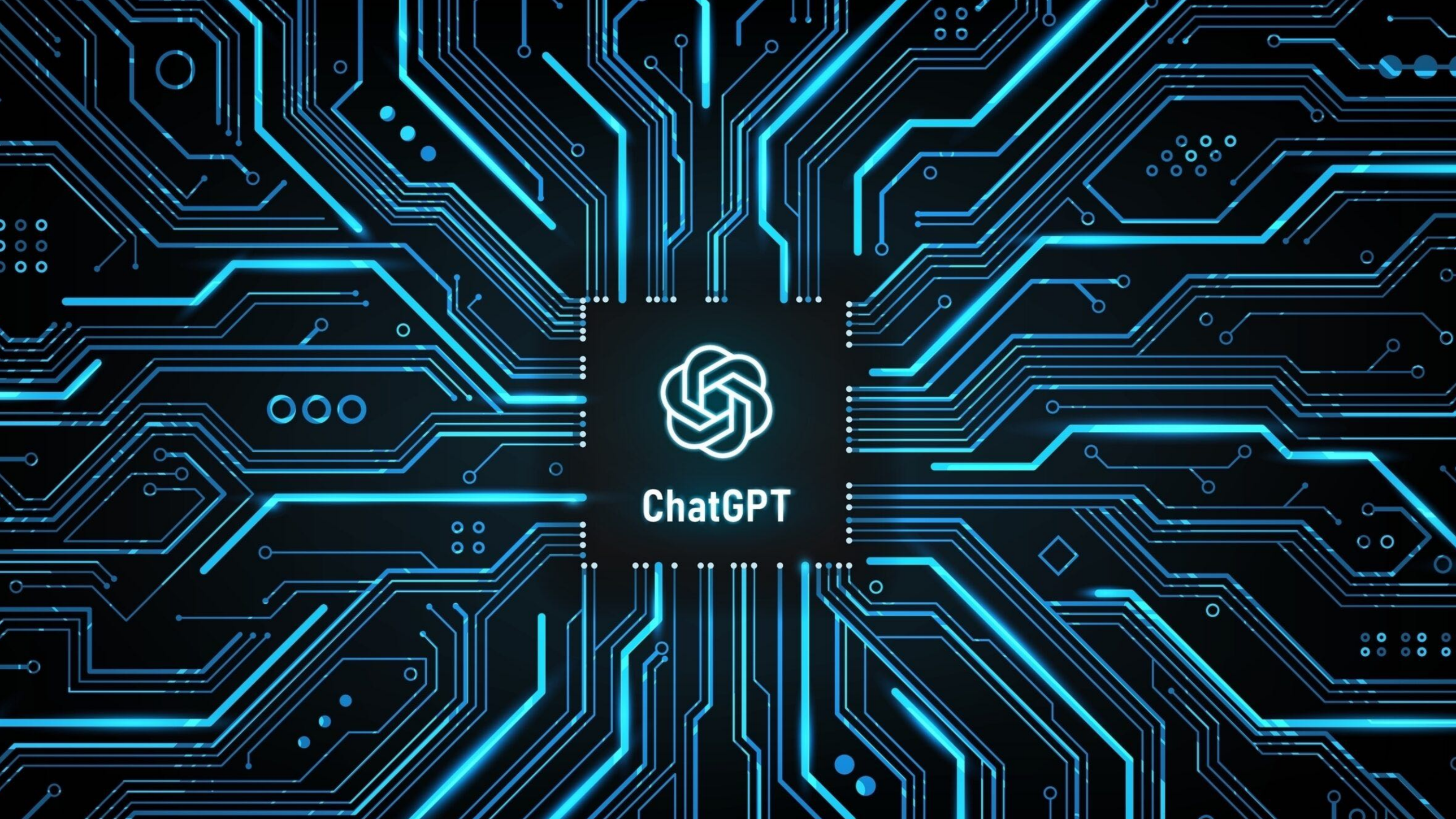
ADDBE










ChatGPT


OpenAI
SORA

All digital content has a history

In this new world of synthetic media and generative AI, the need for transparency has arrived. Using C2PA, Truepic provides publishers, creators, and consumers the ability to trace the origin of different types of media.

2.8B

people regularly use image editing apps

34.0M

images are generated with AI every day

51.1%

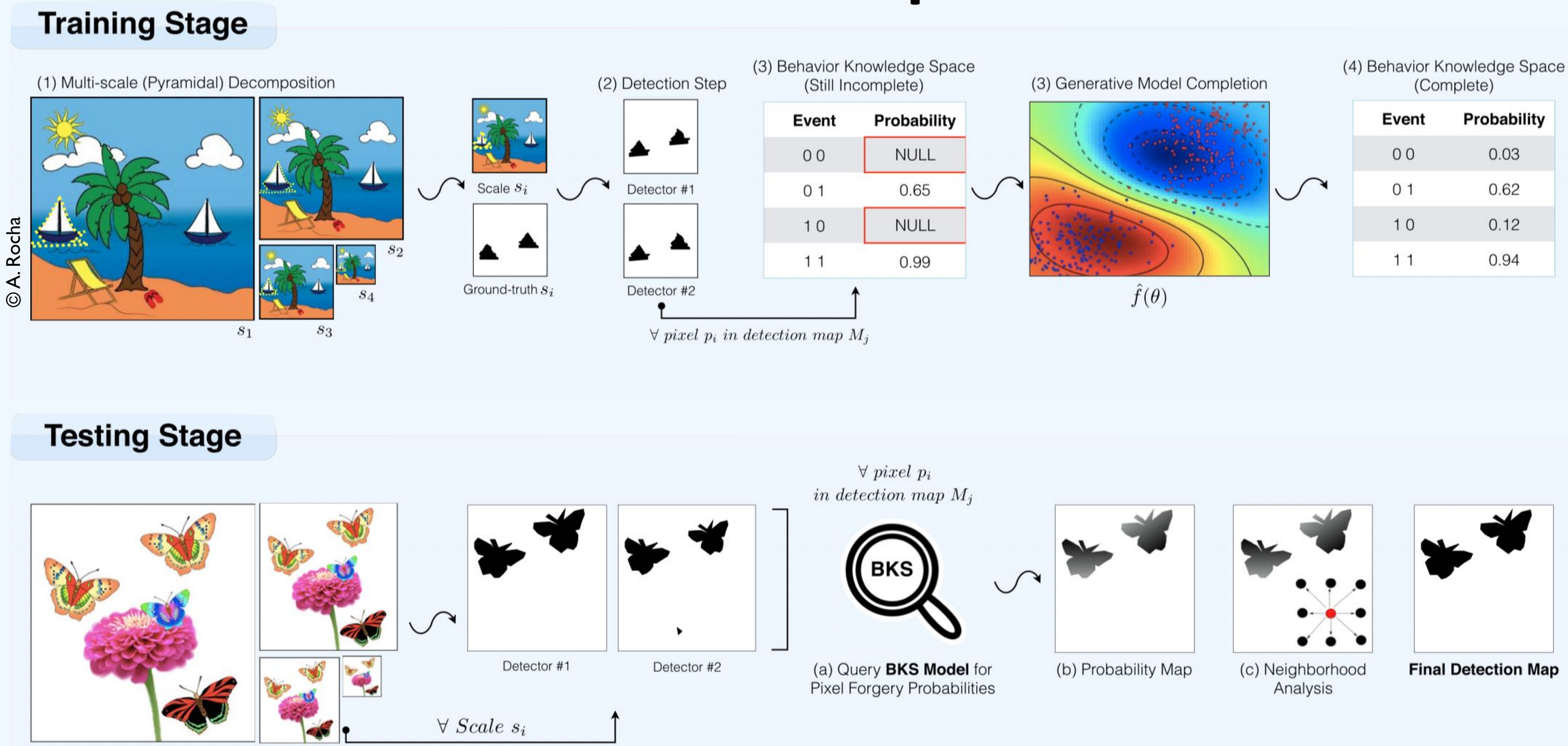
of online misinformation comes from manipulated images

> Data and Image from TruePic.com


https://thispersondoesnotexist.com/
A M I
R E A L ?

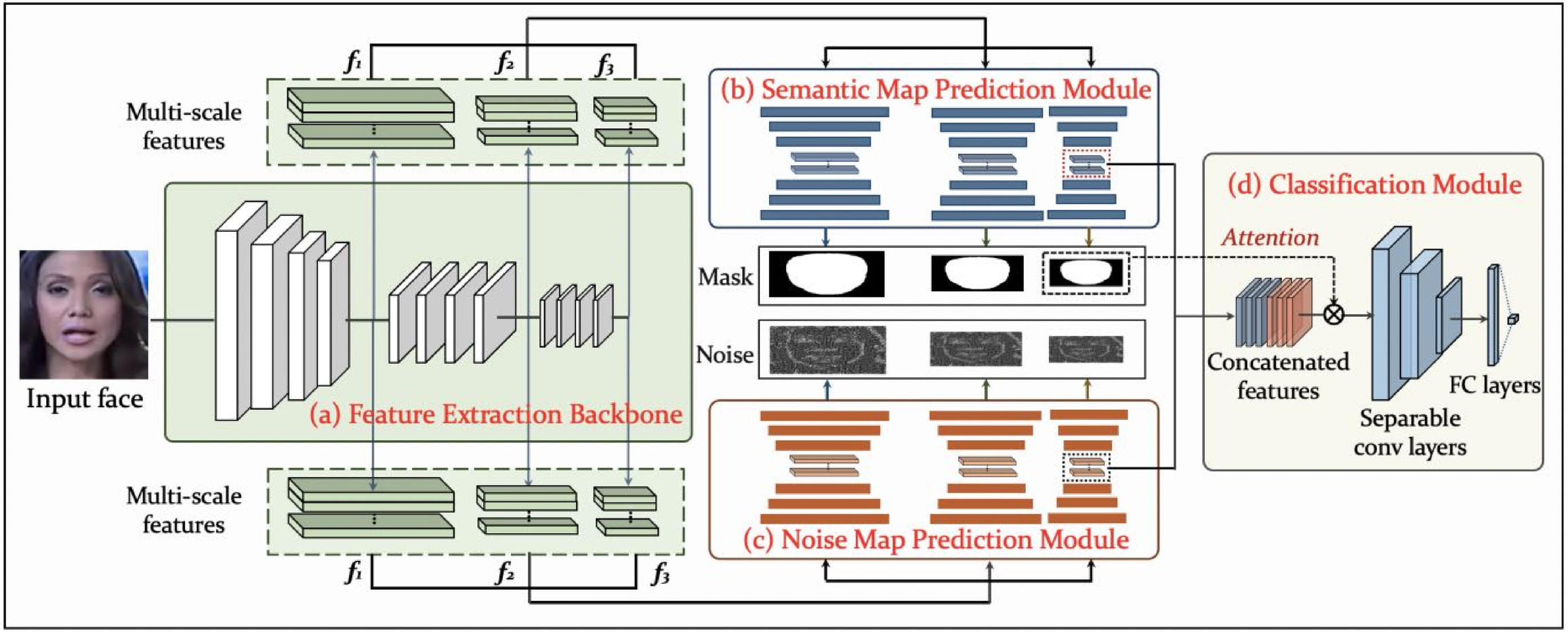
What can we **do**?

Empower detection methods



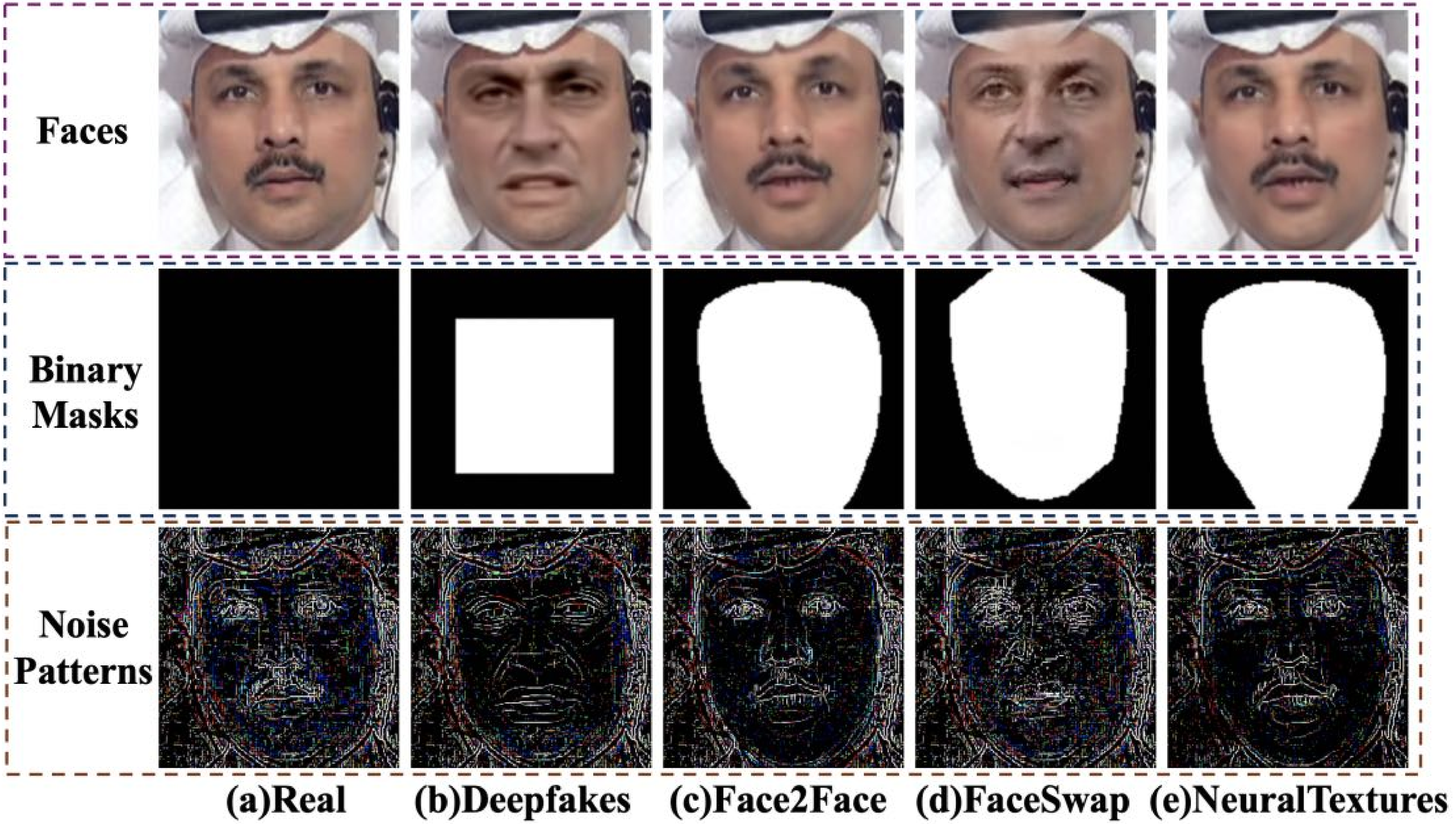
Ferreira, Anselmo, et al. "Behavior knowledge space-based fusion for copy–move forgery detection." IEEE Transactions on Image Processing 25.10 (2016): 4729-4742.

Explore **unseen** telltales



Kong, Chenqi, et al. "Detect and locate: Exposing face manipulation by semantic-and noise-level telltales." IEEE Transactions on Information Forensics and Security 17 (2022): 1741-1756.

Explore **unseen** telltales



Kong, Chenqi, et al. "Detect and locate: Exposing face manipulation by semantic-and noise-level telltales." IEEE Transactions on Information Forensics and Security 17 (2022): 1741-1756.

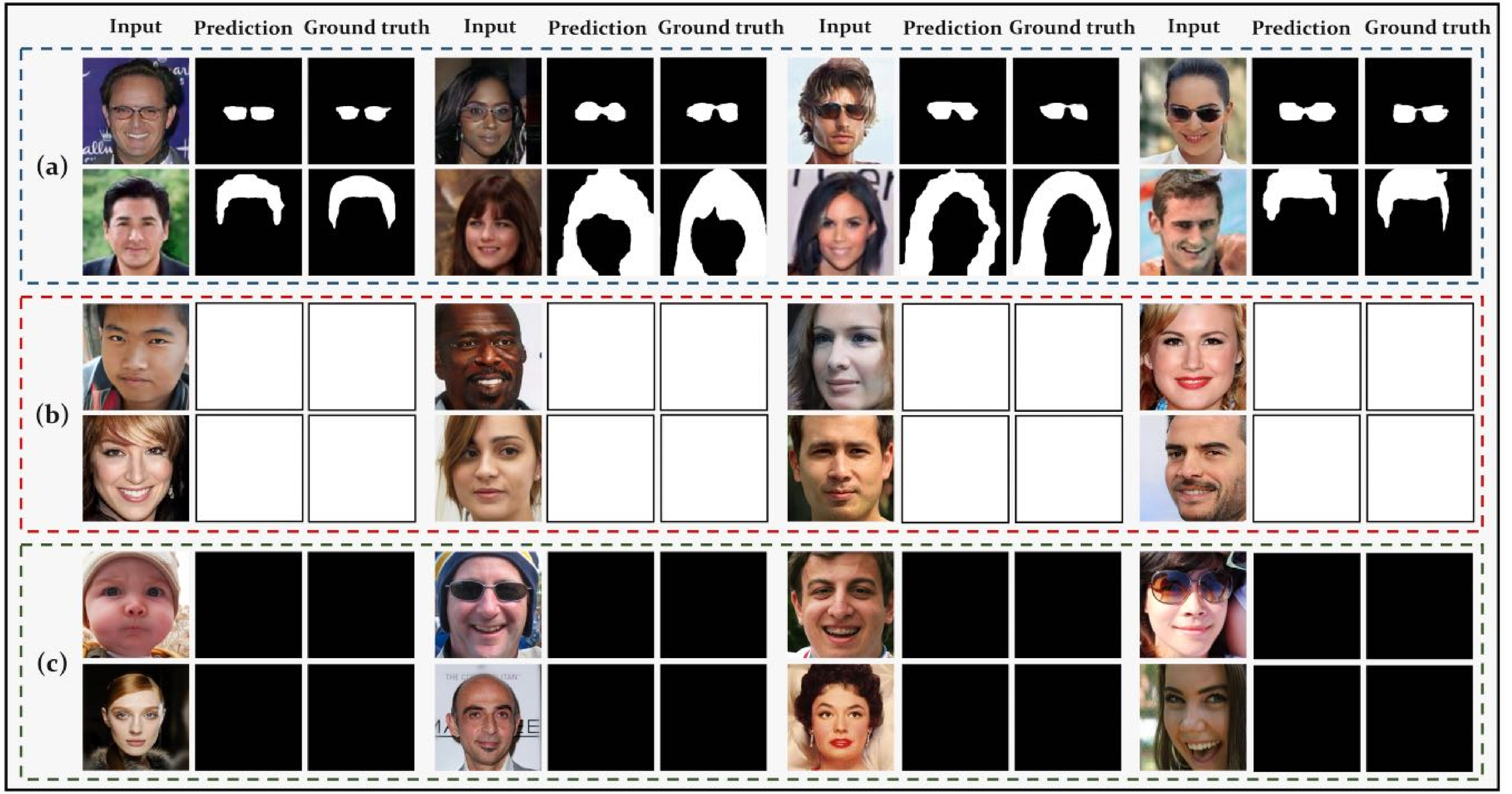
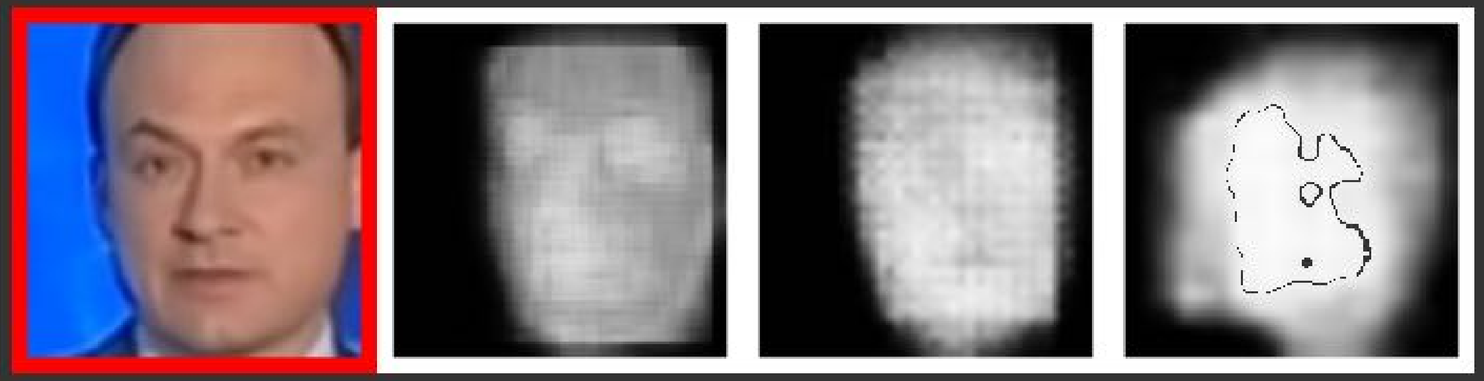


Fig. 10. Face manipulation localization results on our collected dataset. (a). attribute manipulated faces; (b). entirely synthetic faces; (c). real faces.

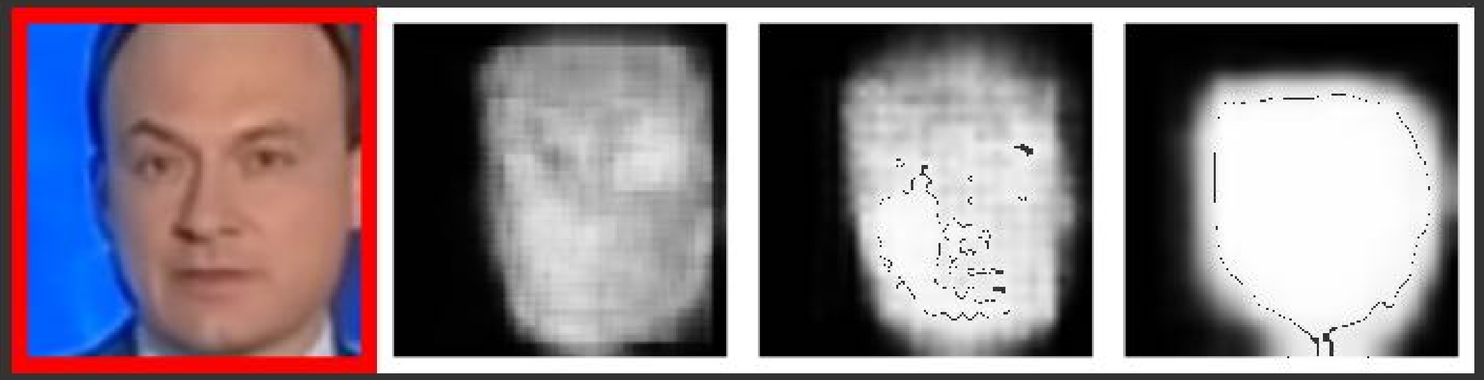
Kong, Chenqi, et al. "Detect and locate: Exposing face manipulation by semantic-and noise-level telltales." IEEE Transactions on Information Forensics and Security 17 (2022): 1741-1756.

recod.ai
reasoning for complex data

DeepFake Detection System



Probability of Fake for Expert #1: 90.07%



Probability of Fake for Expert #2: 99.81%

Upload Image

Detect

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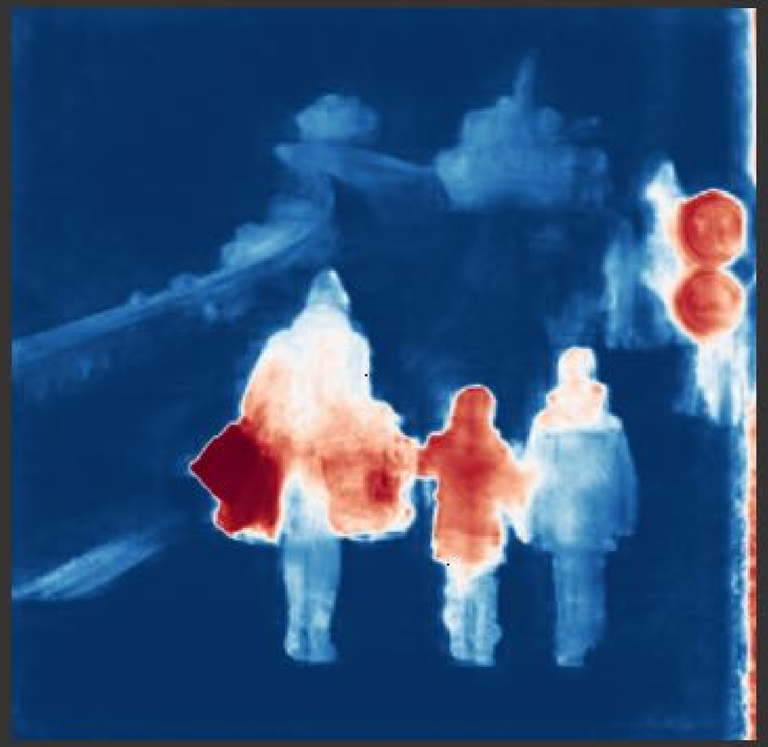
reasoning for complex data

Image Forgery Detection System



Prob. of Forgery for Expert #1: 96.06%

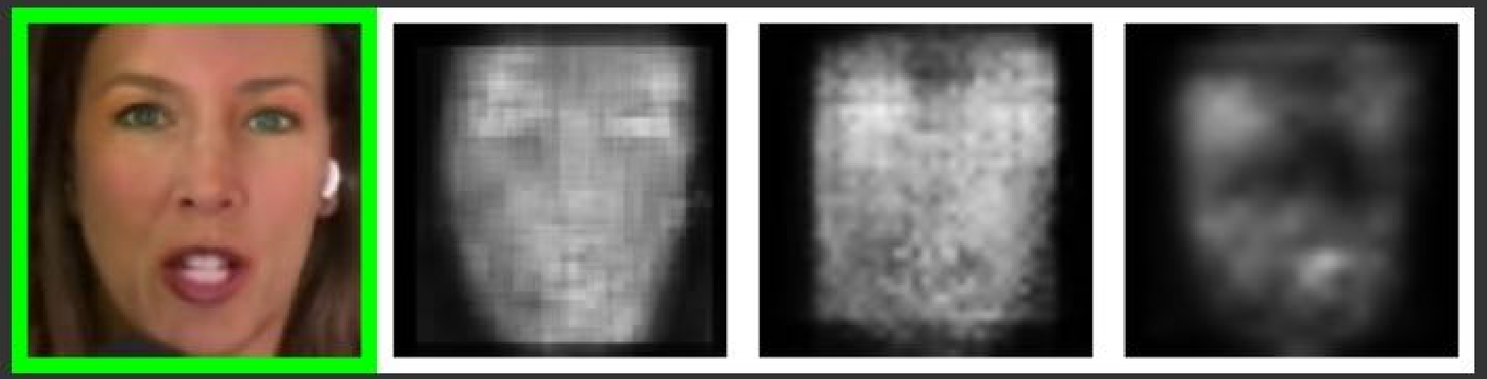
Prob. of of Forgery for Expert #2: 52.40%

Upload Image

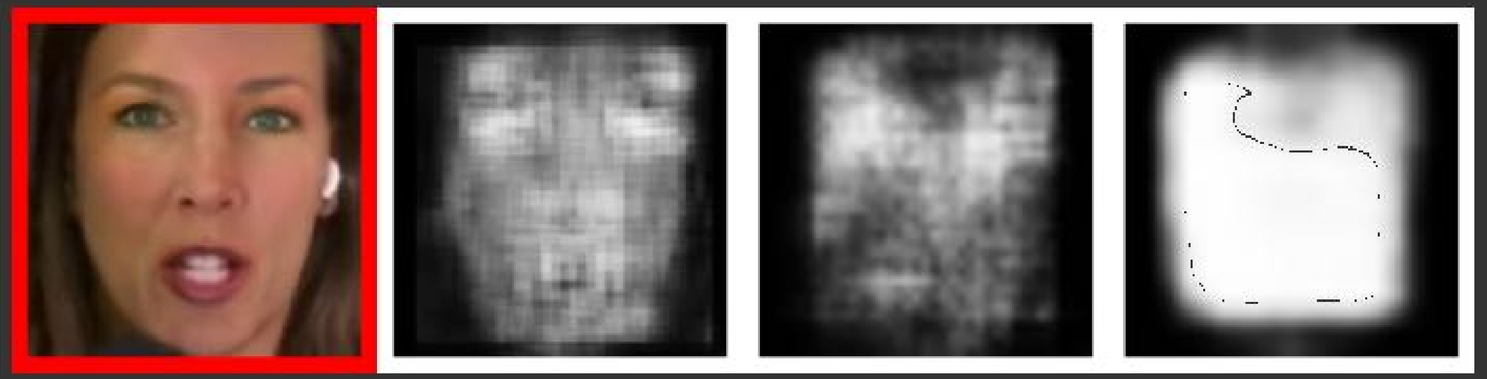
Detect

recod.ai DeepFake Detection System

reasoning for complex data



Probability of Fake for Expert #1: 31.31%



Probability of Fake for Expert #2: 95.91%

Upload Image

Detect

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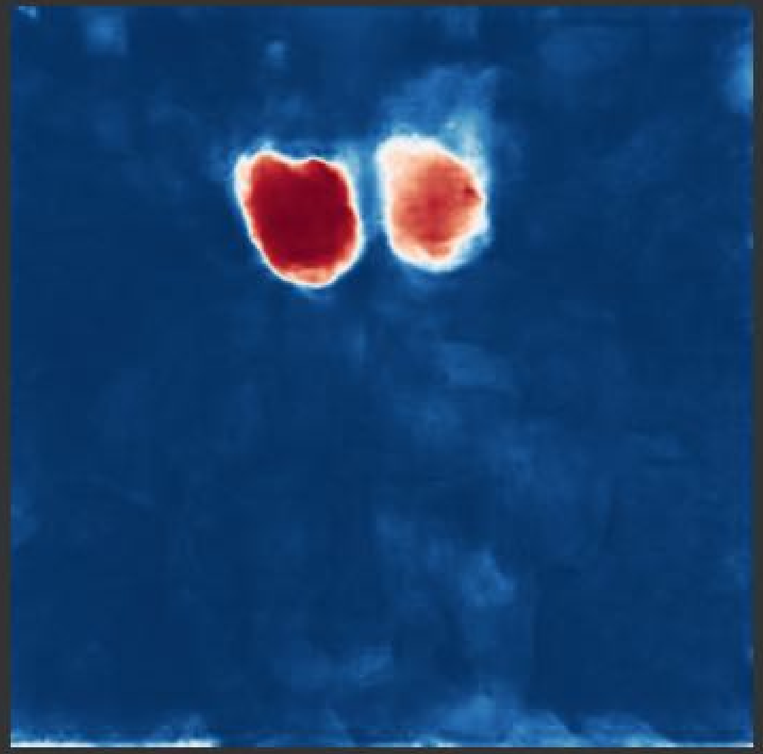
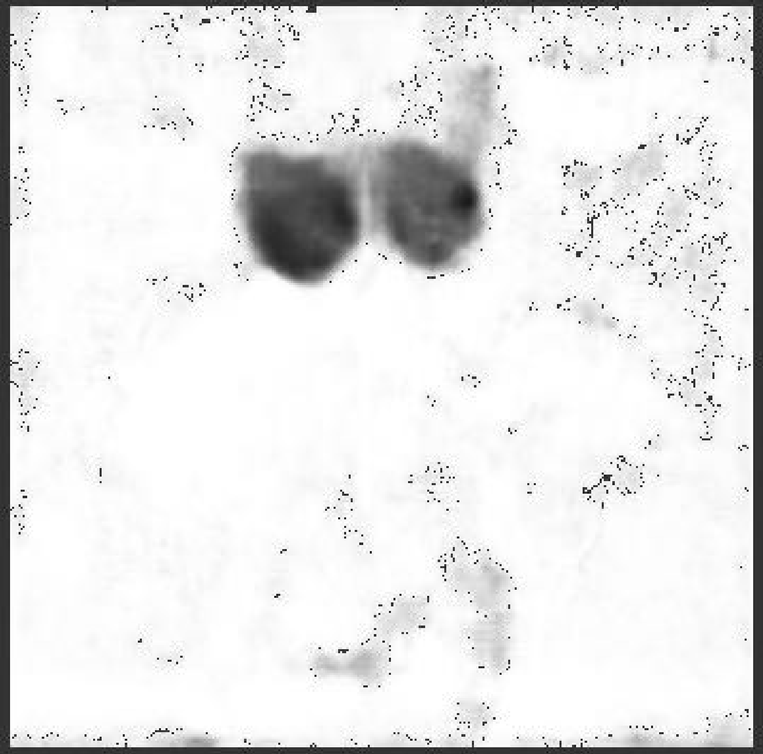
Image Forgery Detection System





Prob. of Forgery for Expert #1: 0.53%

Prob. of of Forgery for Expert #2: 19.99%

Upload Image

Detect

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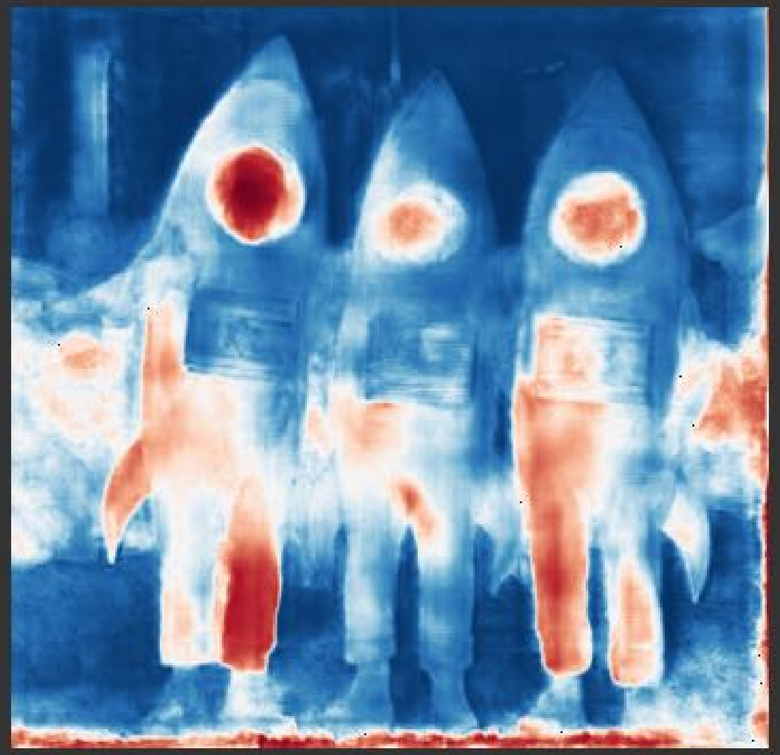
reasoning for complex data

Image Forgery Detection System



Prob. of Forgery for Expert #1: 24.55% Prob. of of Forgery for Expert #2: 31.94%

Upload Image Detect

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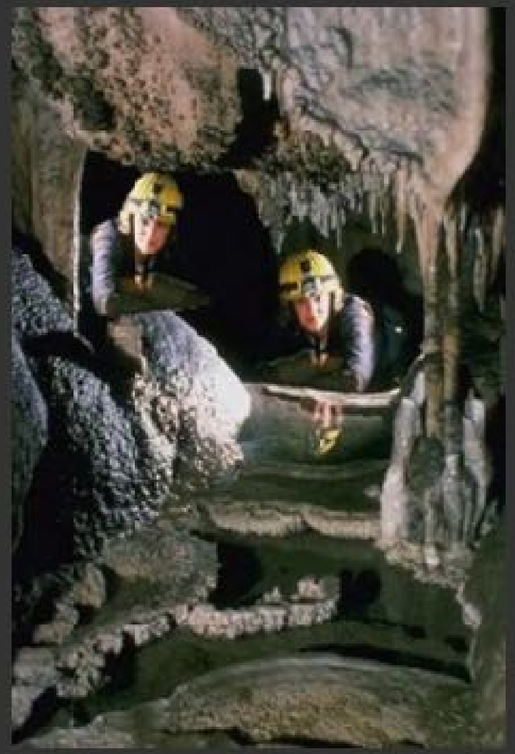
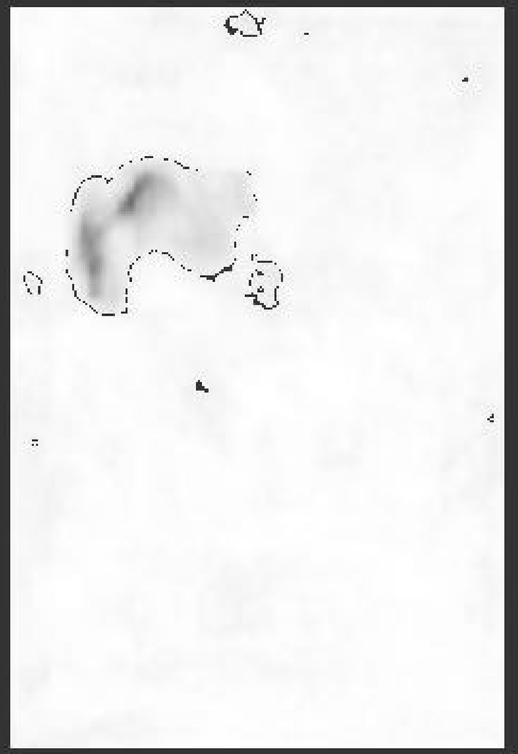
Image Forgery Detection System



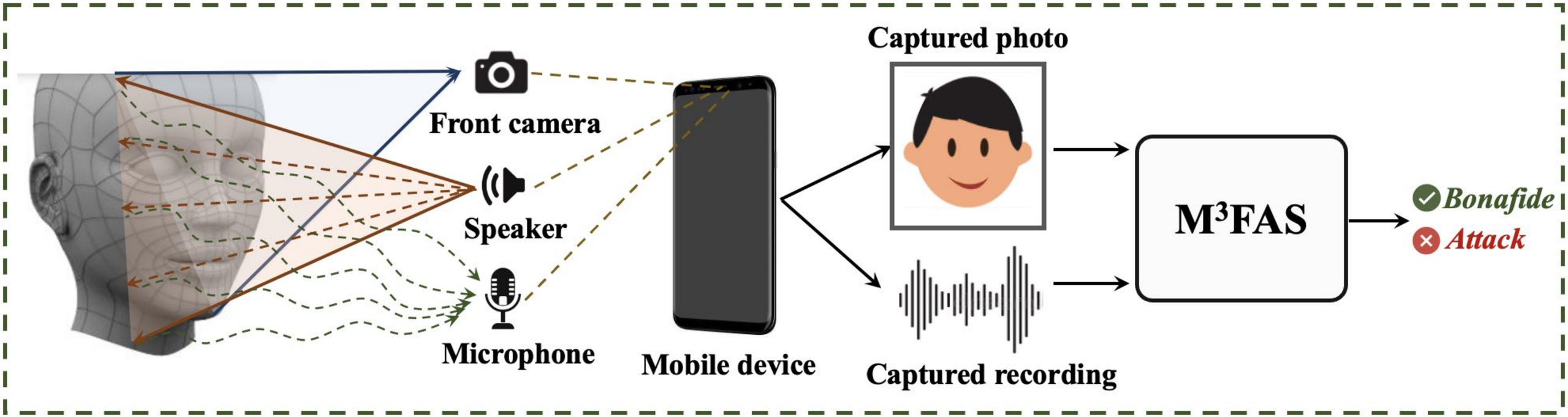


Prob. of Forgery for Expert #1: 99.99%

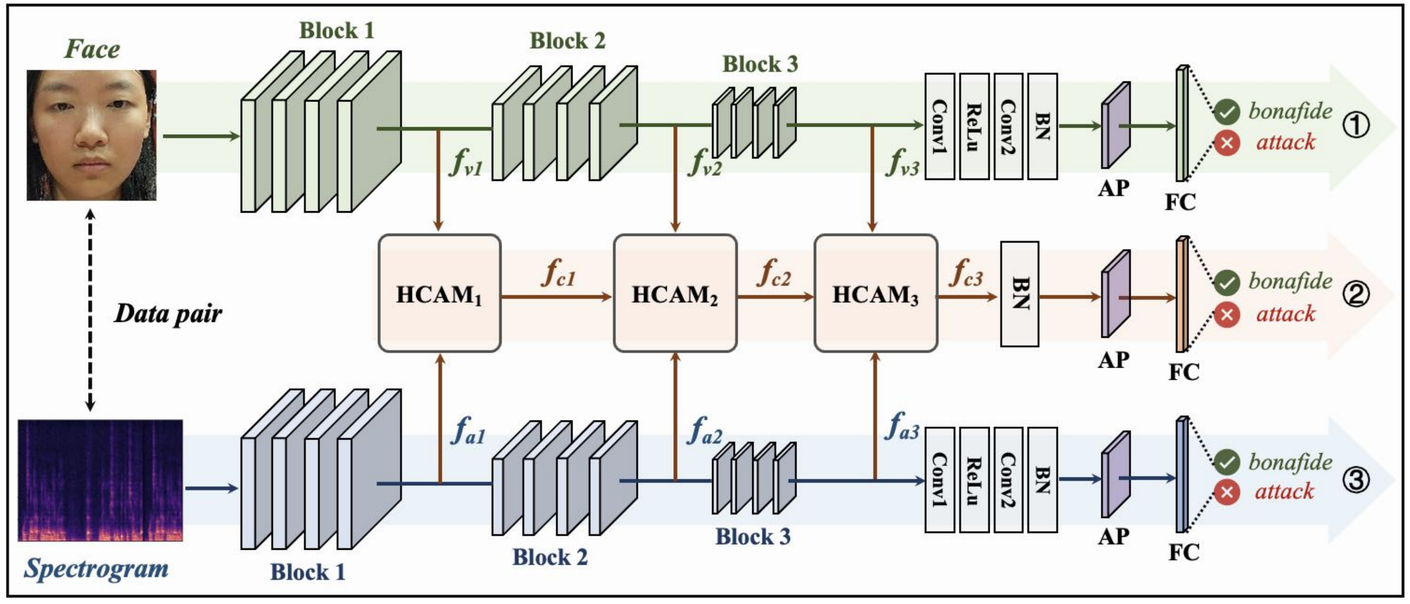
Prob. of of Forgery for Expert #2: 99.68%

Upload Image

Detect



Fighting **Spoofing** (Presentation Attacks)



SYNTHETIC REALITIES: WHERE ARE WE?

Overview Paper

The Age of Synthetic Realities: Challenges and Opportunities

recod.ai

João Phillipe Cardenuto[1*], Jing Yang[1], Rafael Padilha[1], Renjie Wan[2], Daniel Moreira[3], Haoliang Li[4], Shiqi Wang[5], Fernanda Andaló[1], Sébastien Marcel[6,7] and Anderson Rocha[1]

[1] *Artificial Intelligence Lab., Recod.ai, Institute of Computing, Universidade Estadual de Campinas, Campinas, SP, Brazil*
[2] *Department of Computer Science, Hong Kong Baptist University, Hong Kong*
[3] *Department of Computer Science, Loyola University Chicago, USA*
[4] *Department of Electrical Engineering, City University of Hong Kong, Hong Kong*
[5] *Department of Computer Science, City University of Hong Kong, Hong Kong*
[6] *Idiap Research Institute, Martigny, Switzerland*
[7] *University of Lausanne, Lausanne, Switzerland*

Counteracting the contemporaneous proliferation of digital forgeries and fake news

ALEXANDRE FERREIRA[1], TIAGO CARVALHO[2], FERNANDA ANDALÓ[1] and ANDERSON ROCHA[1]

[1]Institute of Computing, University of Campinas (Unicamp), Av. Albert Einstein, 1251, 13083-852 Campinas, SP, Brazil
[2]Instituto Federal de São Paulo (IFSP), Av. Comendador Aladino Selmi, s/n, 13069-901 Campinas, SP, Brazil

Leveraging Ensembles and Self-Supervised Learning for Fully-Unsupervised Person Re-Identification and Text Authorship Attribution

Gabriel Bertocco, Antonio Theophilo, Fernanda Andaló, *Member, IEEE,* and Anderson Rocha, *Senior Member, IEEE*

EXPLAINABLE ARTIFICIAL INTELLIGENCE FOR AUTHORSHIP ATTRIBUTION ON SOCIAL MEDIA

Antonio Theophilo†, Rafael Padilha*, Fernanda A. Andaló*, Anderson Rocha**

* Artificial Intelligence Lab. (Recod.ai) Institute of Computing, University of Campinas, Brazil
† Center for Information Technology Renato Archer, Campinas, Brazil

Content-Based Detection of Temporal Metadata Manipulation

Rafael Padilha[1] ✉, Tawfiq Salem[2], Scott Workman[3], Fernanda A. Andaló[1], Anderson Rocha[1], Nathan Jacobs[4]

[1] University of Campinas, Brazil [2] Purdue University, USA
[3] DZYNE Technologies, USA [4] University of Kentucky, USA

Forensic Event Analysis: From Seemingly Unrelated Data to Understanding

Rafael Padilha, Caroline Mazini Rodrigues, Fernanda Andaló, Gabriel Bertocco, Zanoni Dias, and Anderson Rocha

nature

How to stop AI deepfakes from sinking society — and science

Deceptive videos and images created using generative AI could sway elections, crash stock markets and ruin reputations. Researchers are developing methods to limit their harm.

By Nicola Jones

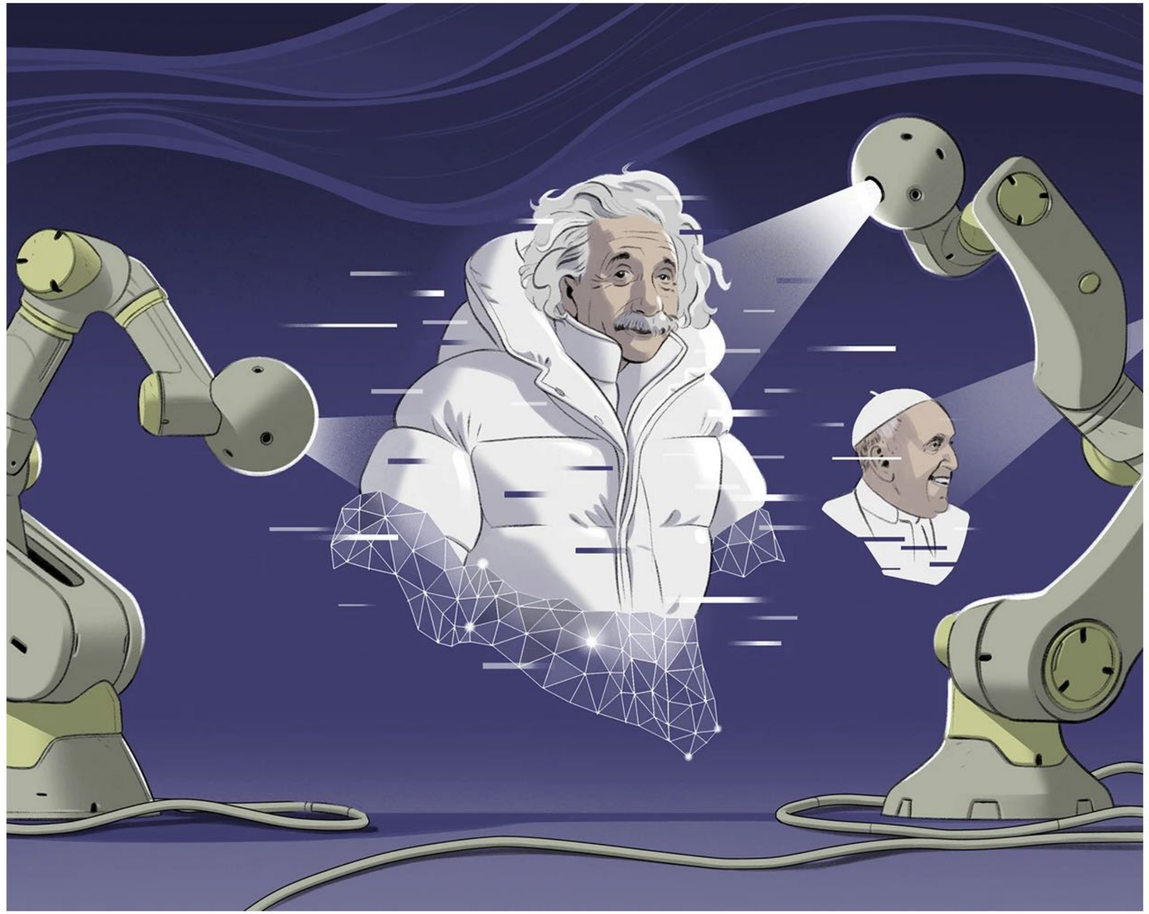


Illustration by Señor Salme

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Article | Open access | Published: 31 October 2022

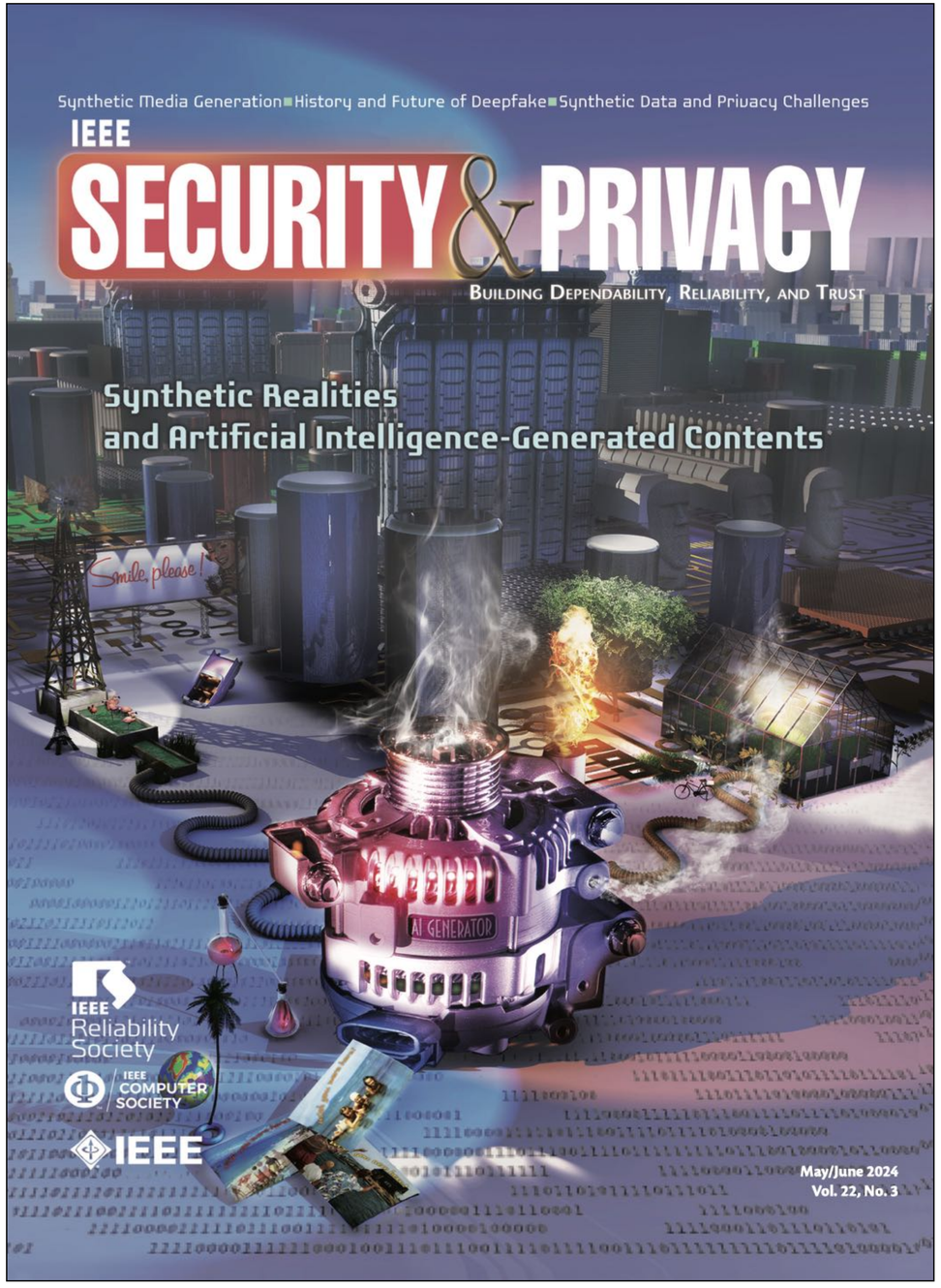
SILA: a system for scientific image analysis

Daniel Moreira, João Phillipe Cardenuto, Ruiting Shao, Sriram Baireddy, Davide Cozzolino, Diego Gragnaniello, Wael Abd-Almageed, Paolo Bestagini, Stefano Tubaro, Anderson Rocha, Walter Scheirer, Luisa Verdoliva & Edward Delp

Scientific Reports **12**, Article number: 18306 (2022) | Cite this article

Abstract

A great deal of the images found in scientific publications are retouched, reused, or composed to enhance the quality of the presentation. In most instances, these edits are benign and help the reader better understand the material in a paper. However, some edits are instances of scientific misconduct and undermine the integrity of the presented research. Determining the legitimacy of edits made to scientific images is an open problem that no current technology can perform satisfactorily in a fully automated fashion. It thus remains up to human experts to inspect images as part of the peer-review process. Nonetheless, image analysis technologies promise to become helpful to experts to perform such an essential yet arduous task. Therefore, we introduce SILA, a system that makes



Synthetic Realities and Artificial Intelligence-Generated Contents

Daniel Moreira | Loyola University Chicago
Sébastien Marcel | Idiap Research Institute
Anderson Rocha | University of Campinas

Welcome to the *IEEE Security & Privacy* special issue on synthetic realities and artificial intelligence-generated contents! In this edition, we delve into the topic of synthetic realities, where generative artificial intelligence (GAI) is revolutionizing the construction of narratives, blurring the boundaries between fact and fiction, for the good and the bad. Indeed, content created or enabled by GAI spans a wide spectrum of usage and intentions, from fostering positive experiences, such as entertainment, training, and education, to more questionable utilization, such as deception, propaganda, and manipulation.

With the advent and maturity of GAI techniques, much has changed in forensics, security, and privacy. The way researchers and experts have been doing forensics and security over the past decades is continuously challenged with each new version of powerful AI content generators. The synthetic content ranges from audio, image, and video to text and their combinations, coming from prominent models, such as ChatGPT, LaMDA, ImageGen, StableDiffusion, Sora, and Gemini, among others.

This special issue seeks to understand the required changes in the way forensics, security, and privacy experts operate, including how to deal with autogenerated fake and synthetic data (e.g., text, images, videos, and 3D content), how much autogeneration methods are "shaping" new realities that do not exist, and what it means for our society. The call presented the following important questions: What are the possible new applications for forensics, security, and privacy? What are the threats and challenges? Forensic aspects should include any topics related to post hoc investigation practices after the occurrence of events regarding created content (eg, generated fake news or deepfakes and how to detect them). Security aspects should include topics related to how such contents might affect our lives in terms of document authenticity and deception. Privacy should

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Date of current version: 10 May 2024

4 Actions

Standardization (e.g., JPEG)
Regulation
Technical Solutions
Technological **Literacy**

3

Social Pillars

Democracy
Individual Freedom
Social Tolerance

Synthetic Realities have

Social
Political
Psychological and
Legal impacts

If not addressed properly
Synthetic Realities will

undermine…

3

Social Pillars

Democracy
Individual Freedom
Social Tolerance

4

Actions

Standardization
Regulation
Technical Solutions
Technological **Literacy**

Horus project focuses on the last two actions!

Let's get real about AI.

WORLD ECONOMIC FORUM

Obrigado!

Merci / Thank You / با تشکر / 谢谢 / Grazie
Danke / شکرًا / Gracias

Horus: AI-Driven Solutions for Synthetic Realities in the Digital Age

Prof. Anderson Rocha
IEEE Fellow
Institute of Computing, Unicamp
arrocha@unicamp.br