INFRA LAB

VISUALIZATION AND VIRTUAL REALITY LAB

Visualization of scientific calculations.

The cinema with 3D projection wall.

Virtual reality.

Computer Vision

- Neural networks
- Image segmentation
- 3D reconstruction
- Blender

Authentication of Holograms with AI

INNOVATIVE APPROACH TO SECURE PERSONAL DOCUMENTS

Ing. Petra Svobodová, Ph.D.

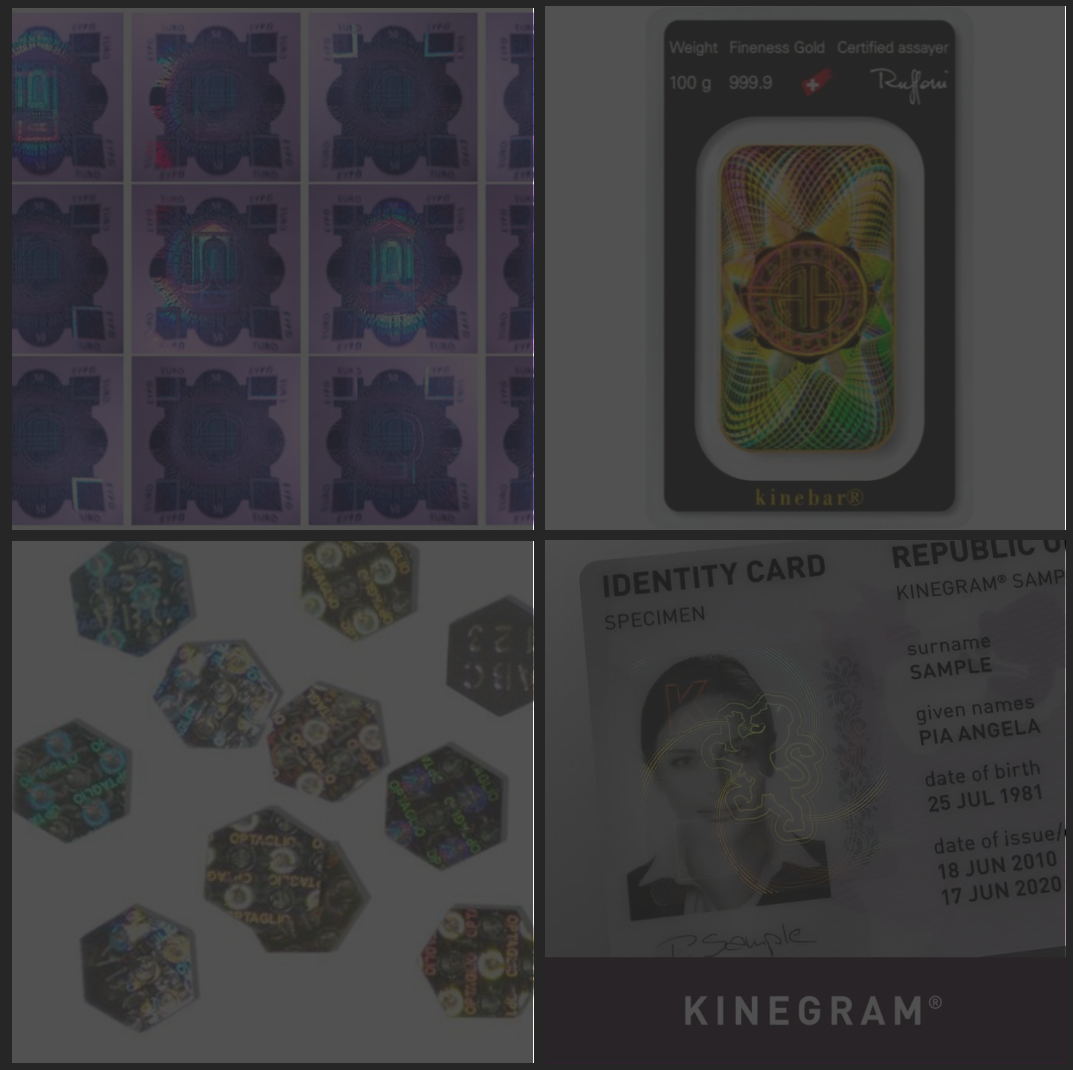
What are holograms

- Each document is equipped with a **security holographic element**
- **Micro-metallic structures randomly distributed** to uniquely identify document
- Holograms change appearance with lighting, angle, and camera type
- Non-reproducible

HOLOGRAMS ARE DESIGNED TO BE HARD TO FORGE – BUT THE IRONY IS, THEY'RE ALSO HARD TO VERIFY WITHOUT THE RIGHT TOOLS

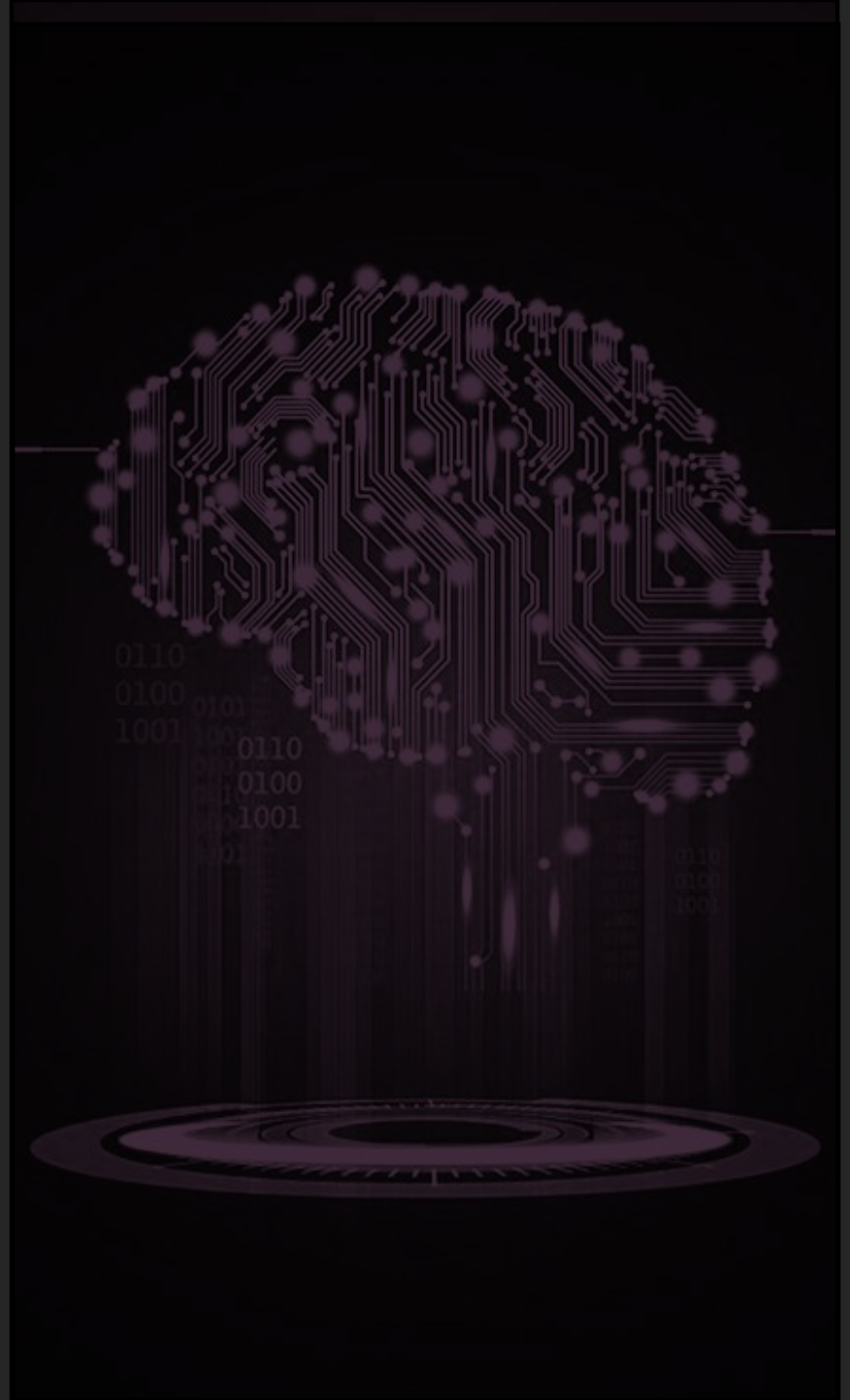
Why holograms matter

- **Holograms** are widely used in ID cards, passports, banknotes, and certificates as **visual security features**
- An example of a successful security holographic structure on documents and precious metals is the **kinegram** and **kinebar**

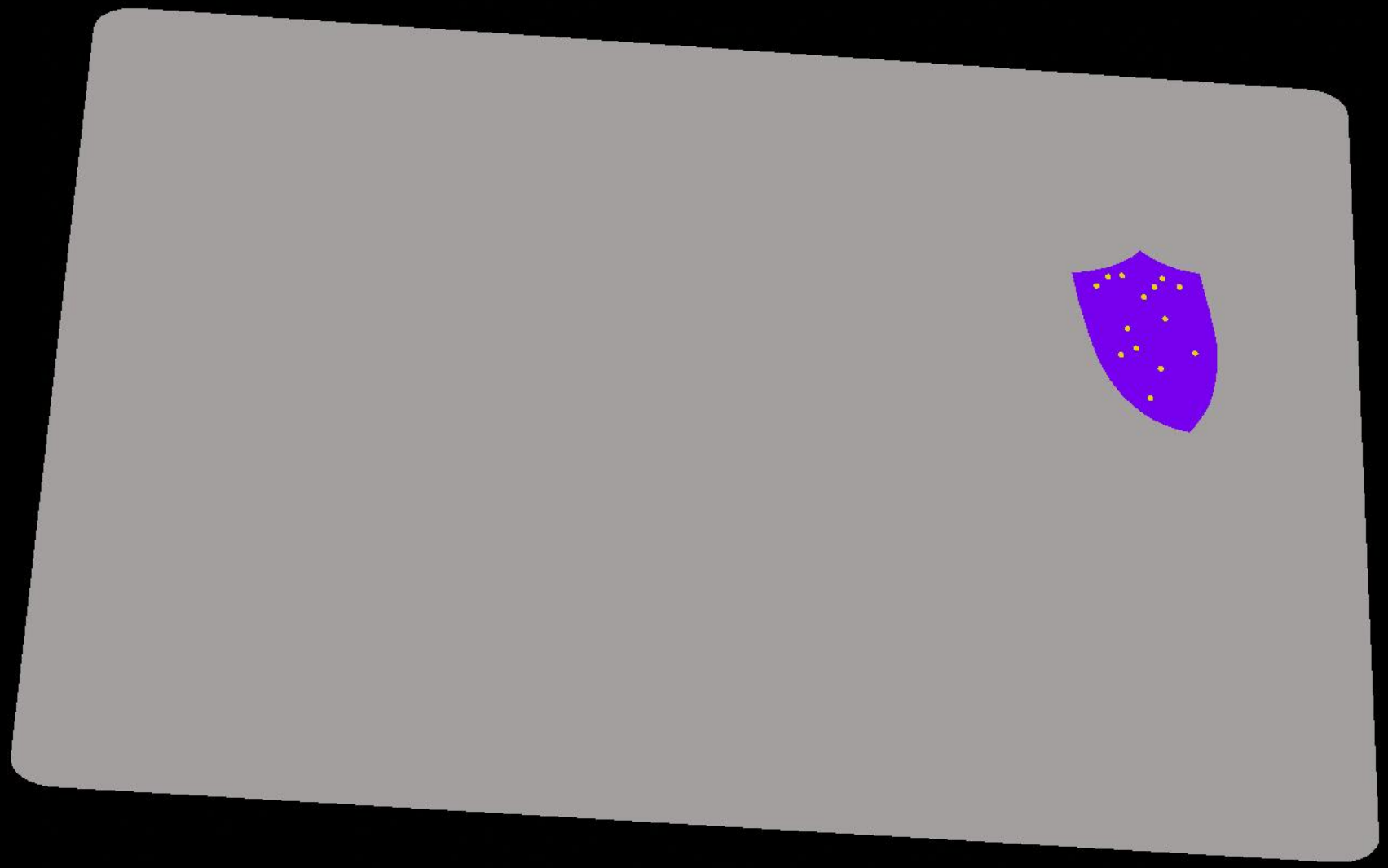


Goals of the Project

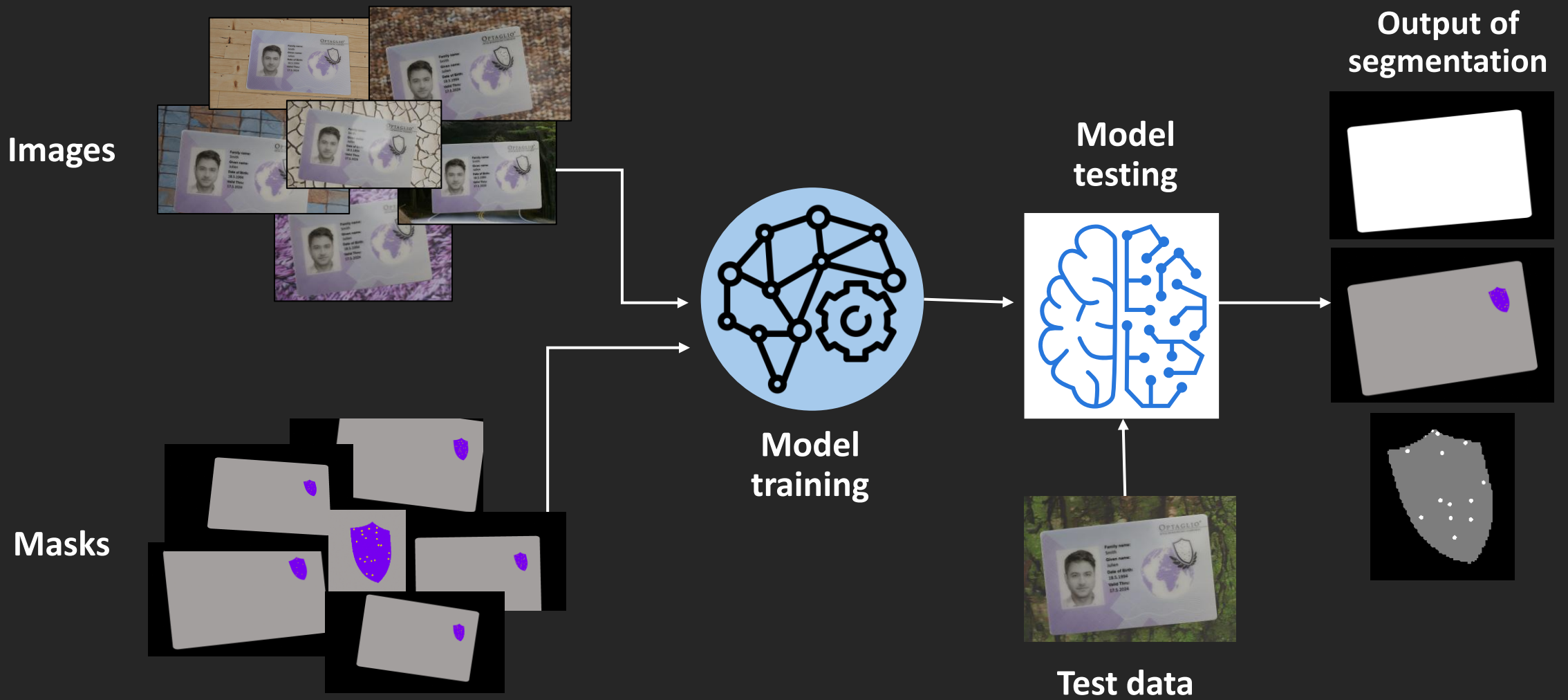
- Visual security of documents by holograms
- Robust machine reading of holograms
- Generating of image (hologram) hashes
- Storing of hashes in the database



Dataset

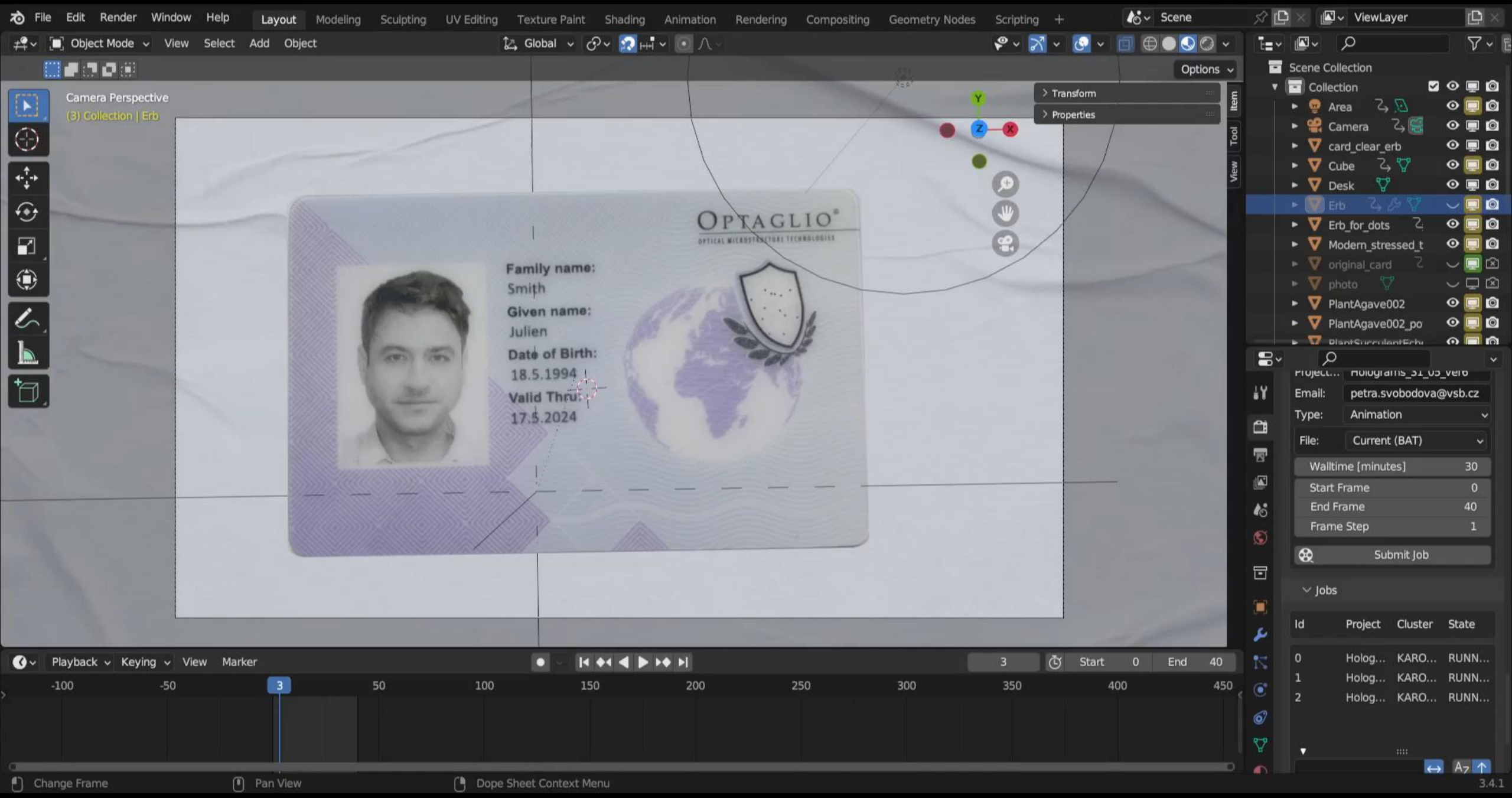


How do Neural Networks work?

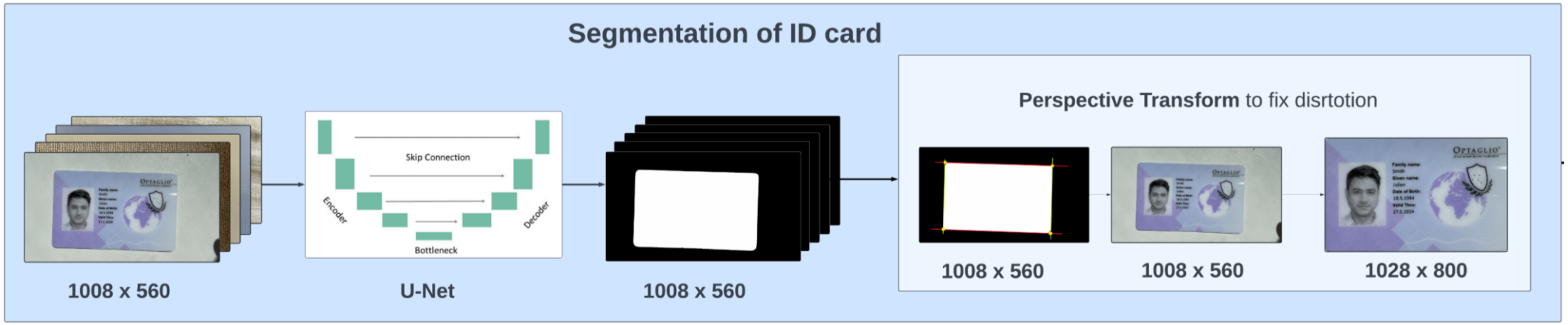


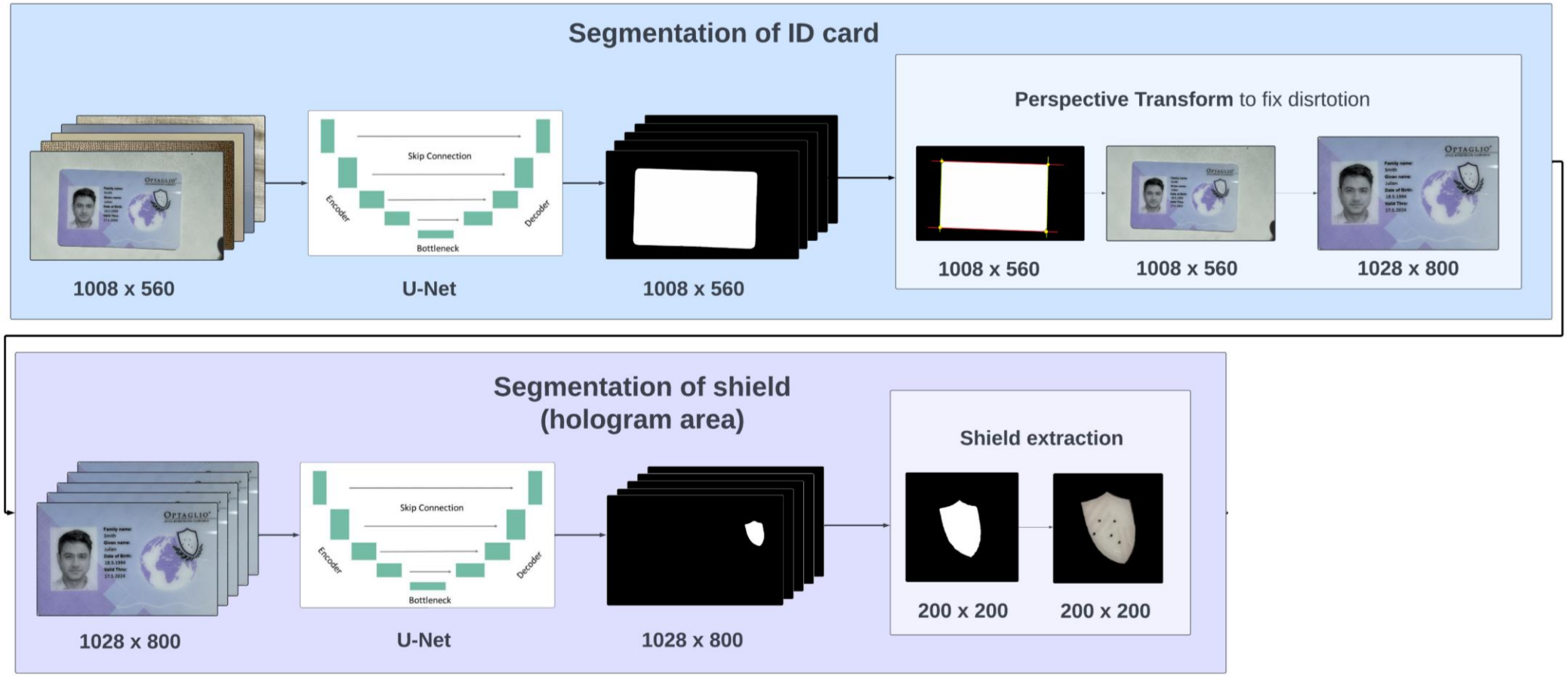
Synthetic Dataset

- The entire scene is **simulated in Blender**
- The scene is **parametrized** to generate micro-holograms with different densities and distributions
- The intensity and position of **lights** also changes
- The **camera** is moving and slightly rotating
- The scene is captured from different angles of view
- We can generate vast amount of synthetic data for training of AI networks


File Edit Render Window Help
Layout Modeling Sculpting UV Editing Texture Paint Shading Animation Rendering Compositing Geometry Nodes Scripting
Scene
ViewLayer
Object Mode View Select Add Object
Global
Options
Camera Perspective
(3) Collection | Erb
Transform
Properties
Item
Tool
View
OPTAGLIO
Family name:
Smith
Given name:
Julien
Date of Birth:
18.5.1994
Valid Thru:
17.5.2024
Scene Collection
Collection
Area
Camera
card_clear_erb
Cube
Desk
Erb
Erb_for_dots
Modern_stressed_t
original_card
photo
PlantAgave002
PlantAgave002_po
Email:
petra.svobodova@vsb.cz
Type:
Animation
File:
Current (BAT)
Walltime [minutes] 30
Start Frame 0
End Frame 40
Frame Step 1
Submit Job
Jobs
Id Project Cluster State
0 Holog... KARO... RUNN...
1 Holog... KARO... RUNN...
2 Holog... KARO... RUNN...
Playback Keying View Marker
3
Start 0 End 40
-100 -50 3 50 100 150 200 250 300 350 400 450
Change Frame
Pan View
Dope Sheet Context Menu
3.4.1

Methodology


Segmentation of ID card
Skip Connection
Encoder
Decoder
Bottleneck
Perspective Transform to fix disrtotion
1008 x 560
U-Net
1008 x 560
1008 x 560
1008 x 560
1028 x 800


Segmentation of ID card
Skip Connection
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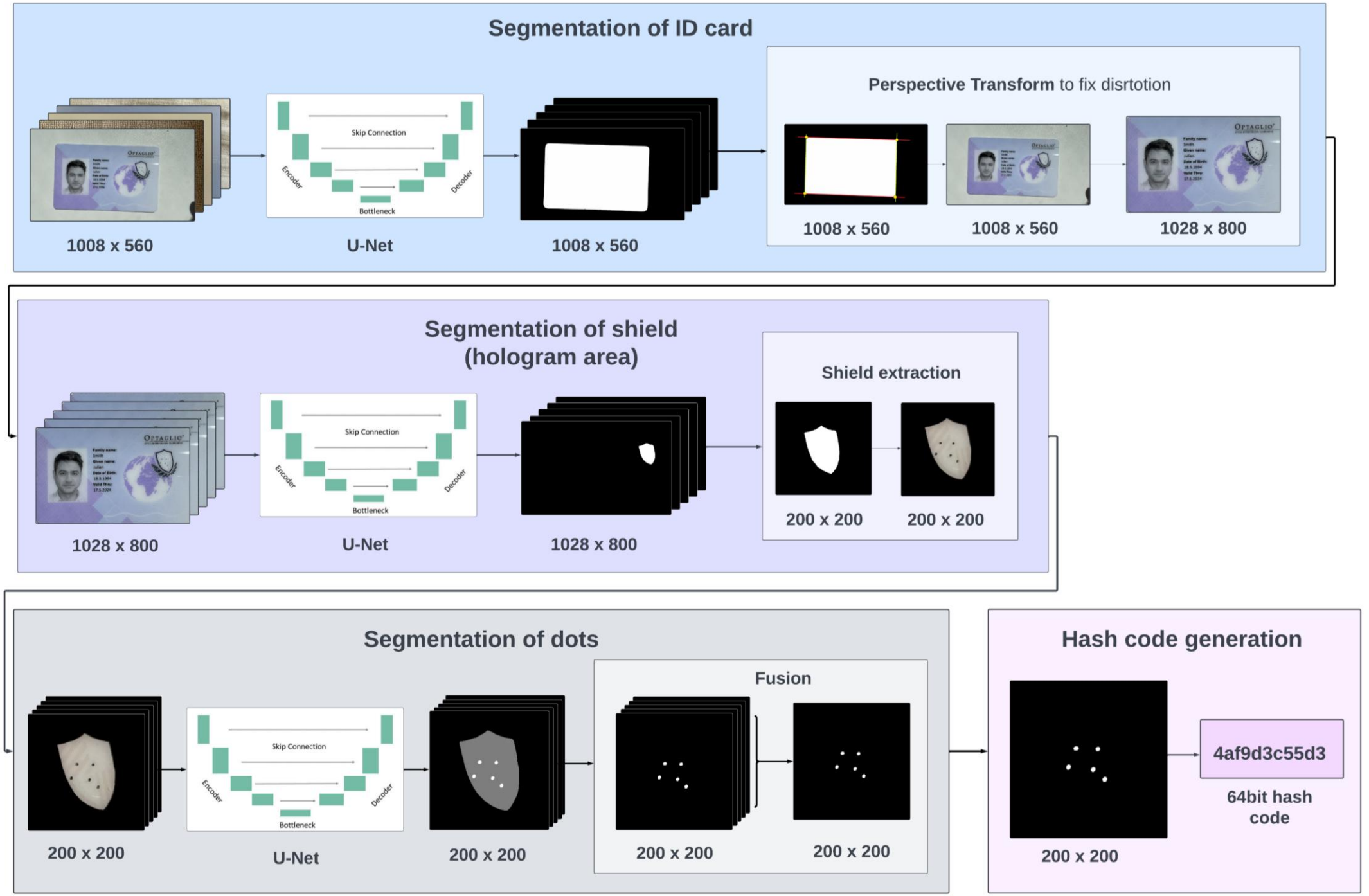
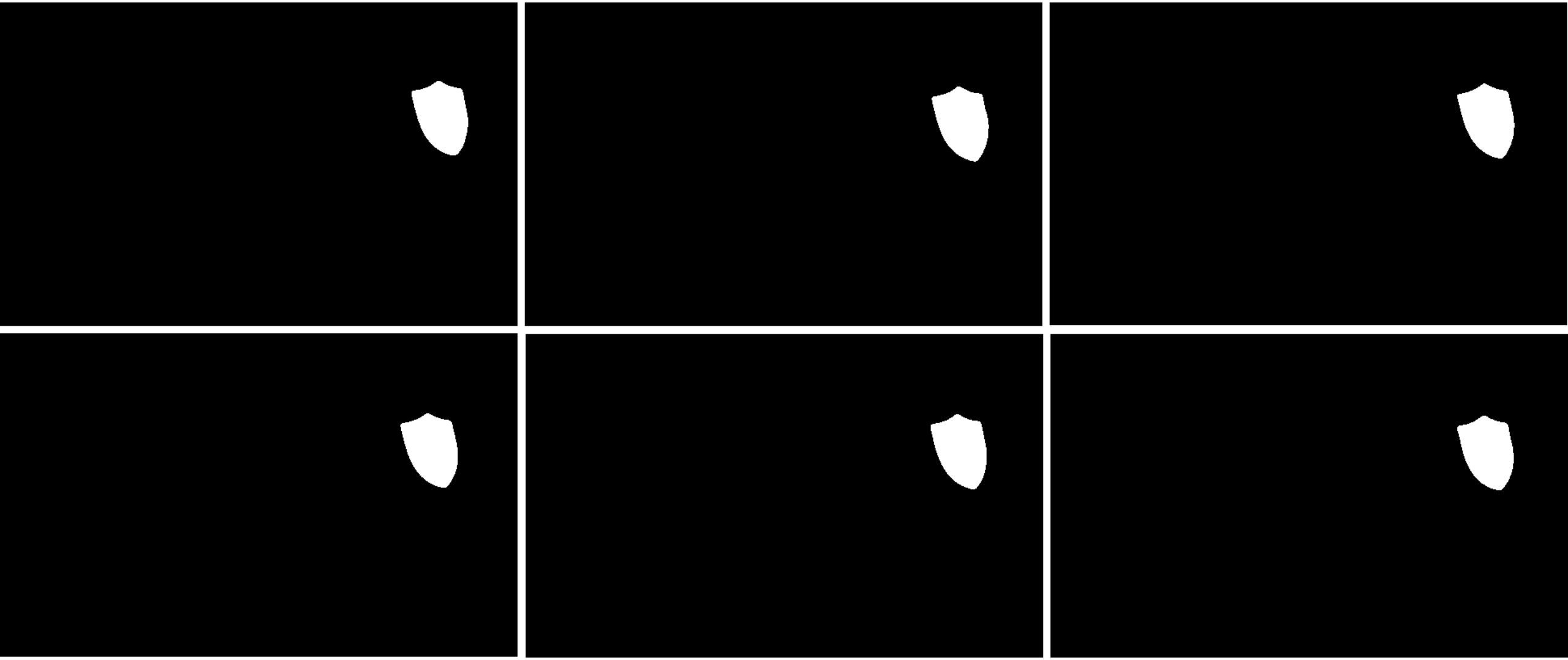
U-Net
1008 x 560
Perspective Transform to fix disrtotion
1008 x 560
1008 x 560
1028 x 800
Segmentation of shield
(hologram area)
Skip Connection
Encoder
Decoder
Bottleneck
1028 x 800
U-Net
1028 x 800
Shield extraction
200 x 200
200 x 200

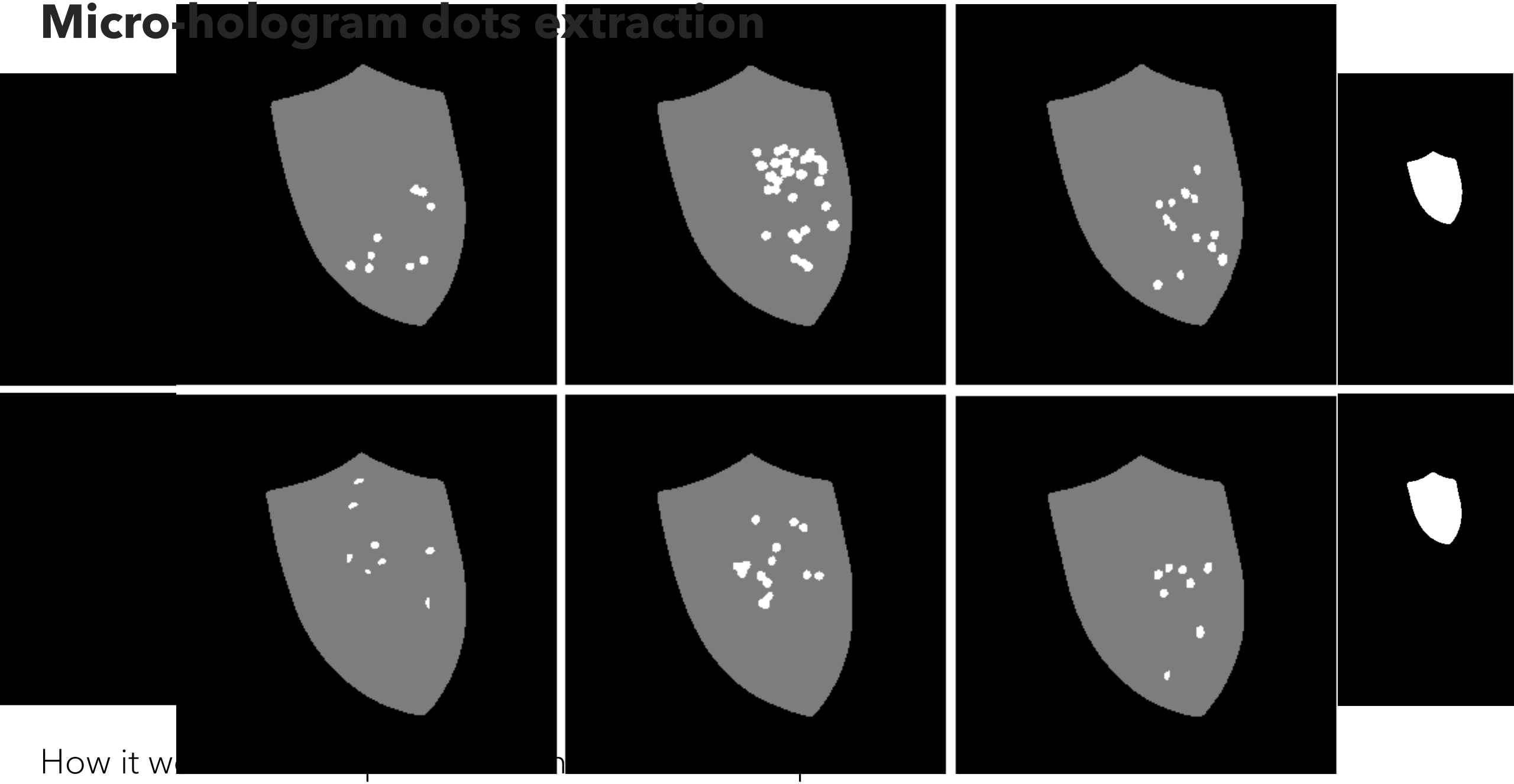

Segmentation of ID card
1008 x 560
Skip Connection
Encoder
Decoder
Bottleneck
U-Net
1008 x 560
Perspective Transform to fix disrtotion
1008 x 560
1008 x 560
1028 x 800
Segmentation of shield
(hologram area)
1028 x 800
Skip Connection
Encoder
Decoder
Bottleneck
U-Net
1028 x 800
Shield extraction
200 x 200
200 x 200
Segmentation of dots
200 x 200
Skip Connection
Encoder
Decoder
Bottleneck
U-Net
200 x 200
Fusion
200 x 200
200 x 200
Hash code generation
200 x 200
4af9d3c55d3
64bit hash
code

Card & shield (holographic area) segmentation

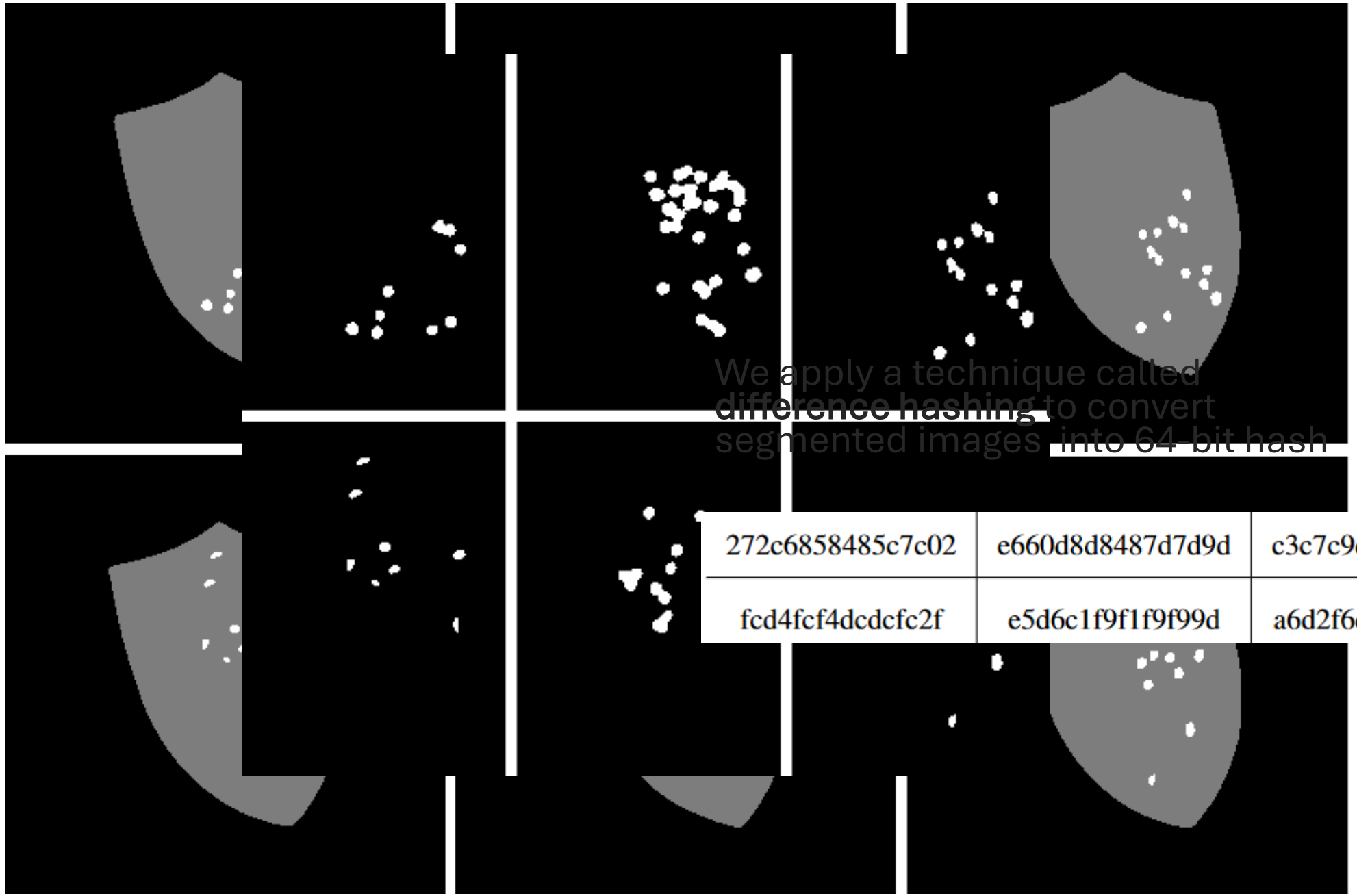


How it works on real photos taken with a mobile phone

Micro-hologram dots extraction



How it w



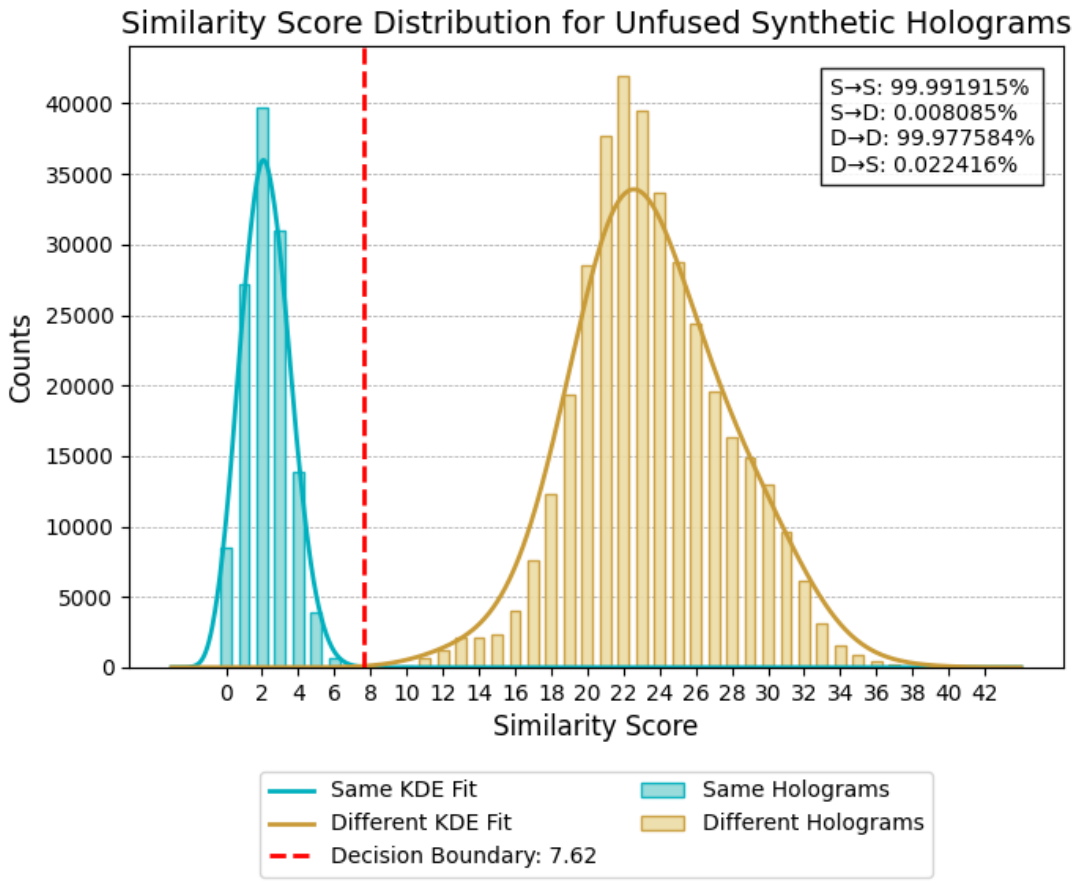
We apply a technique called **difference hashing** to convert segmented images into 64-bit hash

272c6858485c7c02	e660d8d8487d7d9d	c3c7c9d1d5d8dc5a
fcd4fcf4dcdcfc2f	e5d6c1f9f1f9f99d	a6d2f6d4ccc424b5

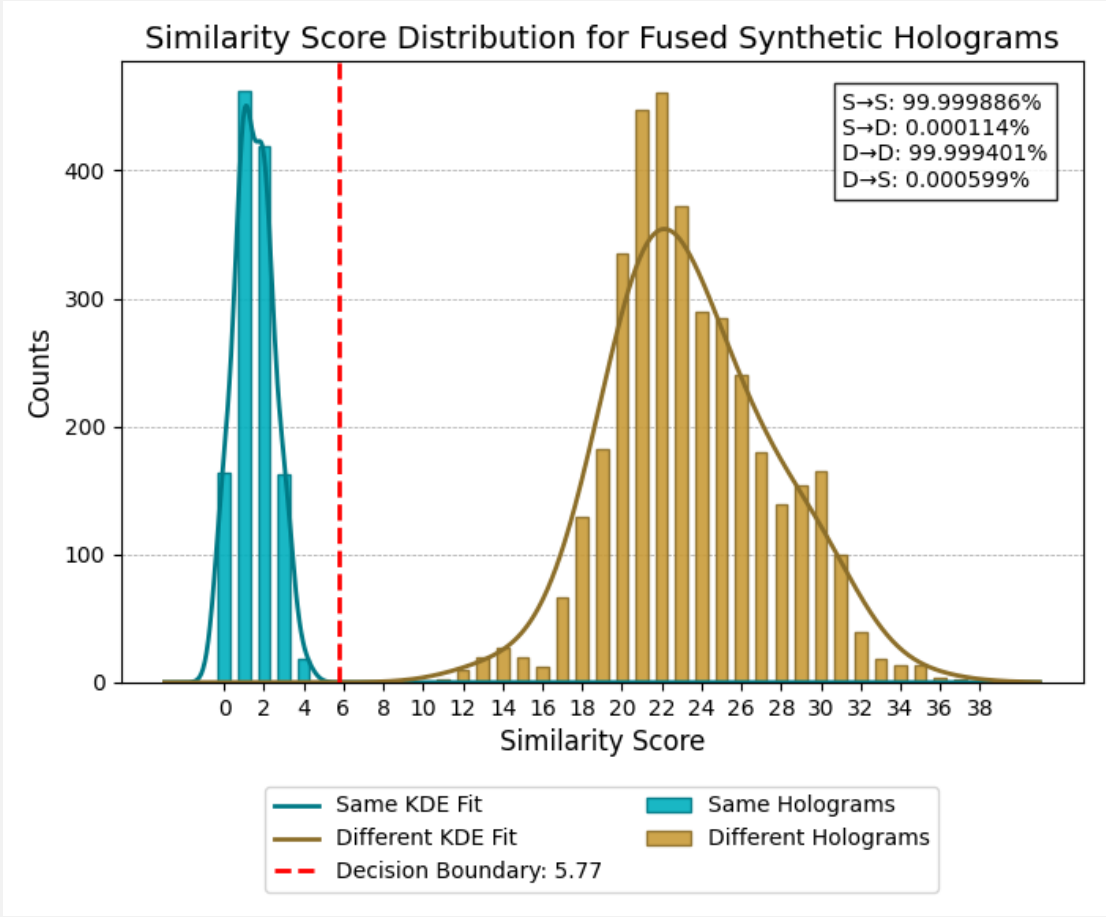
Does it really work?

Synthetic Dataset

DISTRIBUTION OF SIMILARITY SCORES

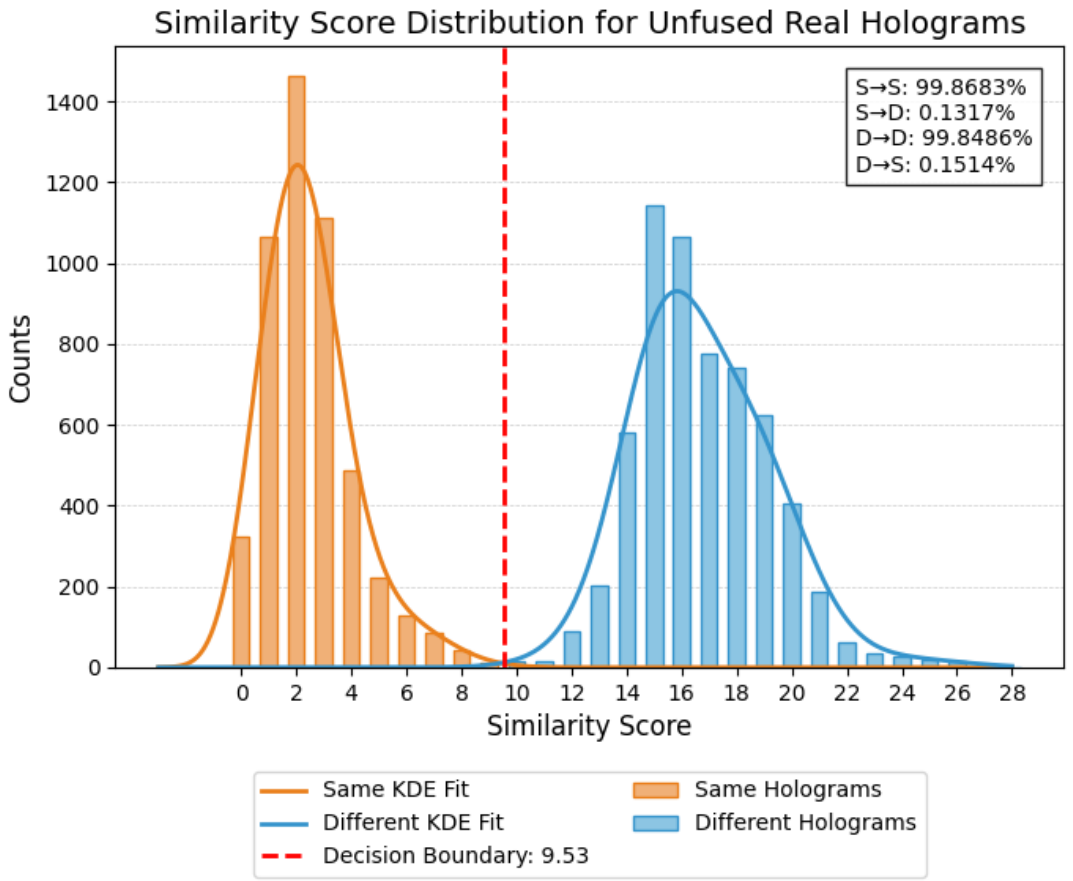


FUSION = stack of ten images

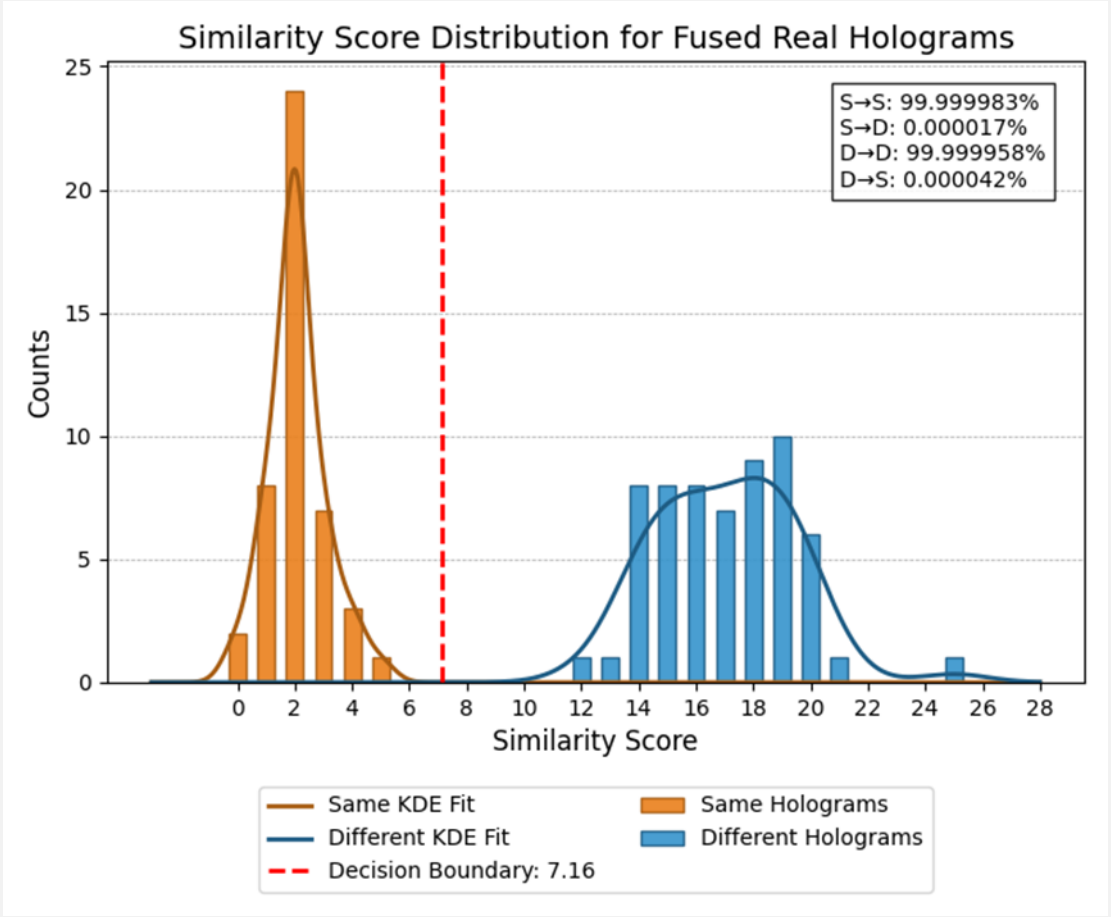


Real Dataset

DISTRIBUTION OF SIMILARITY SCORES



FUSION = stack of ten images



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- **Synthetic dataset rendering** was distributed across HPC nodes using **BHeappe** to parallelize Blender rendering tasks

- **Training and evaluation** of three independent **U-Net models** (ID card, shield, and micro-dot segmentation) were executed on **GPU-accelerated compute nodes**
  - Typical training jobs used **4–8 GPUs per job**, with runs spanning **50–180 epochs** depending on the model
  - The full training campaign required **hundreds of GPU-hours**

Thank you for your attention.