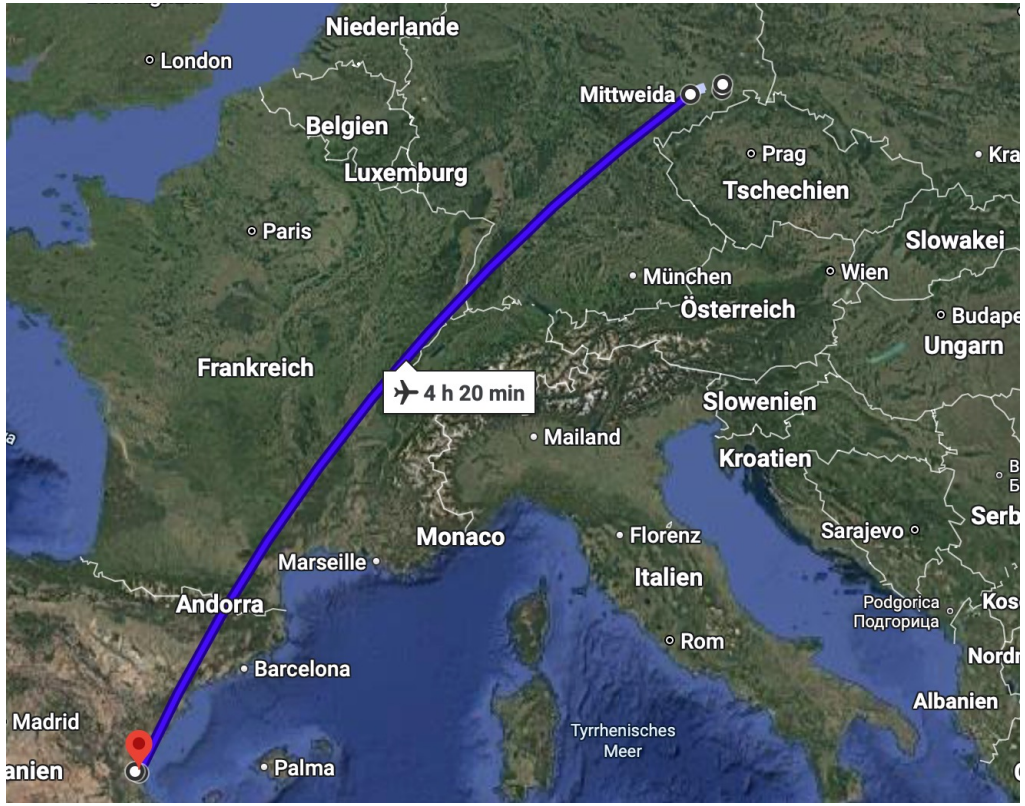
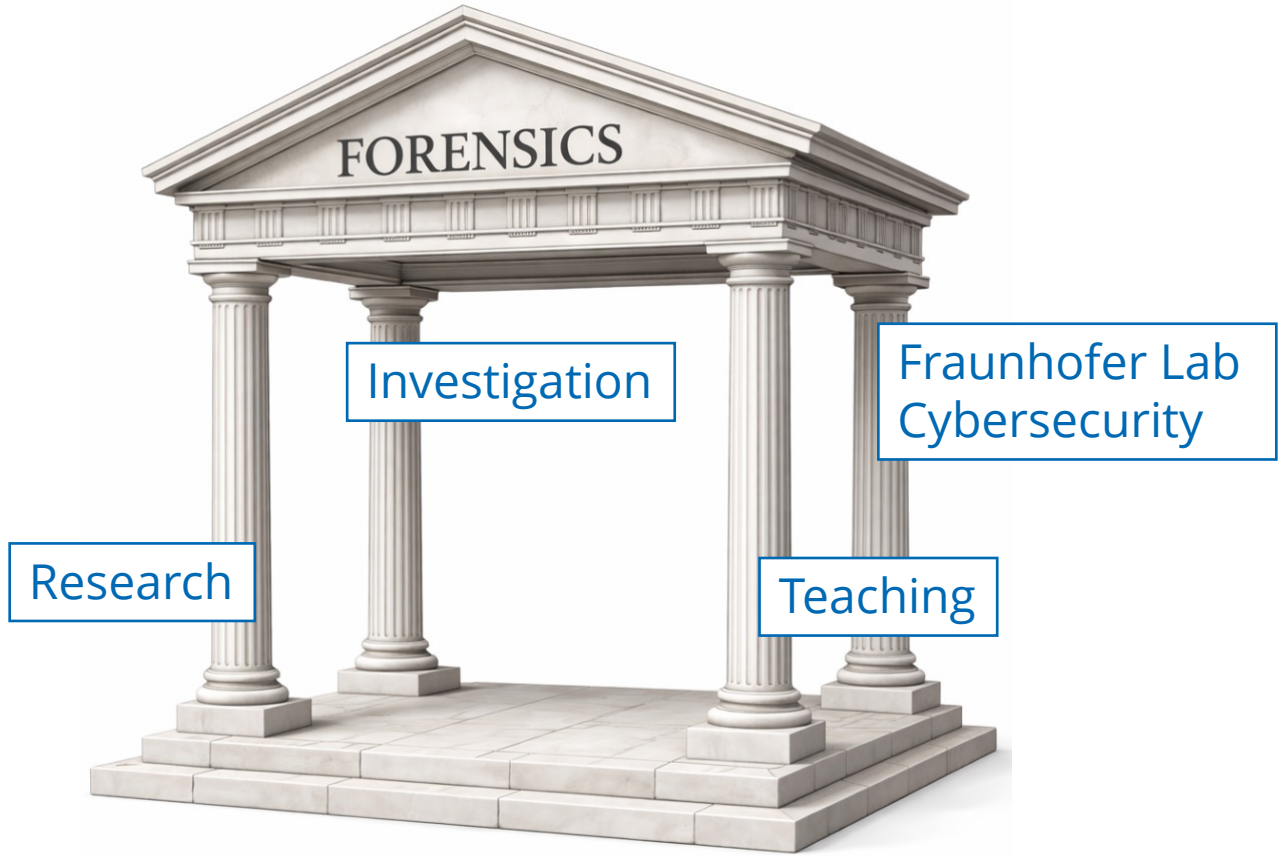
2100 km from Mittweida to Valencia



AI and Forensics

Forensics in Mittweida



Teaching

Study programs

Degree programs (full time)

General and Digital Forensics B.Sc.

Practical study of forensics in the field of general and digital forensics: crime scene analysis with Mr. Locard in the digital and real world.

Cybercrime/Cybersecurity M.Sc.

An in-depth course of study in the field of cybercrime, which allows for optimal focus and qualification through various qualification pathways.

Study programs and part time distance learning courses

IT Forensics/Cybercrime B.Sc.

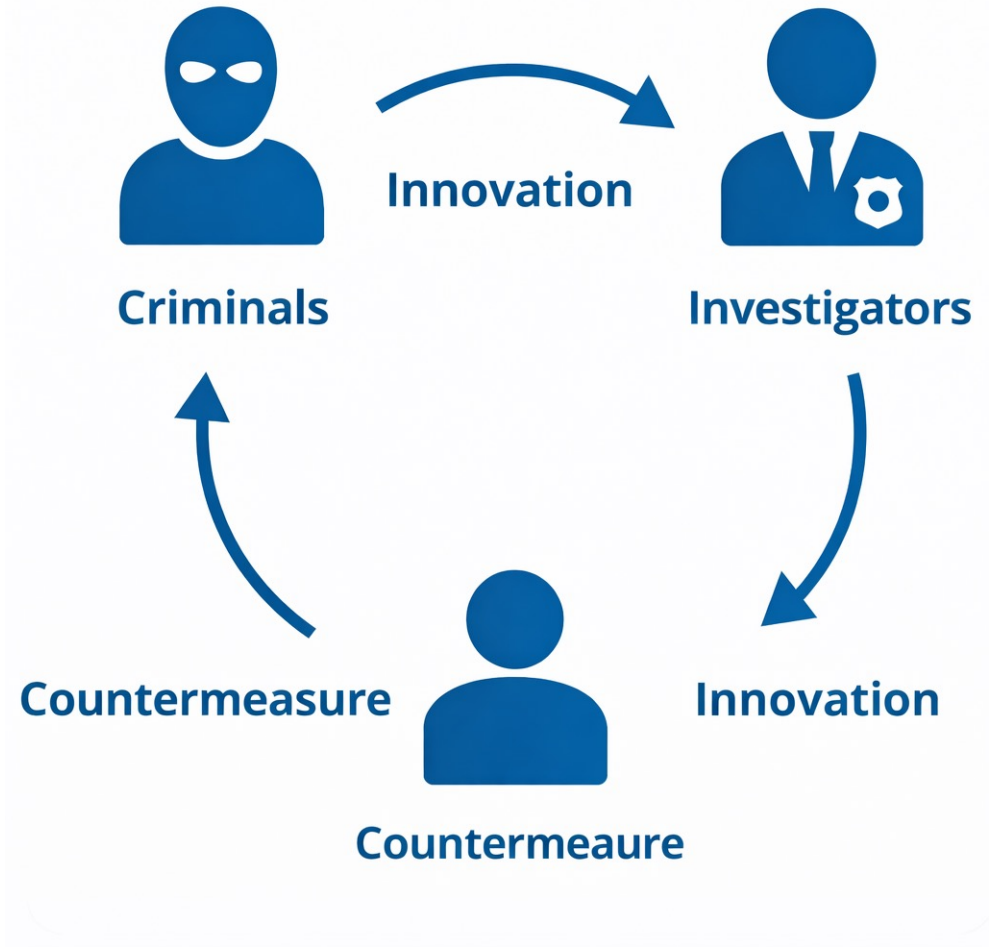
Part time distance learning course in the field of IT forensics/cybercrime.

Digital Forensics Specialist

One-year study programme for government employees in the field of IT forensics. Online course with certificate upon completion.

Research and Investigation

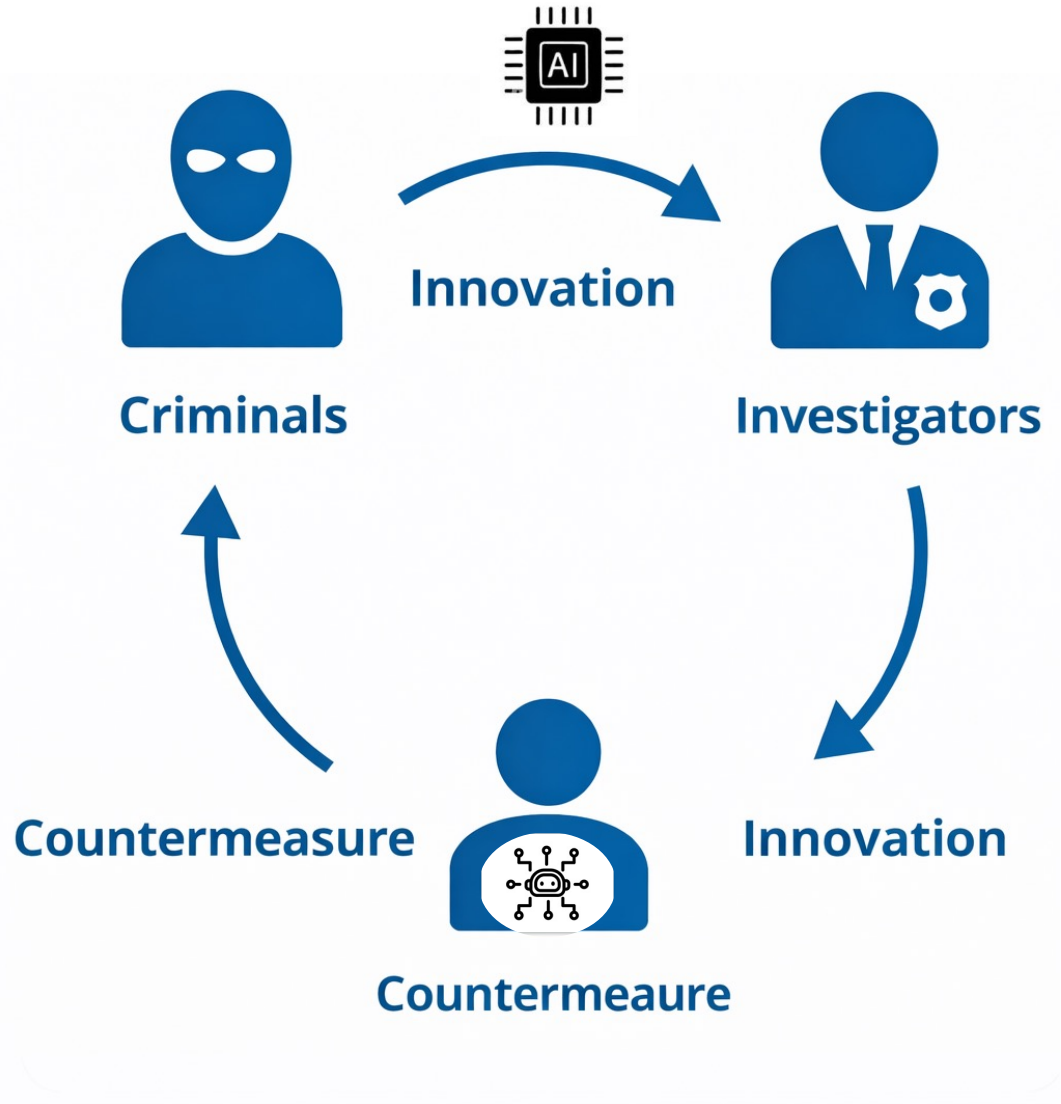
"Contract Research"

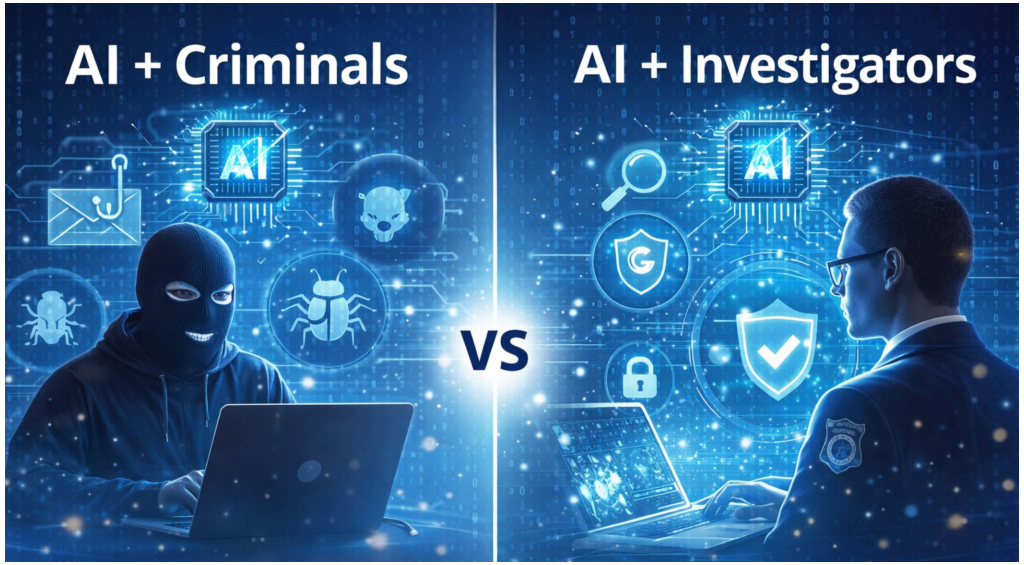


The history of the fight against crime is characterized by an ongoing race between investigative authorities and criminals. This race can be described as a cyclical interplay of innovation and countermeasure: whenever one side develops new methods, the other responds with adjustments or new strategies.

Innovation and Countermeasure

AI as Innovation booster





A tutorial is a digital step-by-step guide that imparts knowledge
or
solves problems.

Tutorial II

Challenges and Opportunities of Intelligent Systems in Forensics

Dirk Labudde

HOCHSCHULE MITTWEIDA
University of Applied Sciences

hs-mittweida.de

VISUAL 2026

March 08, 2026 to March 12, 2026 - Valencia, Spain

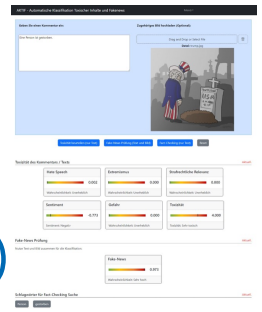
Possibilities of using intelligent systems in criminal proceedings

Image editing

Language model

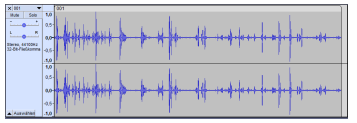
The digital skeleton

Bot and context recognition in the context of hate speech
(Automatic classification)

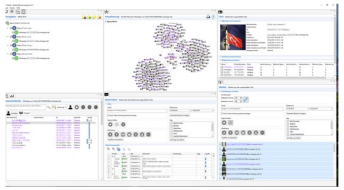


Modern video analysis –
Detection of suspects and series

Audio recording

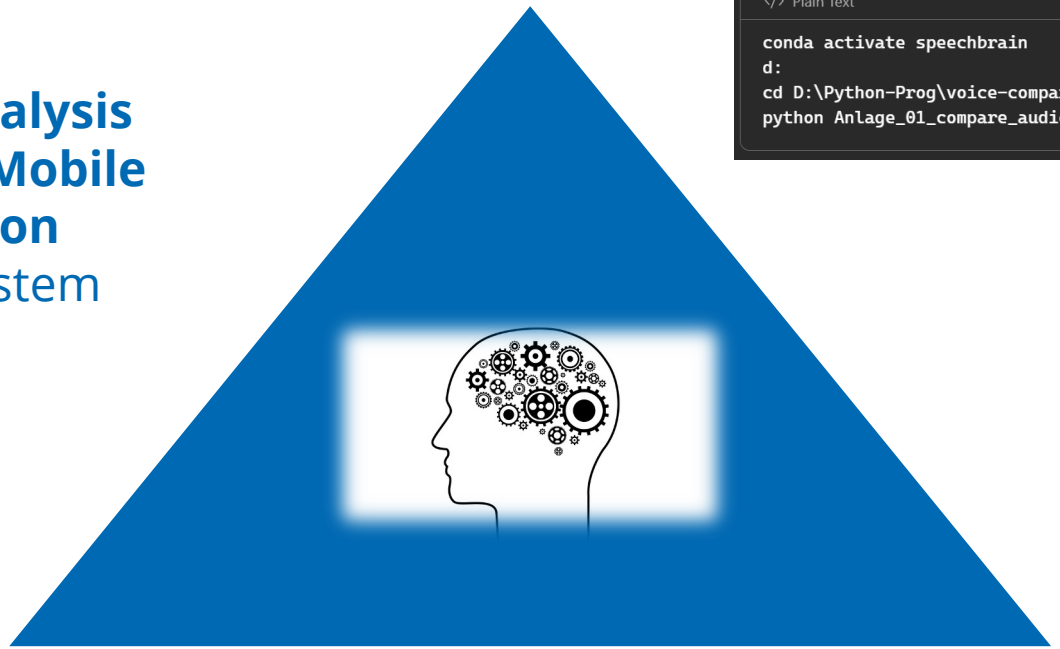


Whisper → Text



A Forensic Analysis Platform for Mobile Communication
ML - Expert system

```
Plain Text
conda activate speechbrain
d:
cd D:\Python-Prog\voice-compare
python Anlage_01_compare_audiofiles.py
```



GenKI-supported process optimisation in police case processing and law enforcement

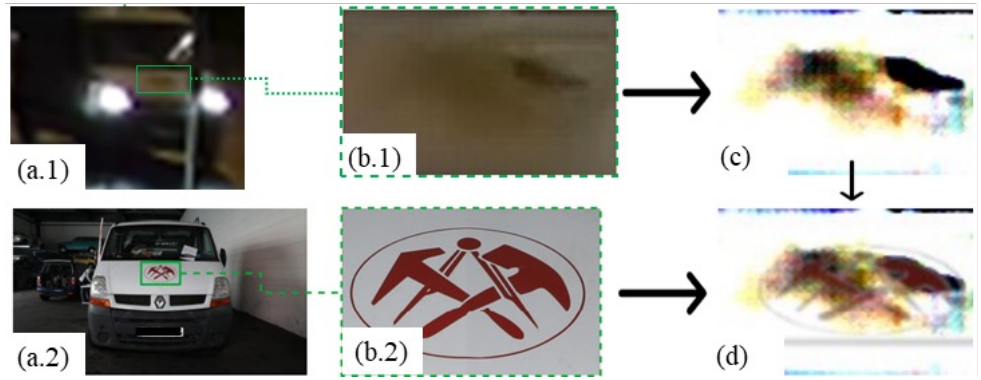
Image analysis

- Image Stacking
- Image Enhancement
- Face recognition
- Object recognition
- Semantic analysis

Grooming/CSAM
AI models and concepts for detection and analysis

FoSIL- pipeline based on selected cases

Preliminary investigation: on suspicion of kidnapping for ransom
Method used: Image stacking



Preliminary investigation: on suspicion of arms trafficking
Method used: Image Enhancement

Preliminary investigation: on suspicion of theft
Method used: Facial recognition

Preliminary investigation: for murder
Method used: Object recognition

Im Fokus stehender Kleintransporter

Kleintransporter Vergleichsmodell

Korrespondenzen und Referenzsystem

Sichergestellter Transporter

Ein durch Überwachungskameras einer örtlichen Tankstelle erfasster Transporter

?

übereinstimmende Korrespondenzen

Nicht herausarbeitbare Korrespondenzen

Bildausschnitt eines/des Kleintransporters im Video

Bildausschnitt vom Bereich der Motorhaube eines/des Kleintransporters im Video

Vergrößerter Bildausschnitt (Bildvergrößerung des Originalframes auf 7689x4320px mittels Neural-Enhance, https://github.com/alexjc/neural-enhance)

Separate Anpassung von Helligkeit und Kontrast (Verwendete Software: GIMP + G'MIC-Qt plug-in for GIMP 2.10, https://gmic.eu/)

Frontale Ansicht auf ein/das Vergleichsfahrzeug

Bildausschnitt

Informationszusammenführung

Motion blur Reduction

- Originals were processed with motion blur filter
- In the case of synthetically generated distortions, the originals are restored almost completely
- **Some details are still lost**

Original

Bearbeitet

Original

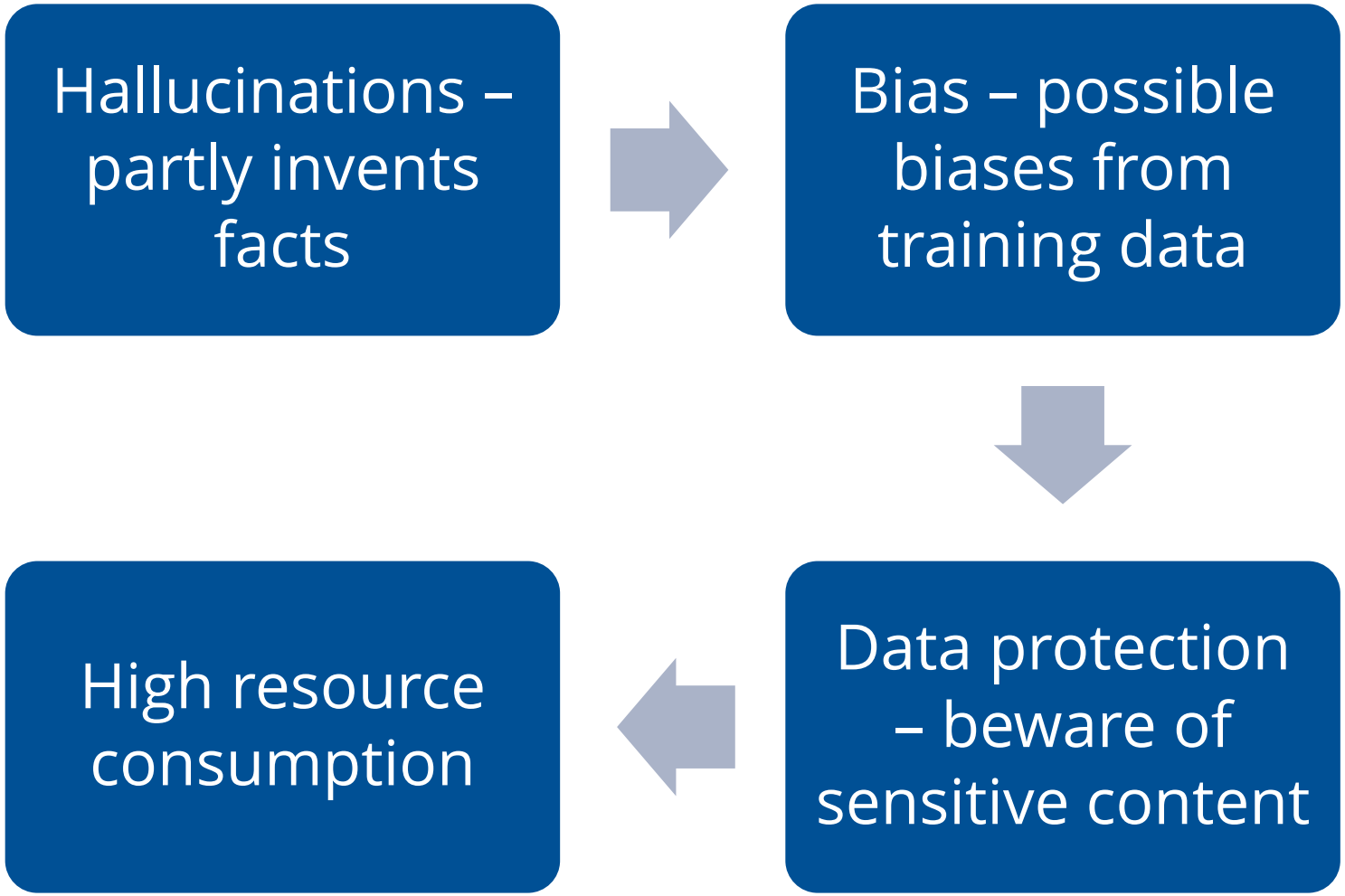
Bearbeitet

The investigation file is the structured memory of criminal proceedings – it documents not only facts, but also the path to the truth.

Language model

Structure of an Investigation File

Limits and challenges



Possibilities of using intelligent systems in criminal proceedings

From RAG to ARG

Retrieval-Augmented Generation (RAG) and Agent Reinforced Generation (ARG) adressieren einige dieser Probleme

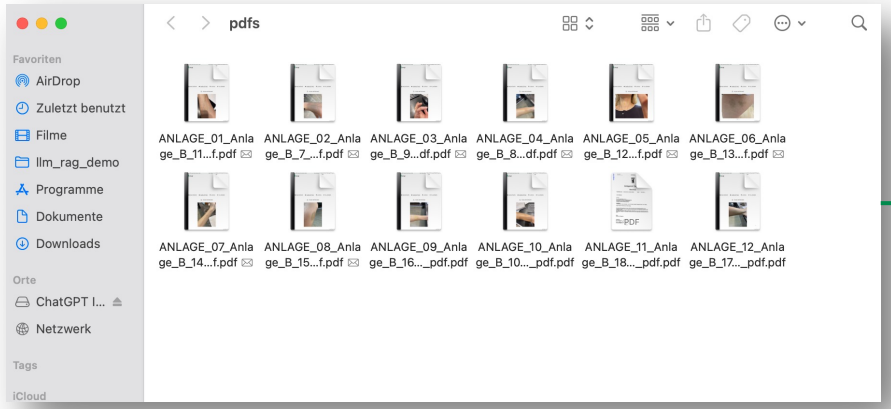
Retrieval-Augmented Generation (RAG)

Retrieval is the process of converting a user query into a semantic representation (e.g., vector) in order to identify the most relevant documents or snippets of text from an external knowledge source and provide them as context for a language model.

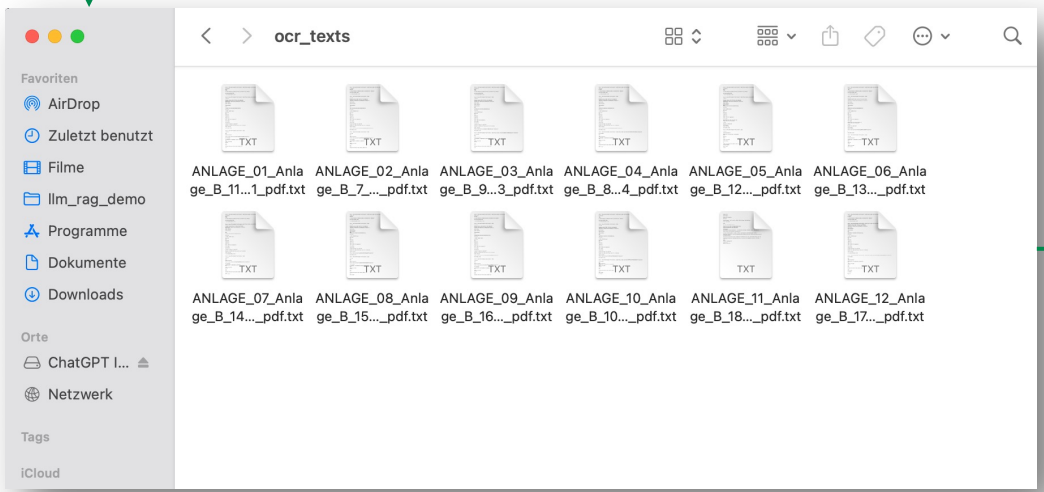
In Retrieval-Augmented Generation (RAG), "Augmented" means: The language model is enriched – not only with its own knowledge/skills learned in training, but also with targeted access to external information that fits the respective request.

Definition: Generation (in RAG) Generation refers to the process in which a large language model (LLM) autonomously generates a natural language response or other text output based on user input and externally retrieved information.

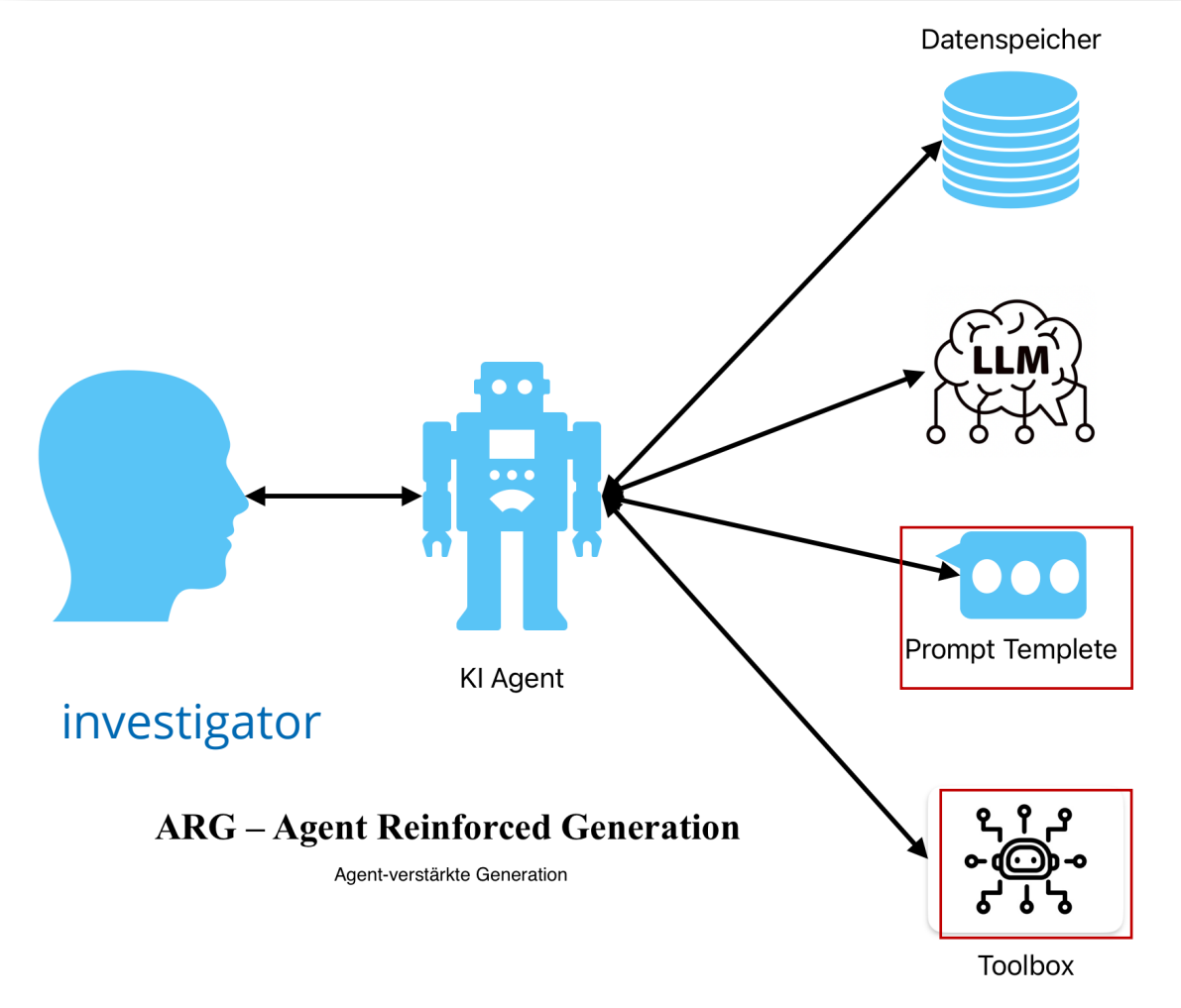
Skript ask_pdf3.py: Ablauf und Funktionen




```
❓ Frage: Wieviele Fotos wurden analysiert?

💬 Antwort:
 Sechs Fotos wurden analysiert.

❓ Frage: Wie lauten die Geo-Koordinaten zu diesen 6 Bildern?

💬 Antwort:
 Die Geo-Koordinaten der sechs Bilder sind wie folgt:

1. **52° 30' 0.33" N, 13° 18' 38.72" E**
2. **52° 27' 39.07" N, 13° 16' 59.31" E**
3. **52° 27' 39.43" N, 13° 16' 59.45" E**
4. **52° 27' 39.35" N, 13° 16' 59.26" E**
5. **52° 30' 0.33" N, 13° 18' 38.72" E**
6. **52° 30' 0.33" N, 13° 18' 38.72" E**

❓ Frage: Wie sind die ISO Werte in den unterschiedlichen Dokumnetn

💬 Antwort:
 Die ISO-Werte in den verschiedenen Dokumenten sind wie folgt:

1. In einem Dokument beträgt der ISO-Wert 100.
2. In anderen Dokumenten ist der ISO-Wert nicht explizit angegeben, daher kann ich keine weiteren Werte nennen.

❓ Frage: Kannst du mir die Anzahl der Papremeter in den Anlagen geben?
```



ARG – Agent Reinforced Generation

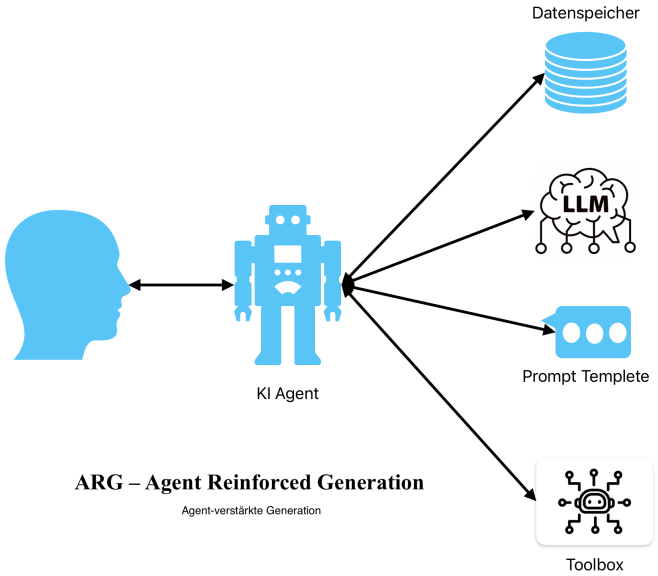


- Automation
- Processing of heterogeneous data in a network

ARG – AGENT REINFORCED GENERATION

ARG combines three core elements:

- **MCP (Model Context Protocol):**
- **Enables contextual exchange with external data, tools, user preferences.**
- **Supports tool usage, memory formation, and dynamic context management.**
- **A2A protocol (agent-to-agent):**
- **Structures communication between agents.**
- **Controls task distribution, state tracking, and adaptive interaction.**
- **DAO (Decentralized Autonomous Organization):**
- **Decentralized Autonomous Organization and Operation (DAO) to enable coordination and execution of tasks in a transparent and tamper-proof manner.**



ARG – AGENT REINFORCED GENERATION – TOOL-BOX PICTURE

1. Szene erkennen: Klassifikation	**Technik**: CNN-basierte Bildklassifikation	**Ziel:** Bild einer Kategorie zuzuordnen
2. Segmentierung: Regionen isolieren	**Technik:** Semantische Segmentierung (z. B. U-Net, DeepLab)	**Ziel:** pixelweise Einteilung in „semantisch“ sinnvolle Regionen
3. Objekterkennung: Konkrete Elemente identifizieren	**Technik:** Objekterkennungsnetzwerke wie YOLO, Faster R-CNN	**Ziel:** Objektdetektion

Multimodal interpretation (Text-image link)

ML - Tollbox

TextMining - Tollbox

Prompting is all you need –
LLMs for systematic file screening

Methodological approach

- Structured prompting approach: Standart- ScreenPrompt
- Clear inclusion and exclusion criteria
- Comparison: Zero-Shot, Few-Shot, Chain-of-Thought, Self-Consistency

Own prompt concepts for processing the file

Possibilities of using intelligent systems in criminal proceedings

Image editing

Language model

The digital skeleton

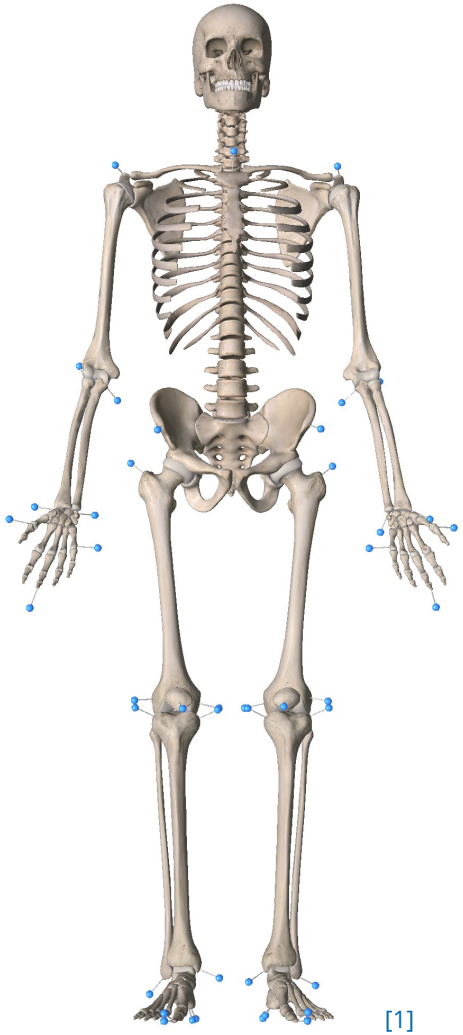
Current problem with recording from public cameras

- Concealment of perpetrators
- Lighting conditions
- Resolution

Identification and/or classification

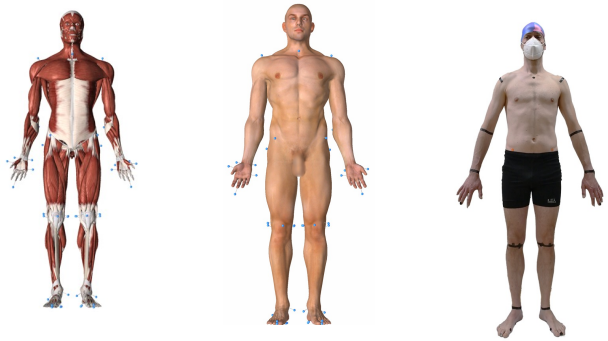
new biometric feature

Abstraction and rig as passive biometric features under realistic conditions

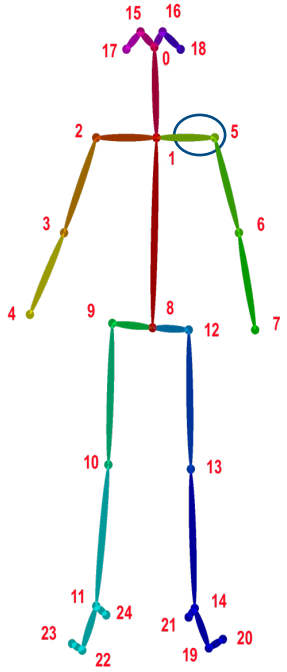


[1]

Representation of anatomy by marking bony anatomical structures at relevant positions

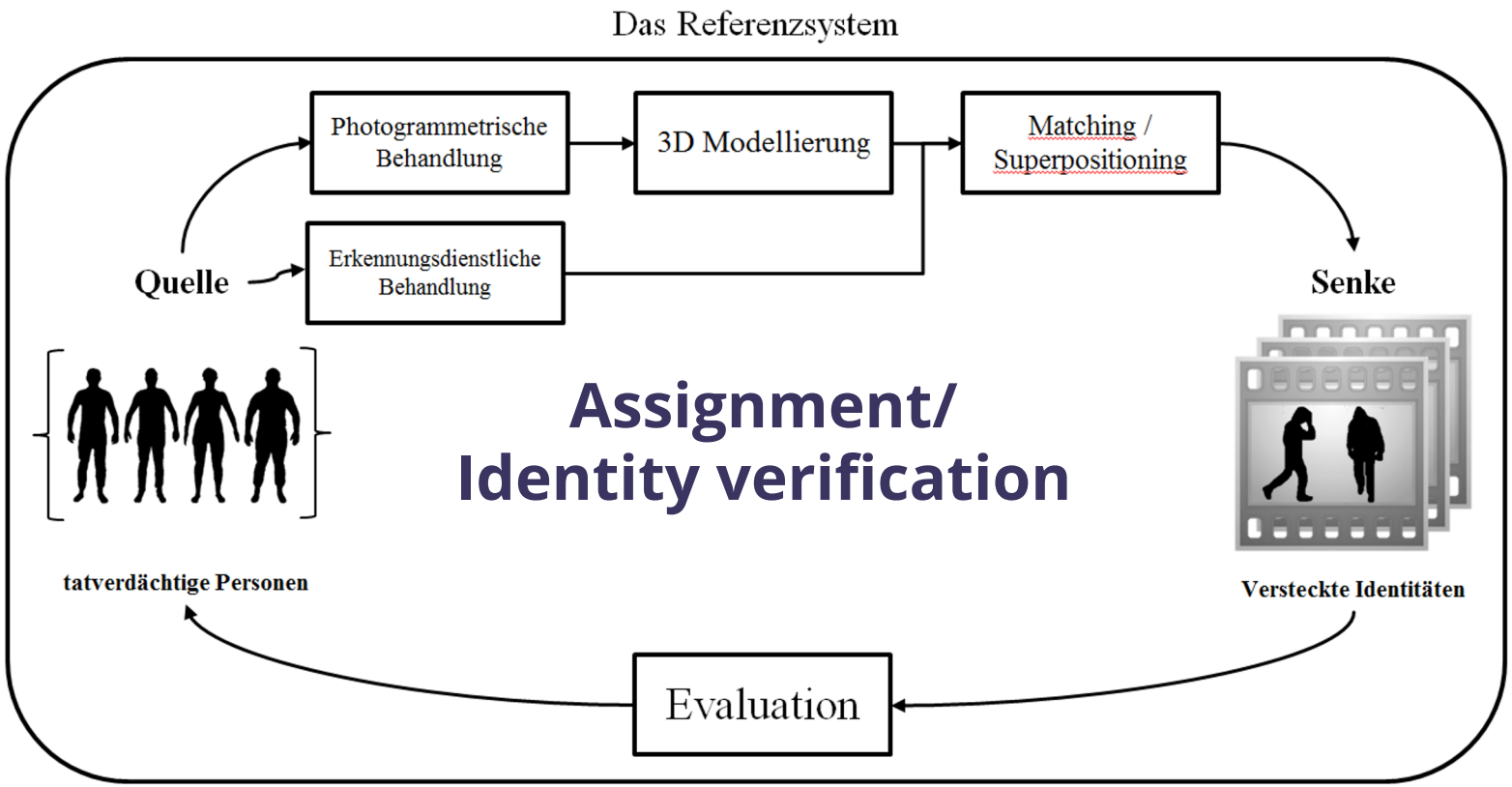


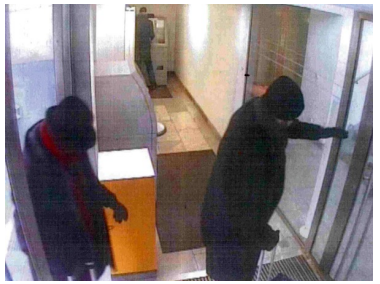
Abstraction



Digitales Rig

Modern video analysis – detection of suspects und Series





Is the person – the offender - in the video „my“ suspect?

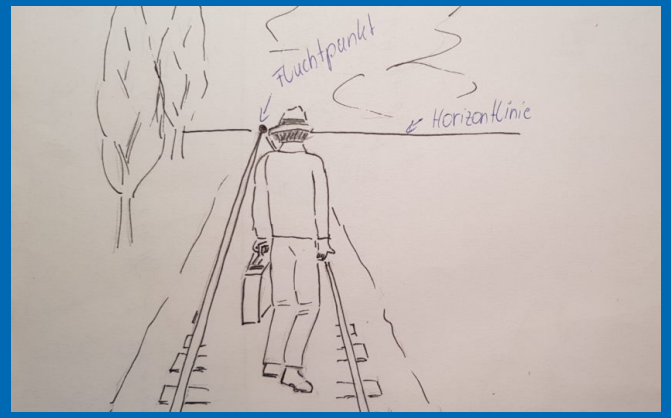
Perpetrators – suspects – classification

Musculoskeletal system

obfuscation
Fraunhofer Lernlabor
Bundeskriminalamt

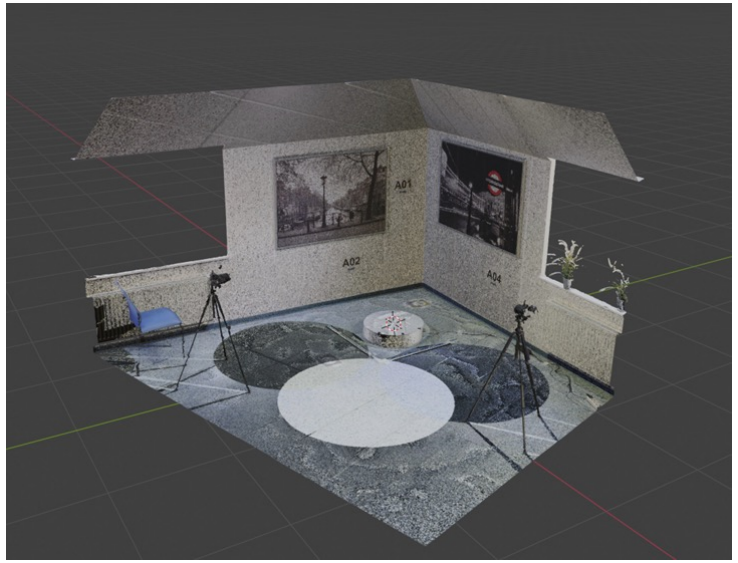
HOCHSCHULE MITTWEIDA

Methodological approach in the rig analysis

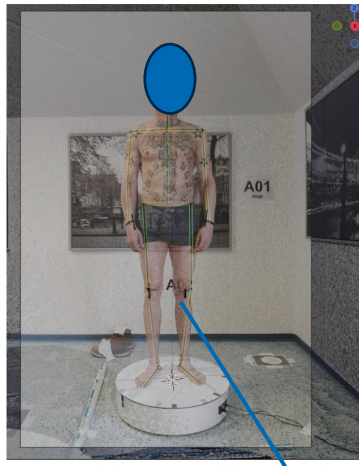


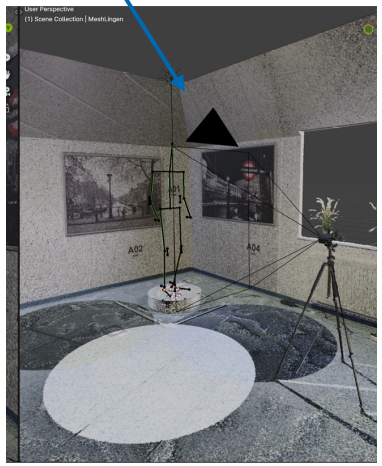
Technical perspective

Overview of processes carried out



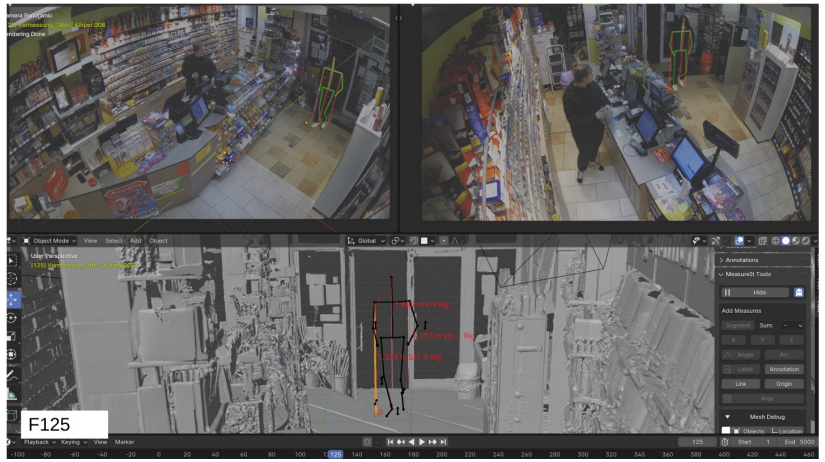
3D model (Police identification services)





3D rig creation

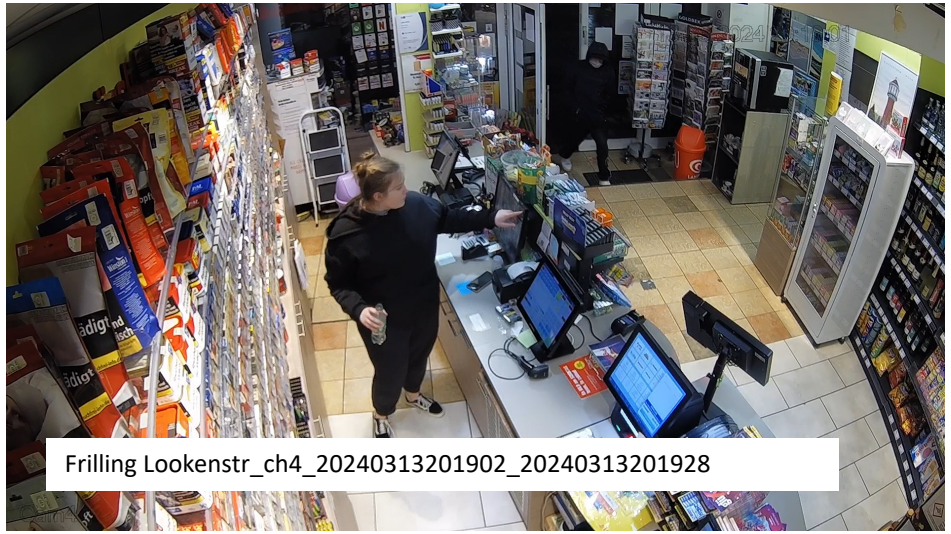
Superposition of the crime scene



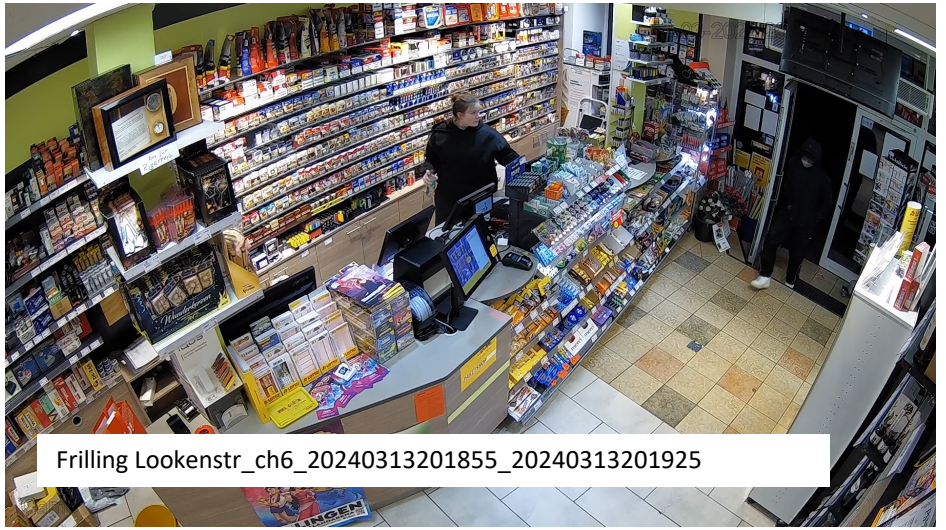
Rig fitting and measurement

Fraunhofer Lernlabor Bundeskriminalamt

HOCHSCHULE MITTWEIDA

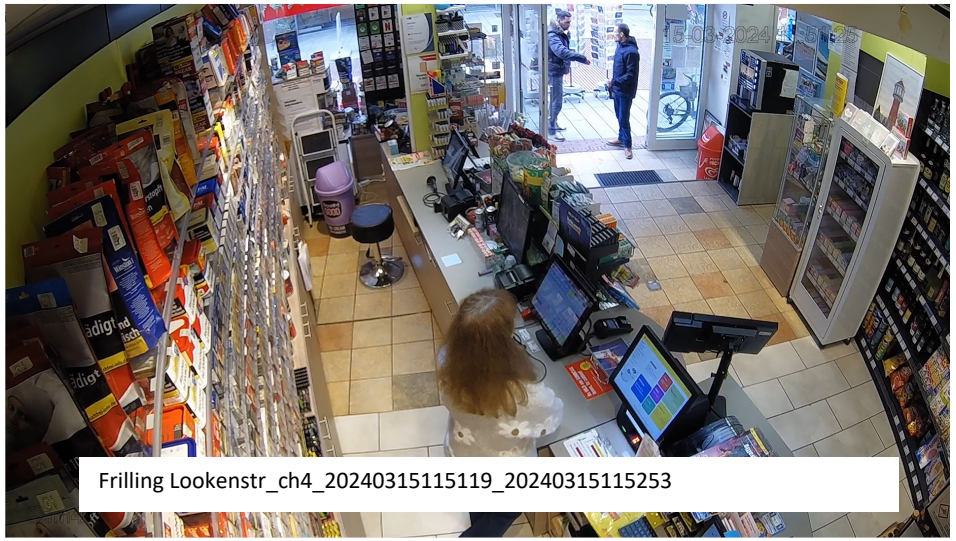


Frilling Lookenstr_ch4_20240313201902_20240313201928



Frilling Lookenstr_ch6_20240313201855_20240313201925

Criminal offence

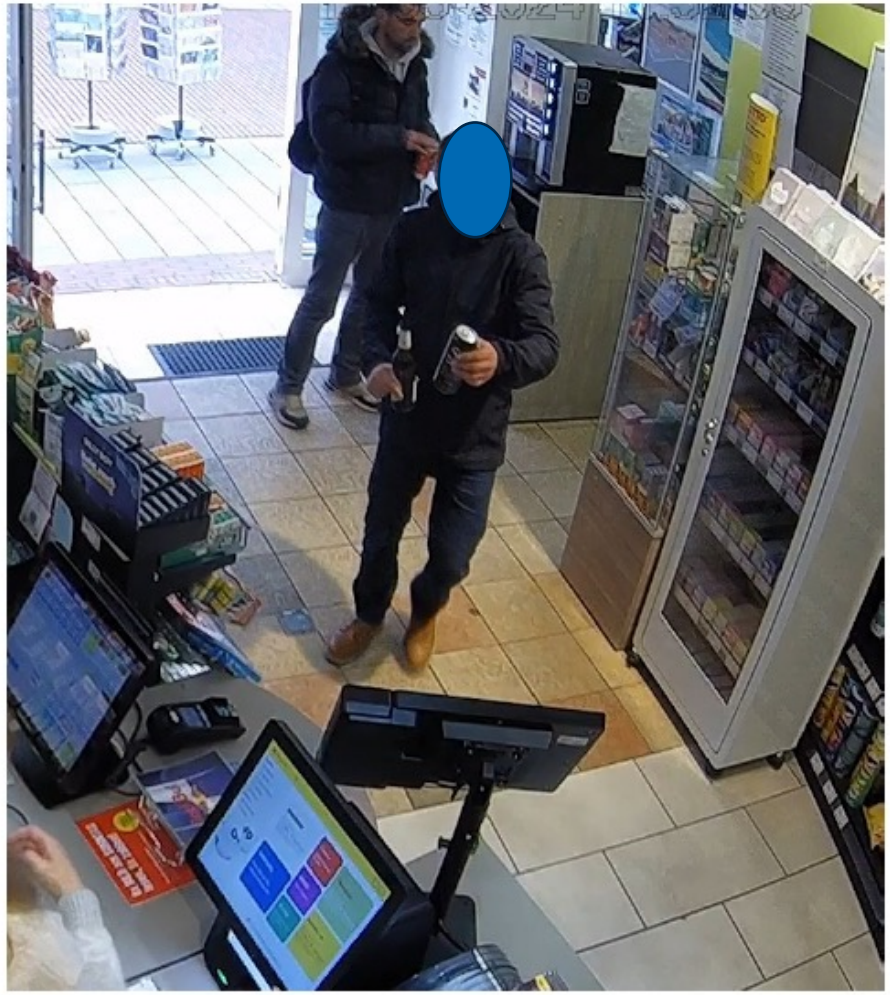


Frilling Lookenstr_ch4_20240315115119_20240315115253

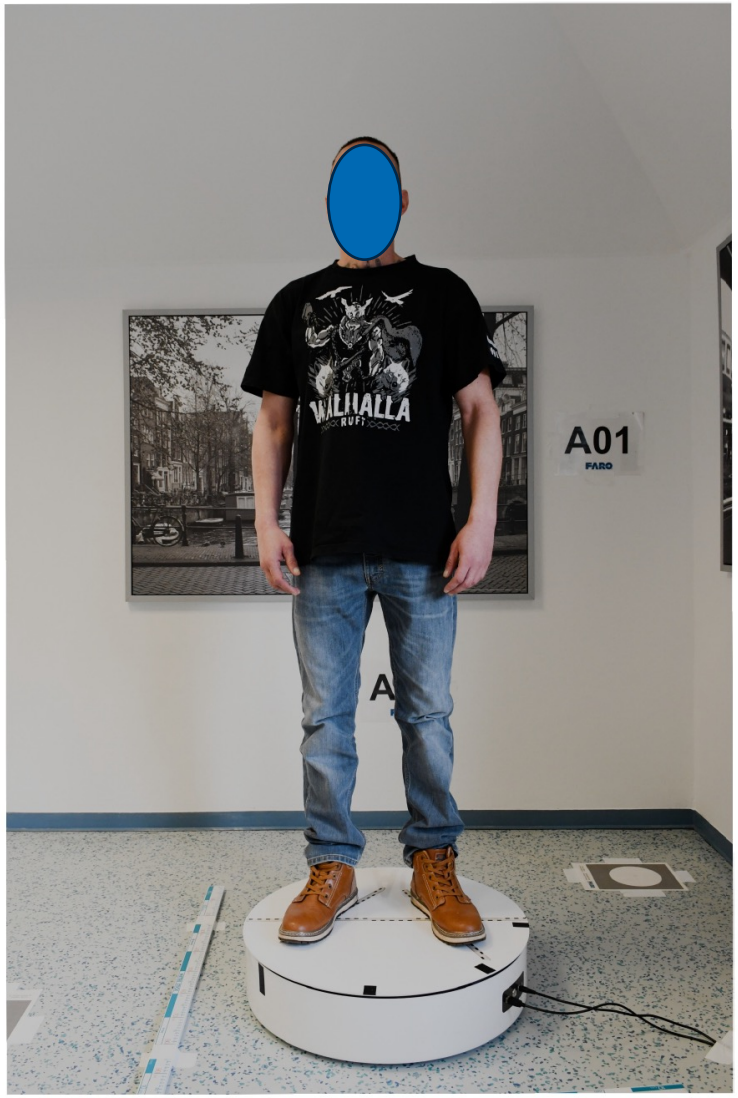
Frilling Lookenstr_ch6_20240315115150_20240315115251

Comparison video

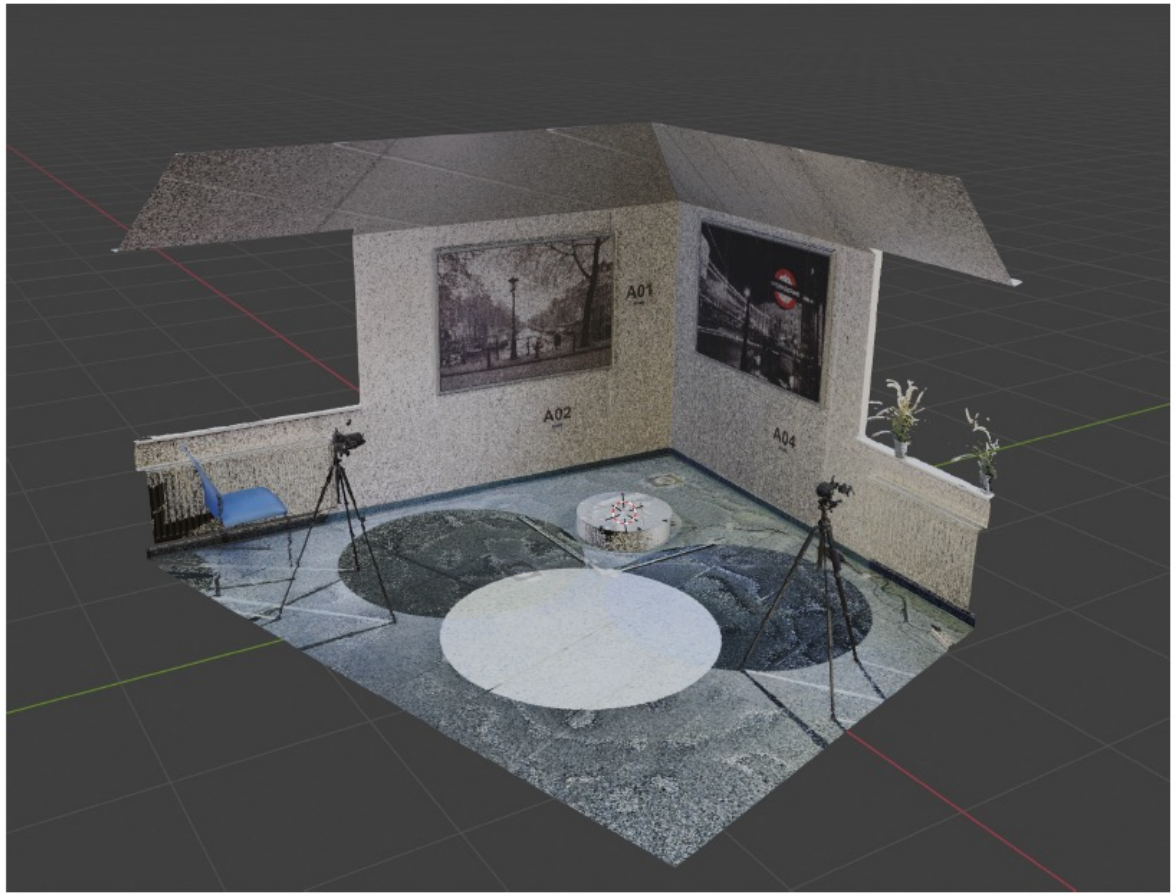
Tatverdächtige Person



- **Image: Left:** Suspect Mr H. buying beer
- **Right:** Mr H. undergoing extended ED treatment

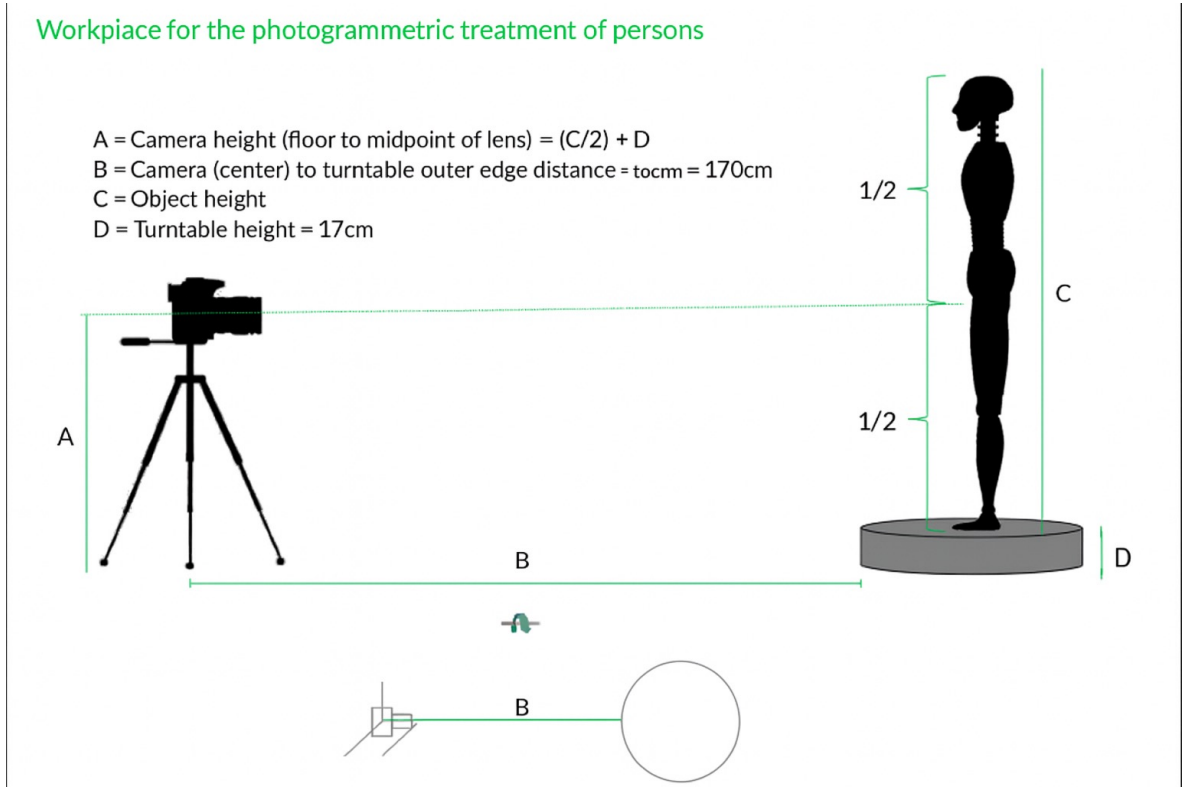


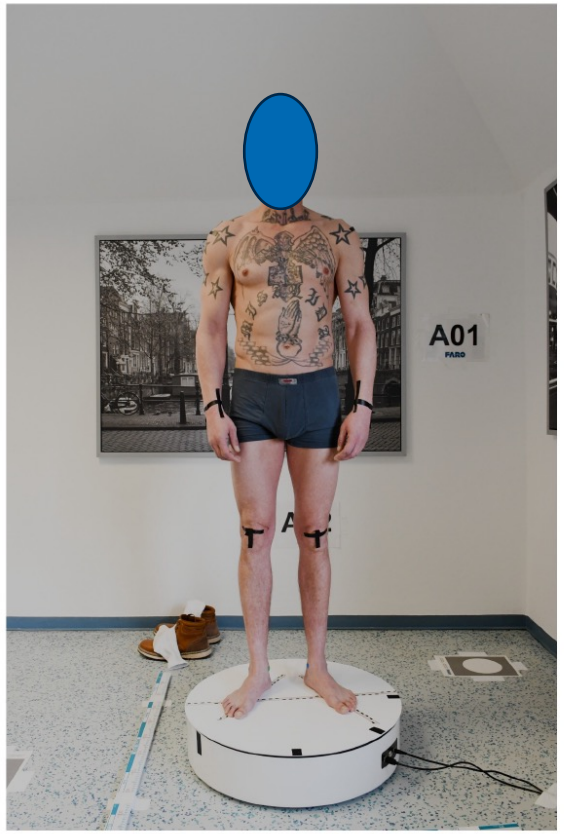
The photogrammetric workstation

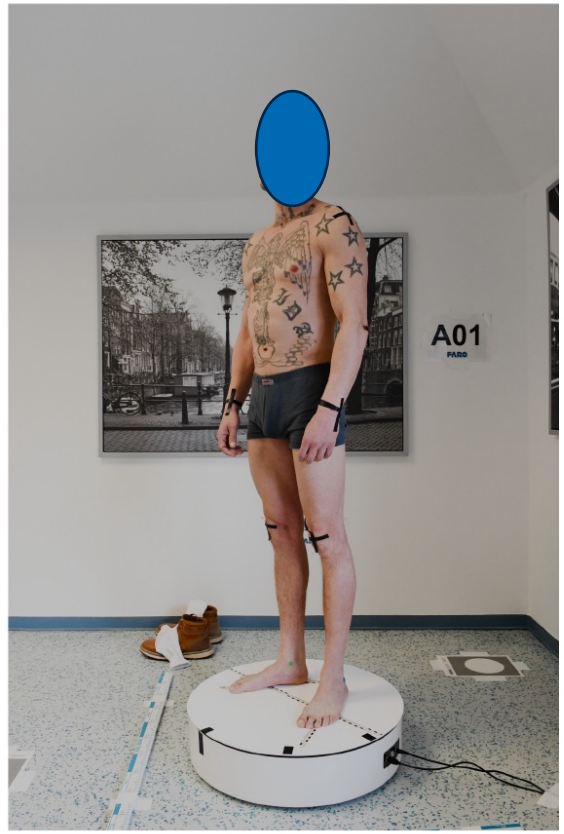


Representation of the 3D model of the photogrammetric workplace with virtual cameras

Der photogrammetrische Arbeitsplatz

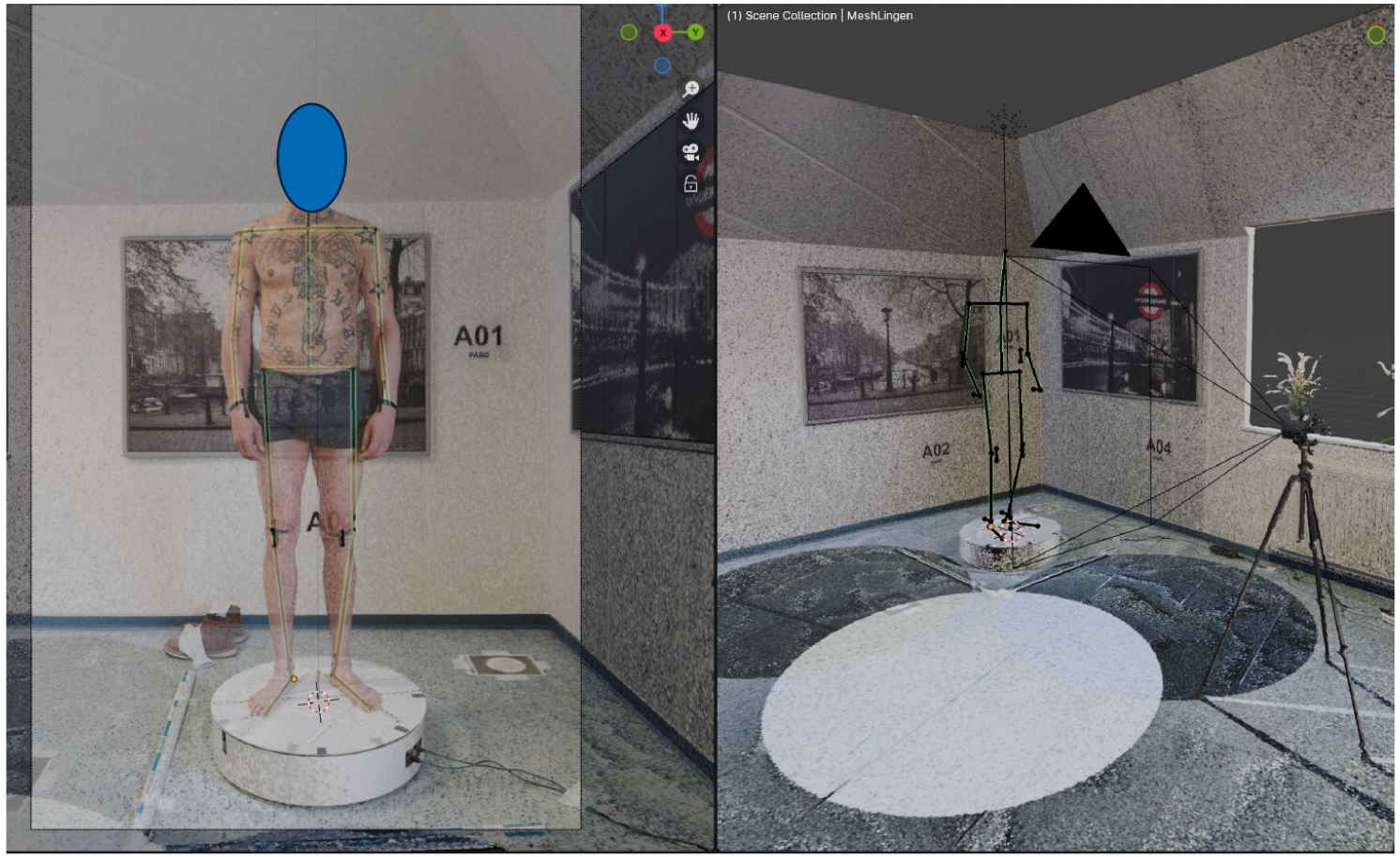






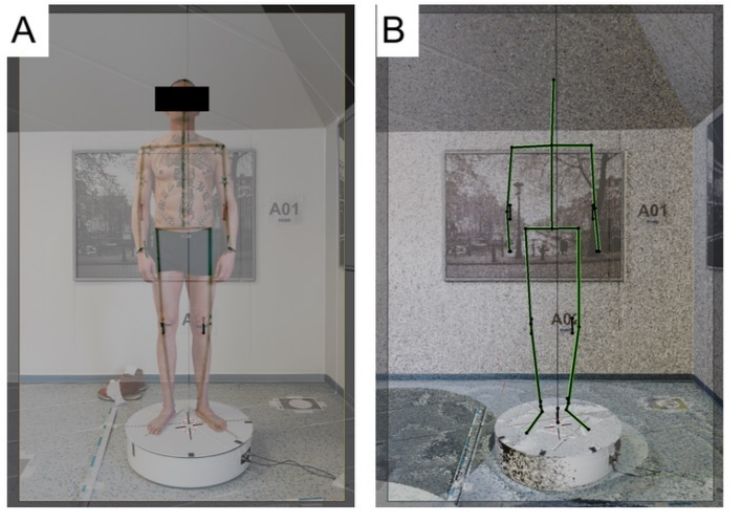
Images: Left: Illustration of the photogrammetric workstation. Right: Illustration of two sample images (camera 1 and camera 2) of the photogrammetric workstation from TV

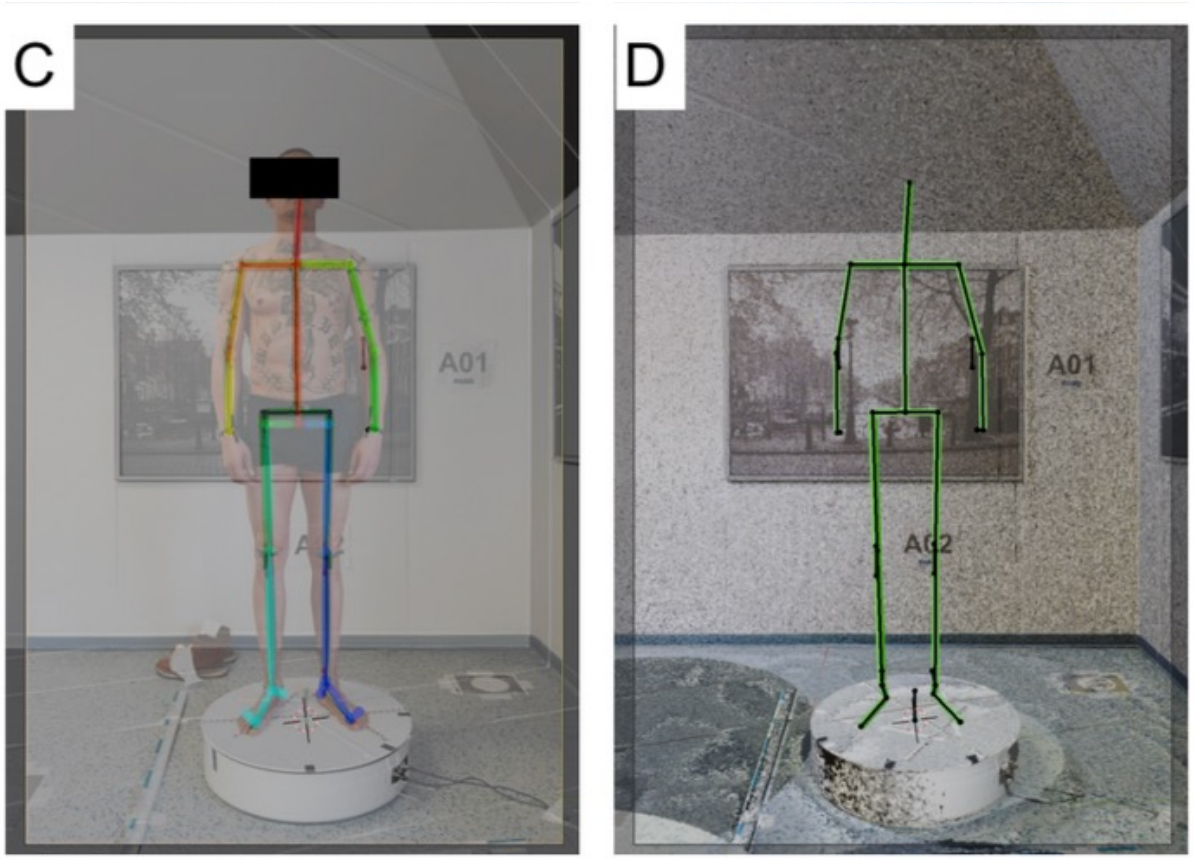
Methodology: Rig derivation (using the joint markers)



Derivation of Mr H.'s rig model based on selected points of the skeletal system by superimposing the 3D model of the treatment room and the image material from the extended identification treatment. The image on the right shows the 3D model with the virtual cameras and the TV rig.

Methodik: Rig pipe (and KI - openpose)





The personalised rig (B) and the OpenPose-based rig (D) of the suspect, as well as
One underlying example frame from the frontal view (A, C) in each case.

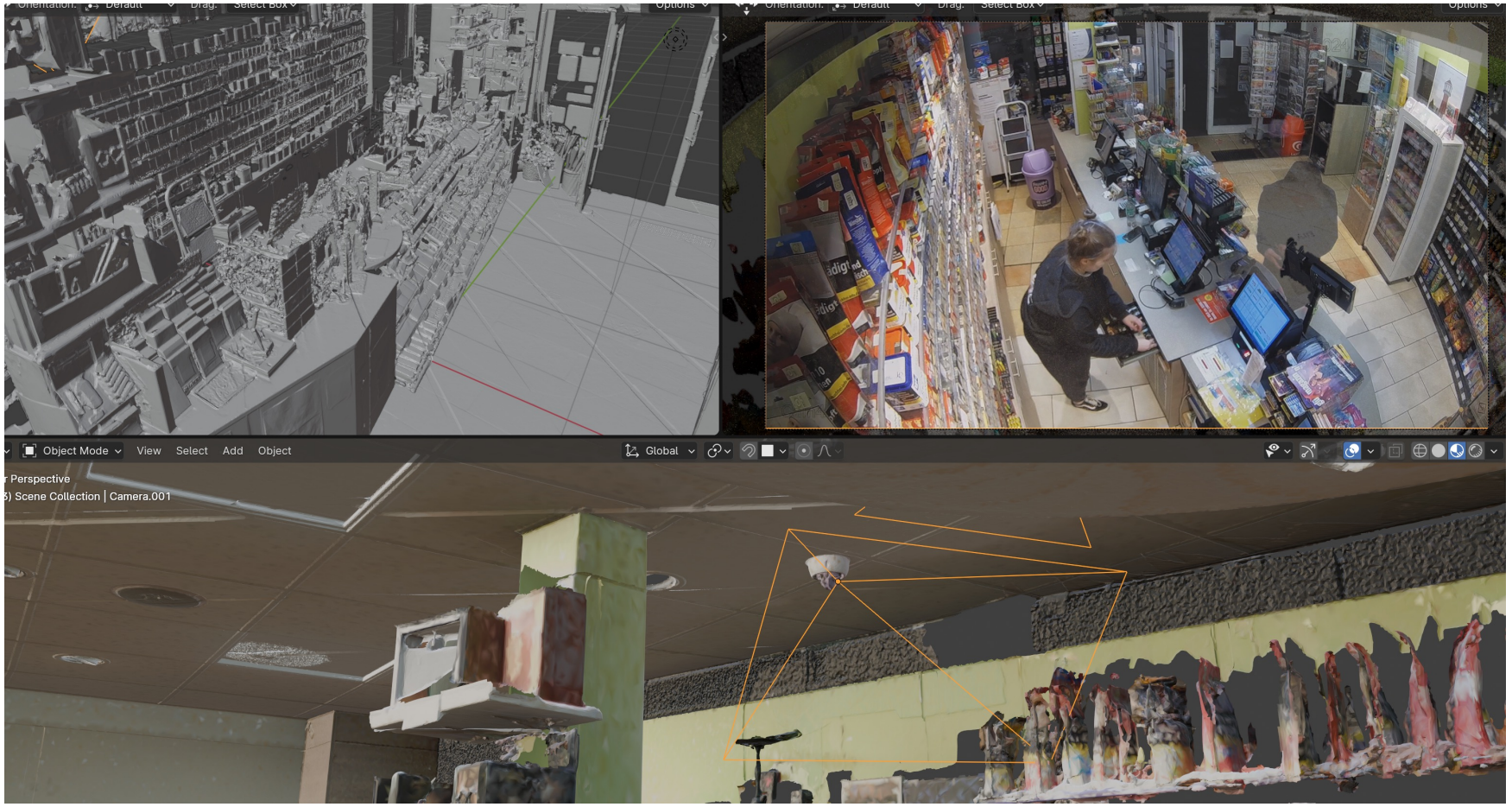
Definition: 3D crime scene reference model (without virtual camera

Representation of the 3D crime scene reference model of the city kiosk

Kameraposition 1

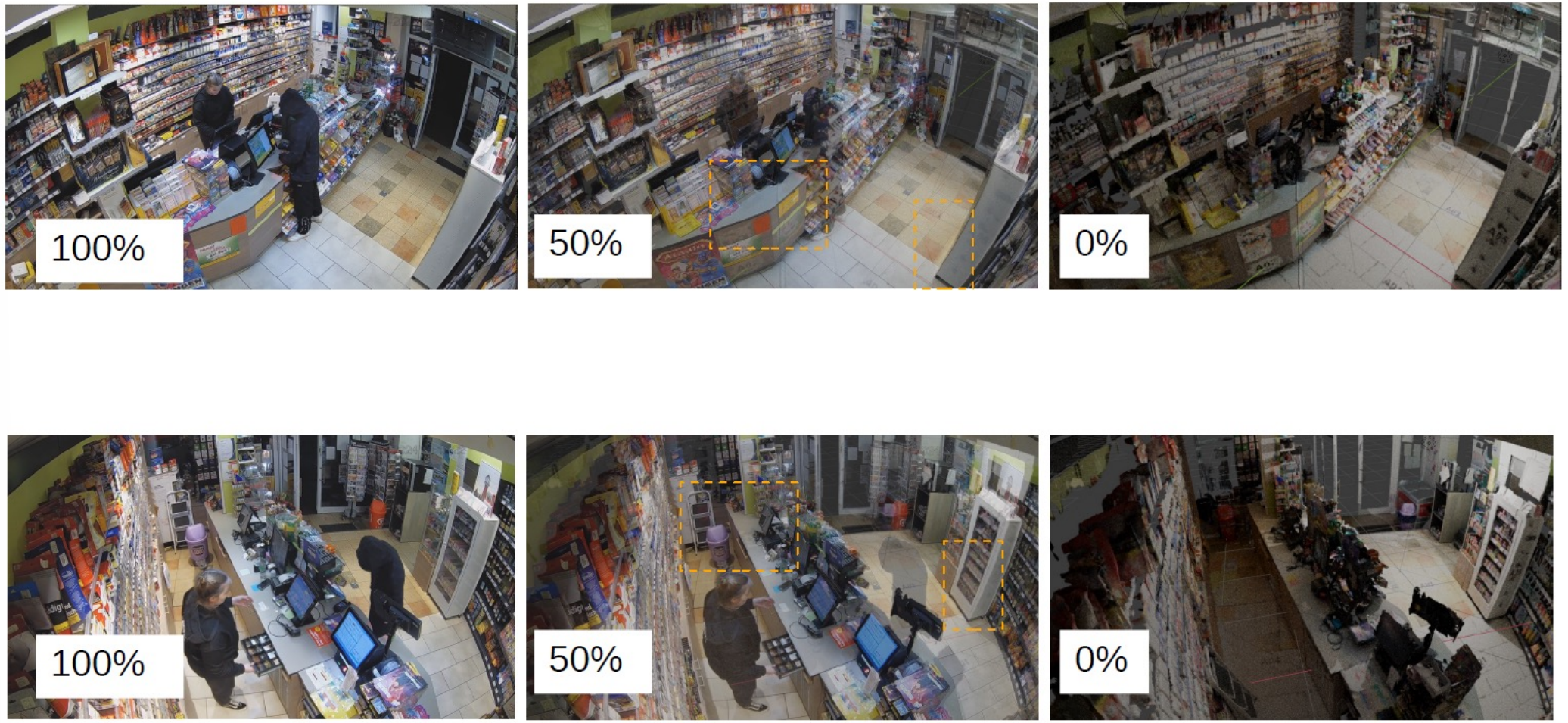
Presentation of the camera position

Kameraposition 2



Presentation of the camera position

3D crime scene reference model – Camera 1



Parametrisation of virtual camera 1 above and 2 below. From left to right, the images correspond to a reduction of the alpha channel from 100%, 50% and 0% transparency

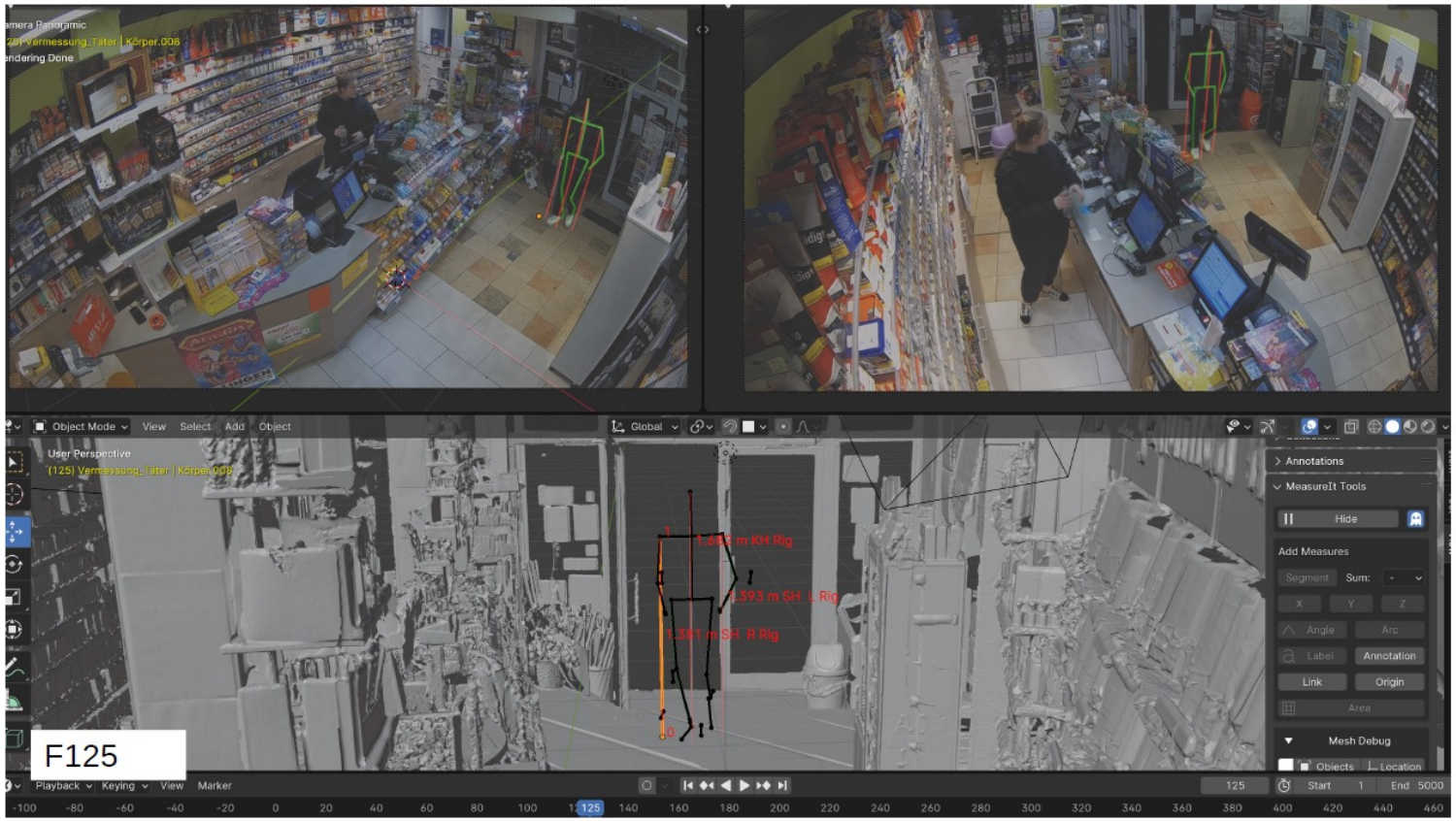
Synchronisation of camera 1 and 2

Frilling Lookenstr_ch4_20240313201902_20240313201928

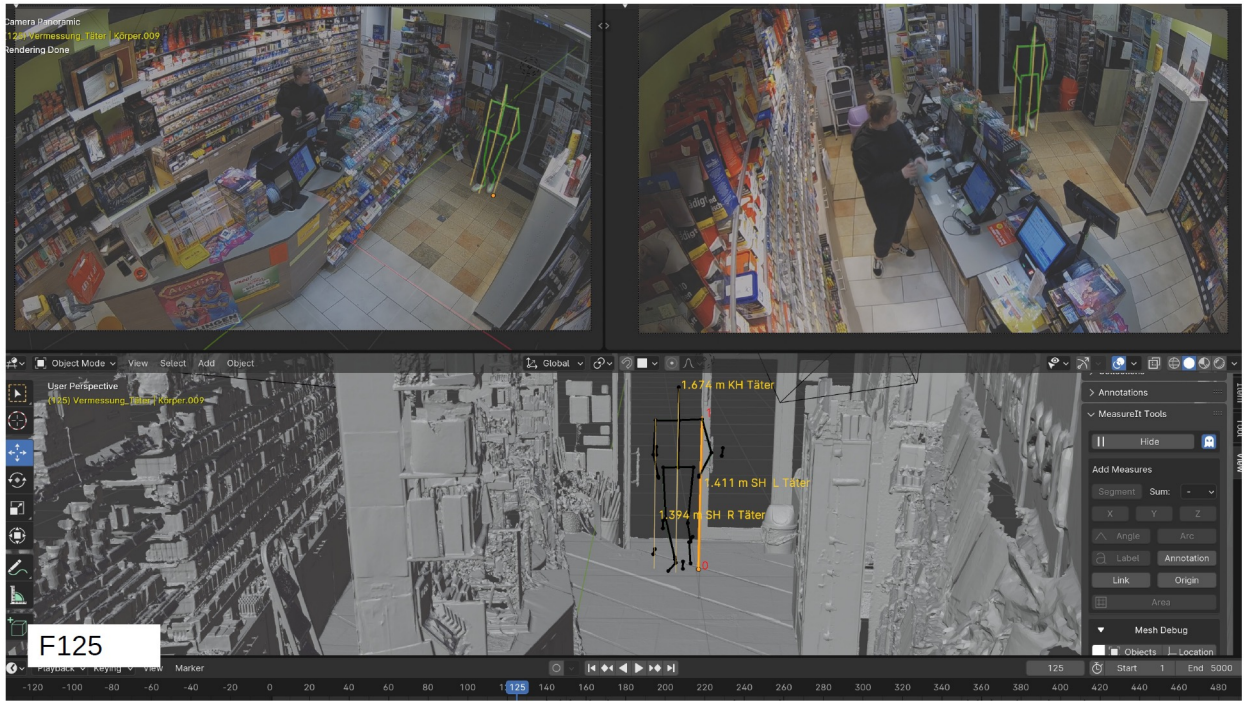
Frilling Lookenstr_ch6_20240313201855_20240313201925

Figure: Illustration of frame-accurate synchronisation of the two camera perspectives using an offset of 101 frames.

Determining shoulder and body height (Rig)

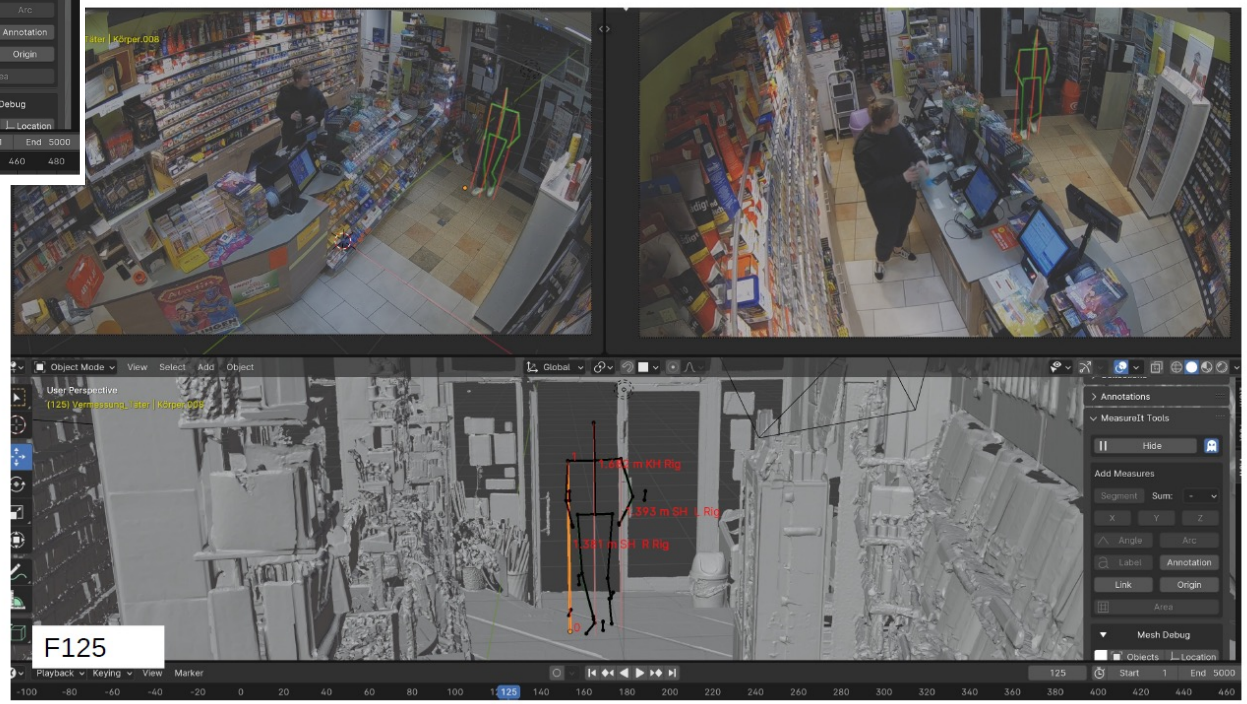


The figure shows an example measurement of the rig based on a selected video frame. The shoulder and body height (cm) were measured in frame 125 using measuring rods (red) in the model of the city kiosk.

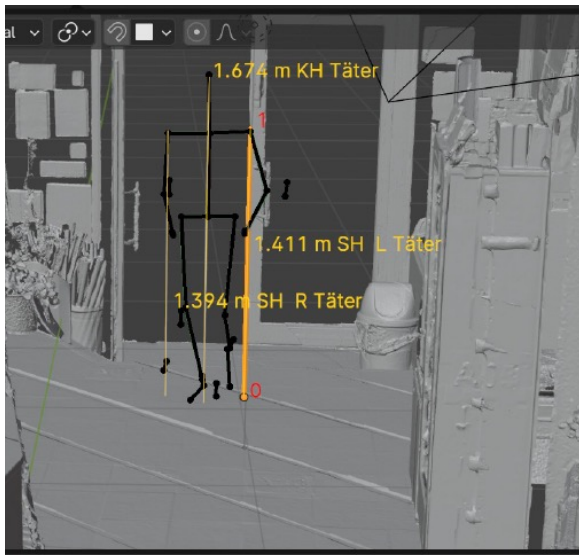


Perpetrator

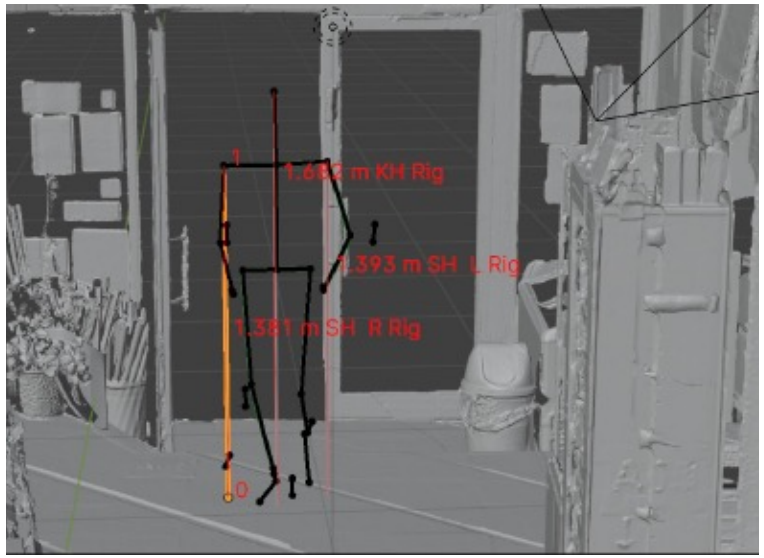
Rig



Calculation of 3 differences – measured values (depiction of the perpetrator) with the measured values of the adjusted rig.



Perpetrator



Rig

Calculation of 3 differences – measured values (depiction of the perpetrator) with the measured values of the adjusted rig.

Determining shoulder and body height (Rig and perpetrator)

Based on **9 synchronous video frames** , the shoulder and body height for the TV rig in the crime video were measured. **For the rig** from the **crime video** dated **13.03.2024**, Based on **9 synchronous video frames** , the perpetrator's shoulder and body height were measured at the same point as the rig measurements in the crime video. **For the perpetrator** from the **crime video** dated **13 March 2024 results in an average shoulder height of 141.1 cm/138,0 cm (l/r)** and a body height of **166,6 cm.**

Comparison of the tables

Suspects

offender

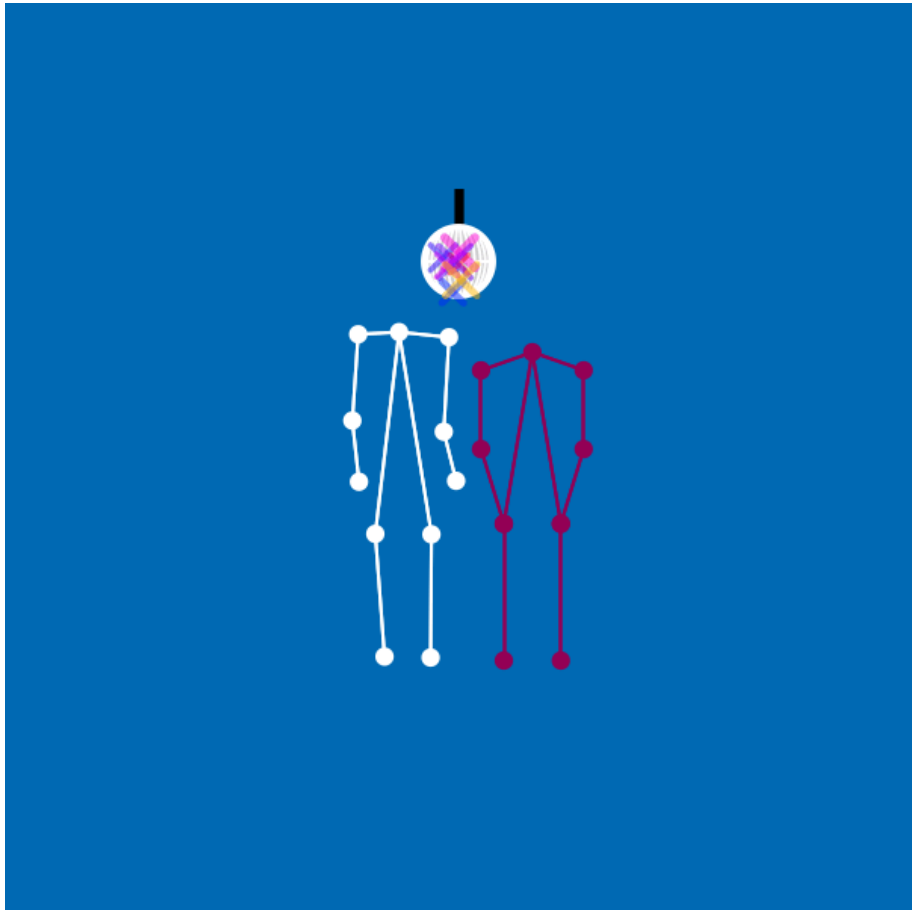
	Rig			Täter			Differenzen		
Frame	KH	SH L	SH R	KH	SH L	SH R	KH	SH L	SH R
125	168,2	139,3	138,1	167,4	141,1	139,4	0,8	1,8	1,3
140	168,2	139,2	139,4	168,0	140,1	140,4	0,2	0,9	1,0
147	162,5	137,4	132,3	163,1	137,9	133,2	0,6	0,5	0,9
152	168,9	140,9	138,0	168,7	141,1	138,0	0,2	0,2	0,0
162	165,0	138,6	136,8	164,8	138,6	136,6	0,2	0,0	0,2
171	166,5	140,6	139,6	167,6	141,4	139,2	1,1	0,8	0,4
182	166,6	141,6	137,9	167,5	142,4	139,2	0,9	0,8	1,3
235	166,8	142,9	138,2	167,1	143,8	138,6	0,3	0,9	0,4
258	164,3	143,2	136,2	165,5	143,4	137,5	1,2	0,2	1,3
Median	166,6	140,6	138,0	167,4	141,1	138,6	0,6	0,8	0,9
Mittelwert	166,3	140,4	137,4	166,6	141,1	138,0	0,6	0,7	0,8
Varianz	4,3	3,8	4,8	3,2	4,0	4,5	0,2	0,3	0,3

Suspects

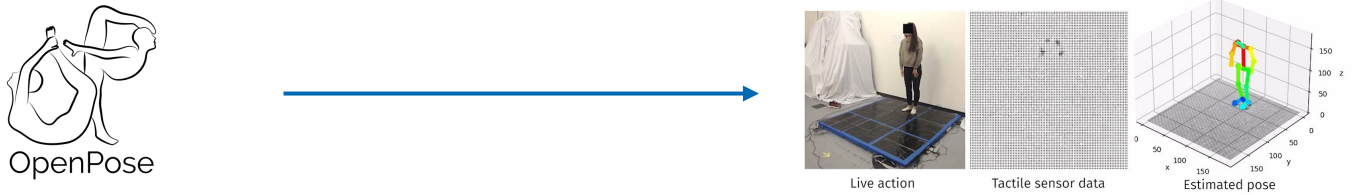
Suspects

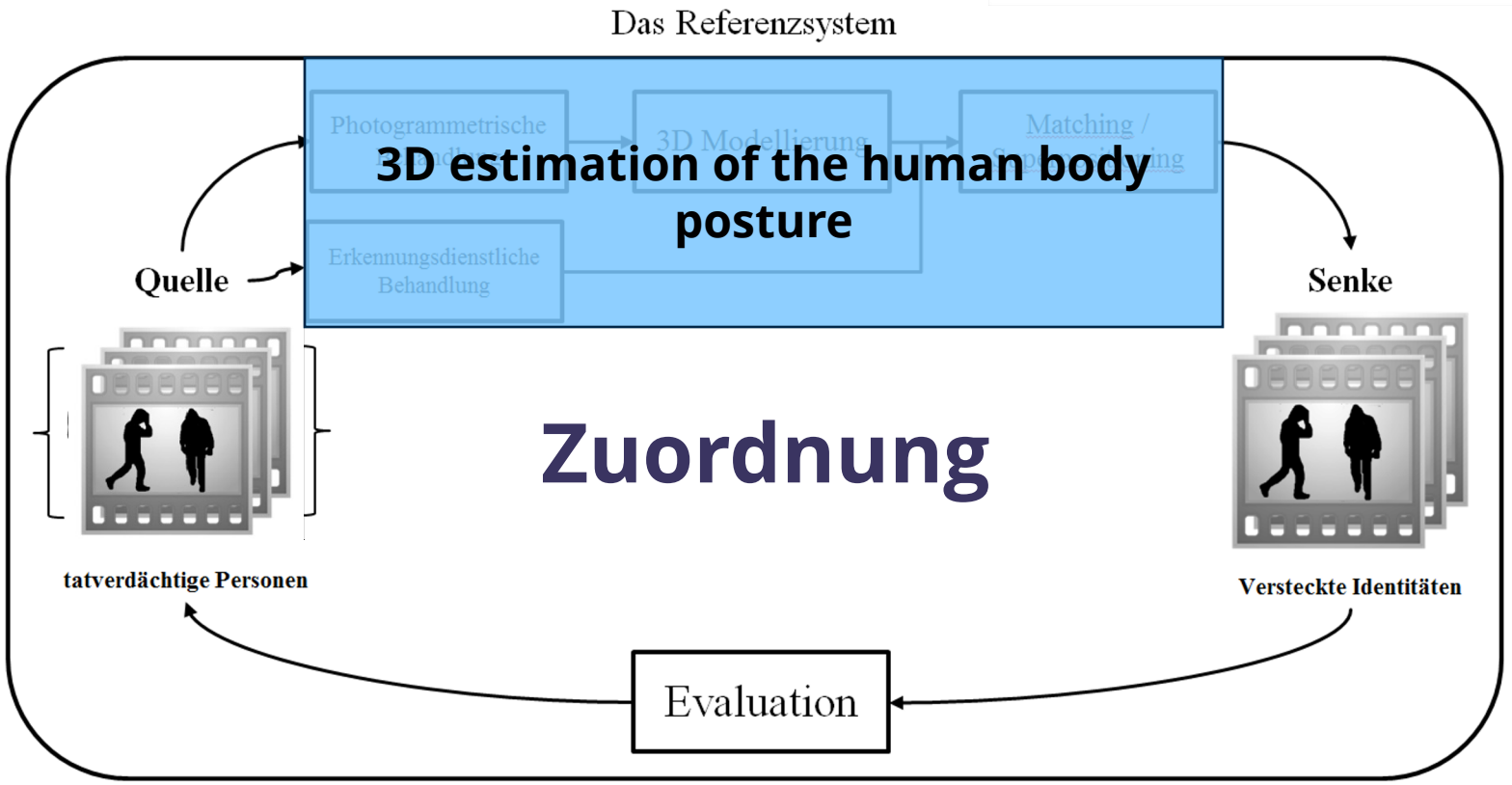
	Rig			~~TV~~			Differenzen		
Frame	KH	SH L	SH R	KH	SH L	SH R	KH	SH L	SH R
353	164,8	138,0	134,7	164,2	138,9	136,1	0,6	0,9	1,4
358	167,9	141,0	137,8	166,9	141,0	136,1	1,0	0,0	1,7
360	168,3	142,9	136,6	168,3	142,4	137,3	0,0	0,5	0,7
365	164,1	137,5	134,6	165,5	138,2	136,0	1,4	0,7	1,4
378	165,7	138,5	136,4	167,0	139,3	137,4	1,3	0,8	1,0
394	167,4	140,5	139,1	167,9	140,7	140,0	0,5	0,2	0,9
412	165,3	140,5	139,2	164,6	140,4	139,3	0,7	0,1	0,1
Median	165,7	140,5	136,6	166,9	140,4	137,3	0,7	0,5	1,0
Mittelwert	166,2	139,8	136,9	166,3	140,1	137,5	0,8	0,5	1,0
Varianz	2,7	3,7	3,6	2,6	2,0	2,6	0,2	0,1	0,3

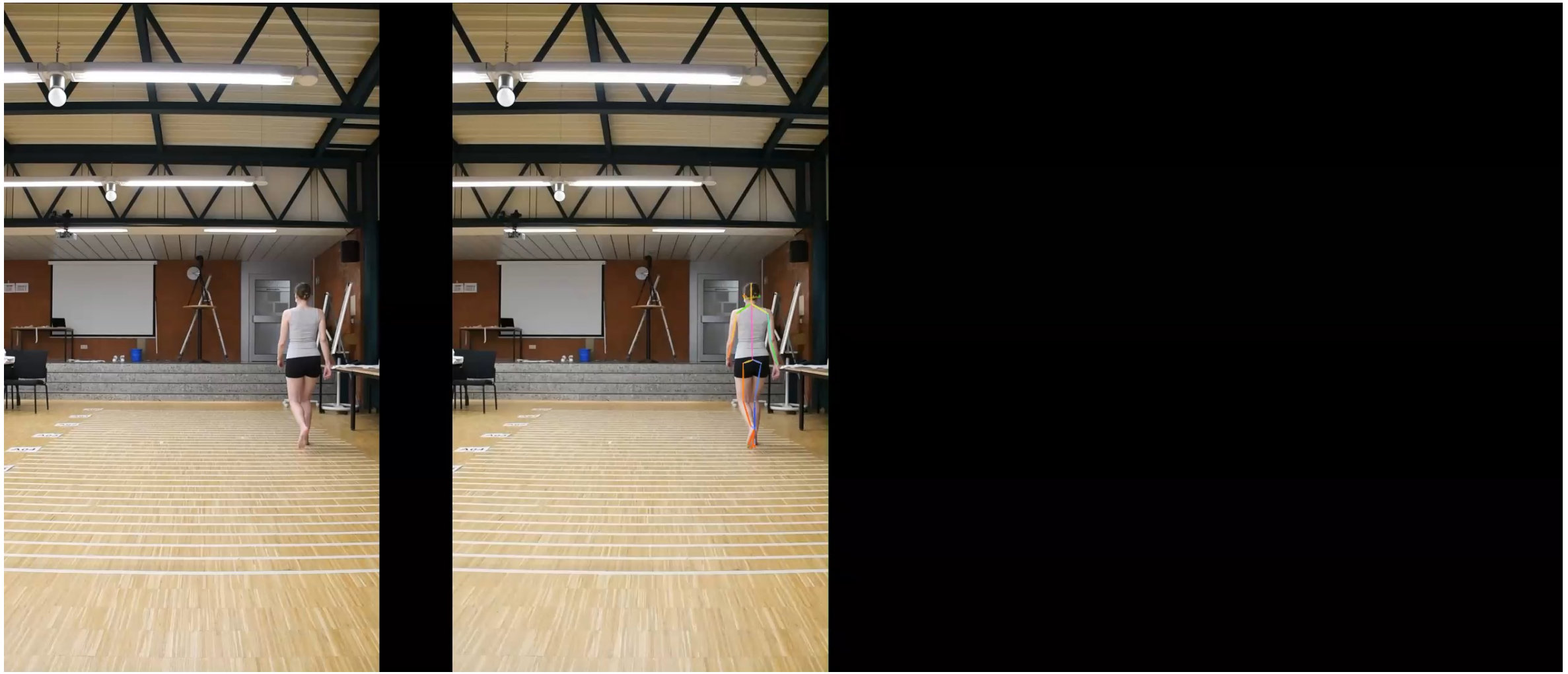
No reason for dancing



Perpetrator – ~~(suspect)~~ - Assignment

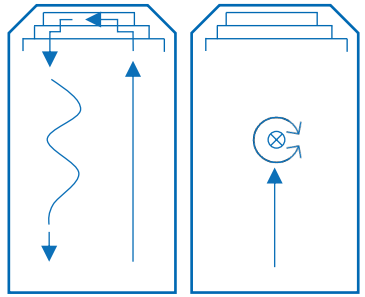


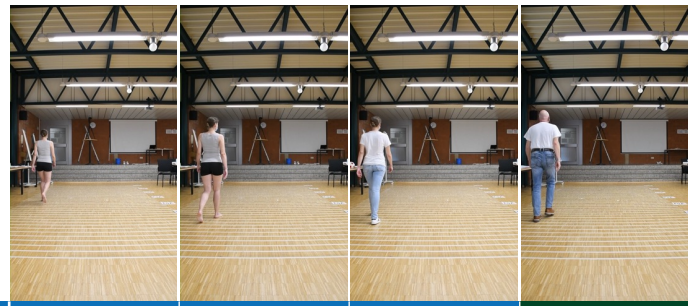




Automated rig creation

Bewegung 1 Bewegung 2





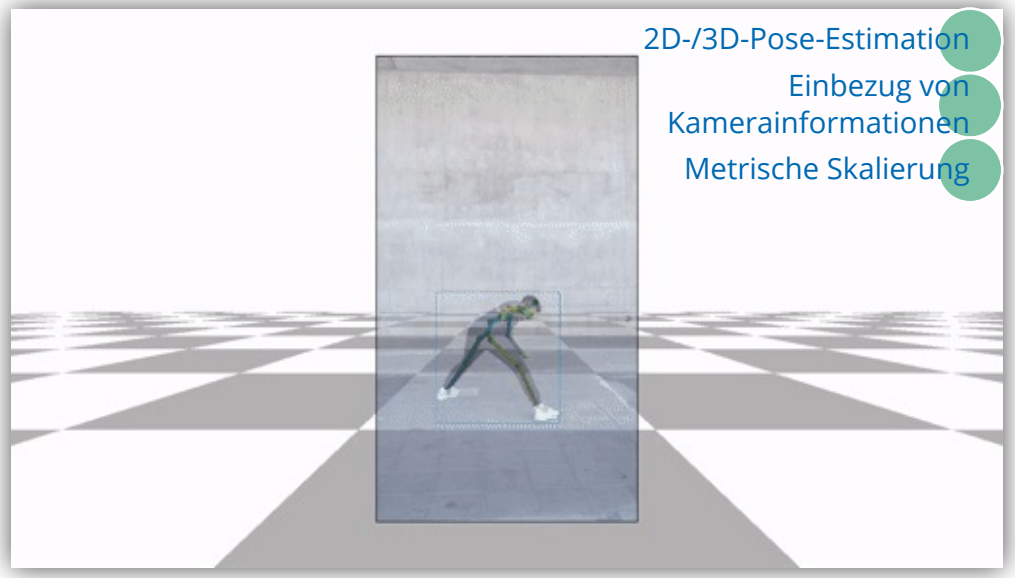
	Person 1 Bewegung 1 Bekleidung 1	Person 1 Bewegung 2 Bekleidung 1	Person 1 Bewegung 1 Bekleidung 2	Person 2 Bewegung 1 Bekleidung 2
Person 1 Bewegung 1 Bekleidung 1	0	2,12	3,29	15,17
Person 1 Bewegung 2 Bekleidung 1	2,12	0	4,33	14,61
Person 1 Bewegung 1 Bekleidung 2	3,29	4,33	0	15,97
Person 2 Bewegung 1 Bekleidung 2	15,17	14,61	15,97	0

Length RMSD [mm] between two rigs from the same (length RMSD = 0) or different videos (length RMSD > 0)

Idee

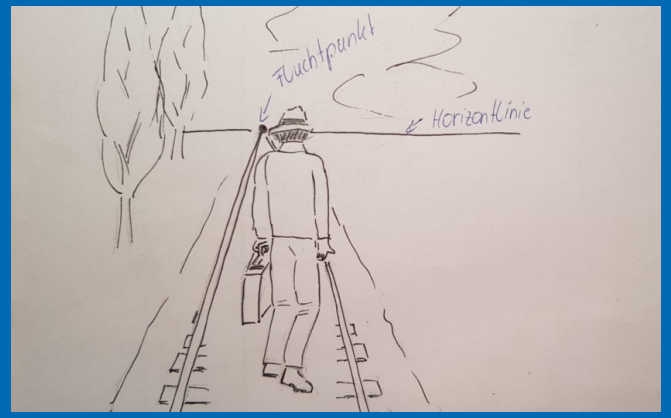
Direkter Abgleich zweier Aufnahmen einer Person

MeTRAbs



https://github.com/isarandi/metrabs/blob/master/img/demo.gif

Comparison of person-specific anthropometric characteristics



Scientific perspective

**Example frame of an adjustment of the OpenPose-based rig for the day before the crime (A) and the day of the crime (B). The single frame of the camera recording (top) is shown in each case.
and the OpenPose-based rig in the respective pose (below)**

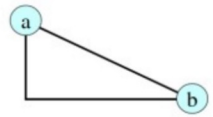
	RMSD im Vergleichsvideo	RMSD im Tatvideo
Kleinster RMSD	1,8 cm	1,9 cm
Größter RMSD	3,3 cm	2,3 cm

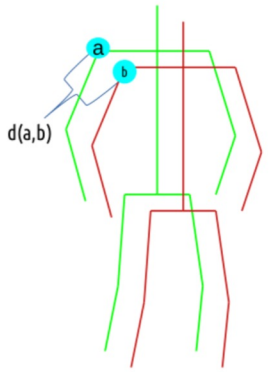
Root Mean Square Deviation

Assessment by control functions

Euklidischer Abstand *d(a,b)*

$$d(a,b) = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$$





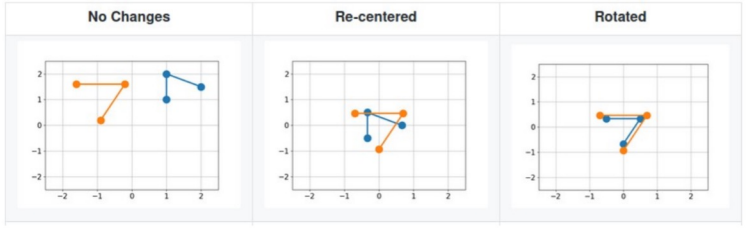
Control function 1

Wurzel aus der mittleren quadratischen Abweichung
(englisch für *root-mean-square Deviation* (RMSD))

$$\mathrm{RMSD} = \sqrt{1/n \sum_i d_i^2}$$

Control function 2

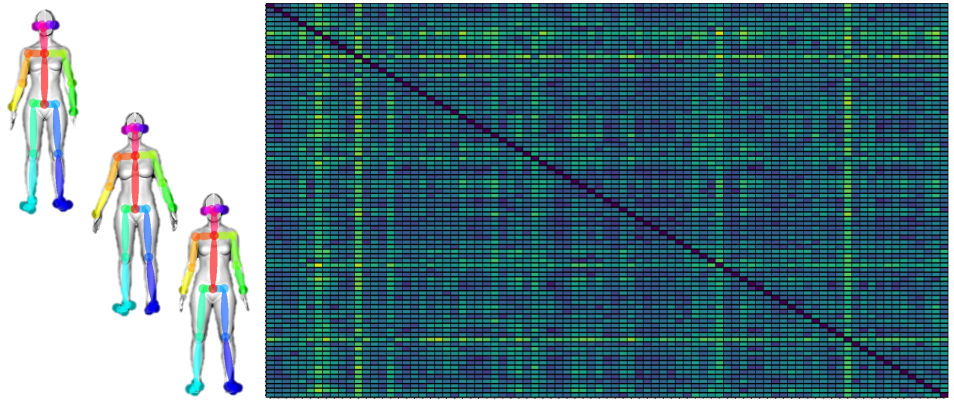
Kabsch-Algorithmus (erweiterte Form des RMSDs)



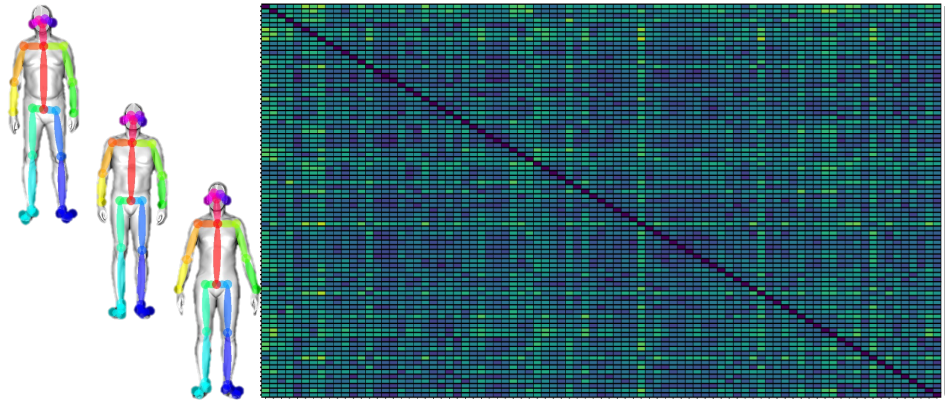
Control function 3

How similar or different are the rigs of 340 individuals? 4 - Sample

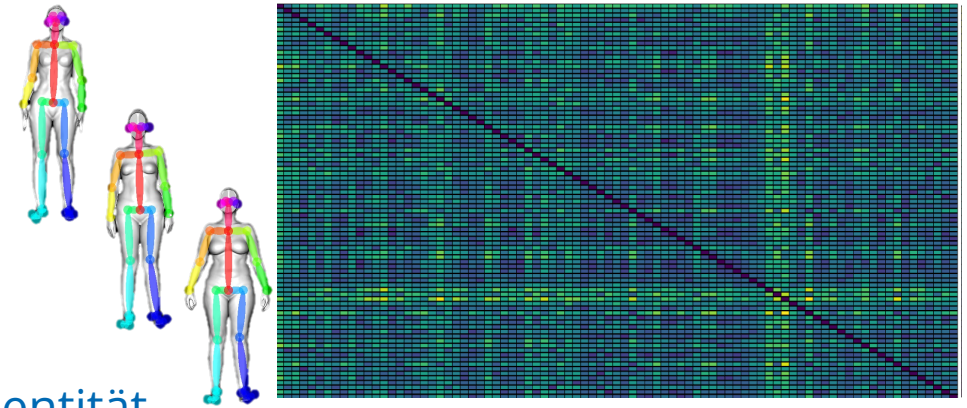
Women who are 163 cm tall



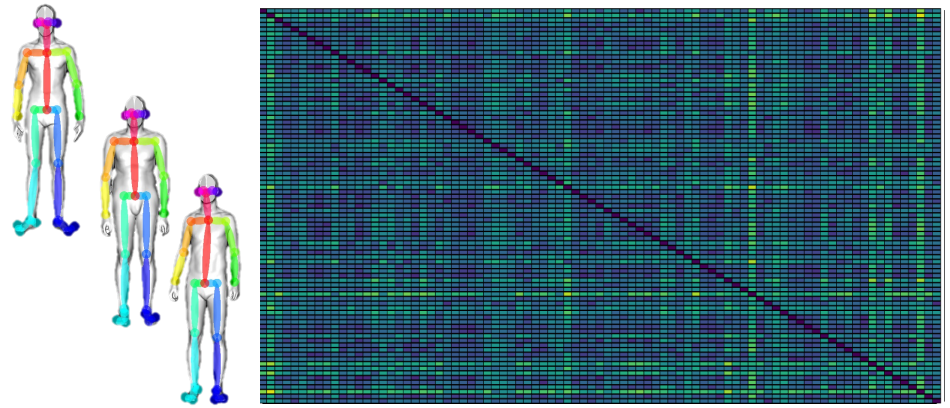
Men who are 175 cm tall



Women who are 173 cm tall



Men who are 185 cm tall



Identität

Geringe Ähnlichkeit

On the individuality of rigs Probability of random hits

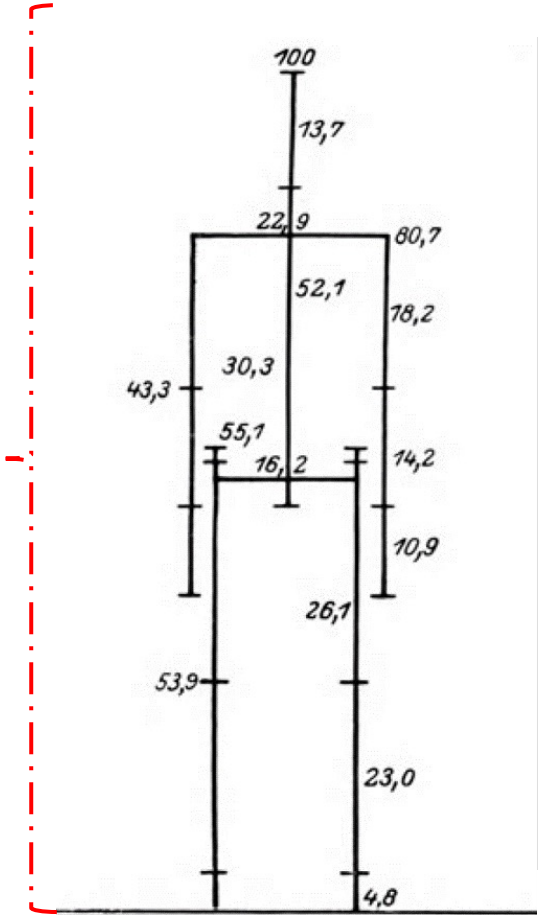
A frequentist estimation of duplicate probability as a baseline for person identification from image and video material using anthropometric measurements

Florian Heinke[1] Marie-Luise Heuschkel[1] Dirk Labudde[1]

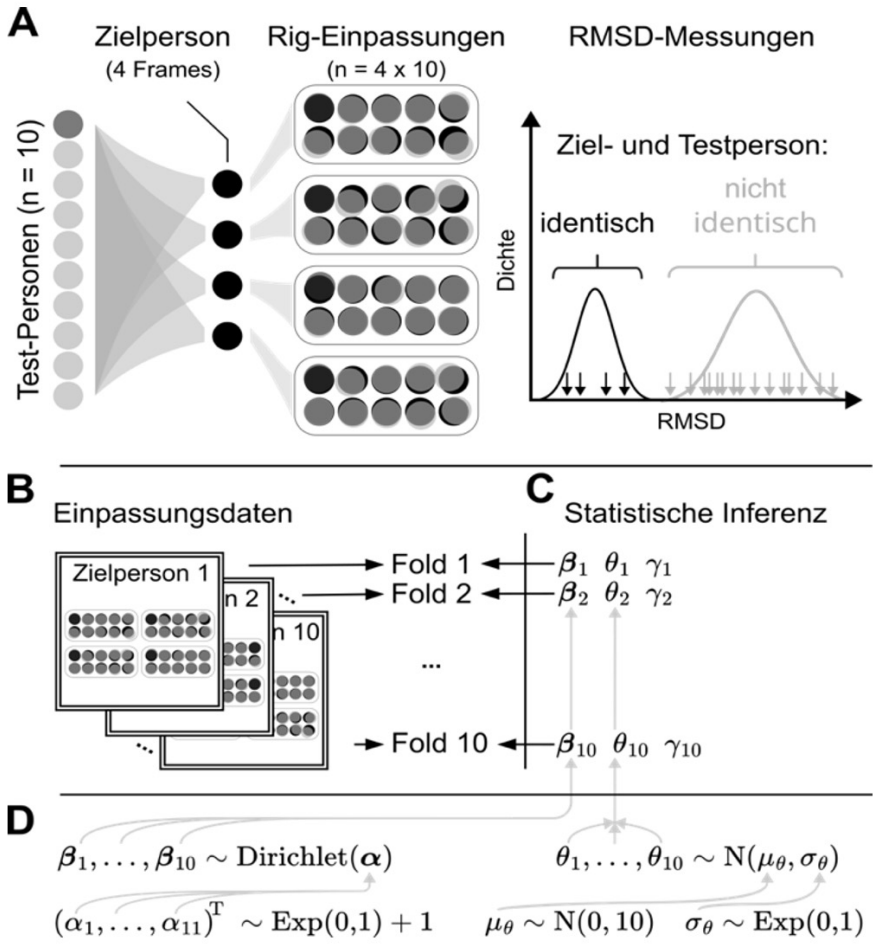
Abstract: Video and image material is becoming increasingly ubiquitous thus its potential as evidence in forensic investigations is growing. Once faces are hidden however, the value of surveillance footage is restricted unless there is another biometric trait that can be observed by camera such as linear body measurements. There is much biological evidence for human body proportions exhibiting much individual variation. Nevertheless, the probability of there being two individuals that match in their respective proportions ultimately determines its usability for the assignment, exclusion and even identification of persons in the forensic domain. This work is concerned with approaches for duplicate probability estimations derived from anthropometric measures.
Here, we present a novel frequentist estimation using a dataset of 340 individuals and their respective anthropometric measurements. Drawing on density kernel estimations of measurement dissimilarity, we propose the duplicate probability to be in the order of 10^{-15} to 10^{-8}.

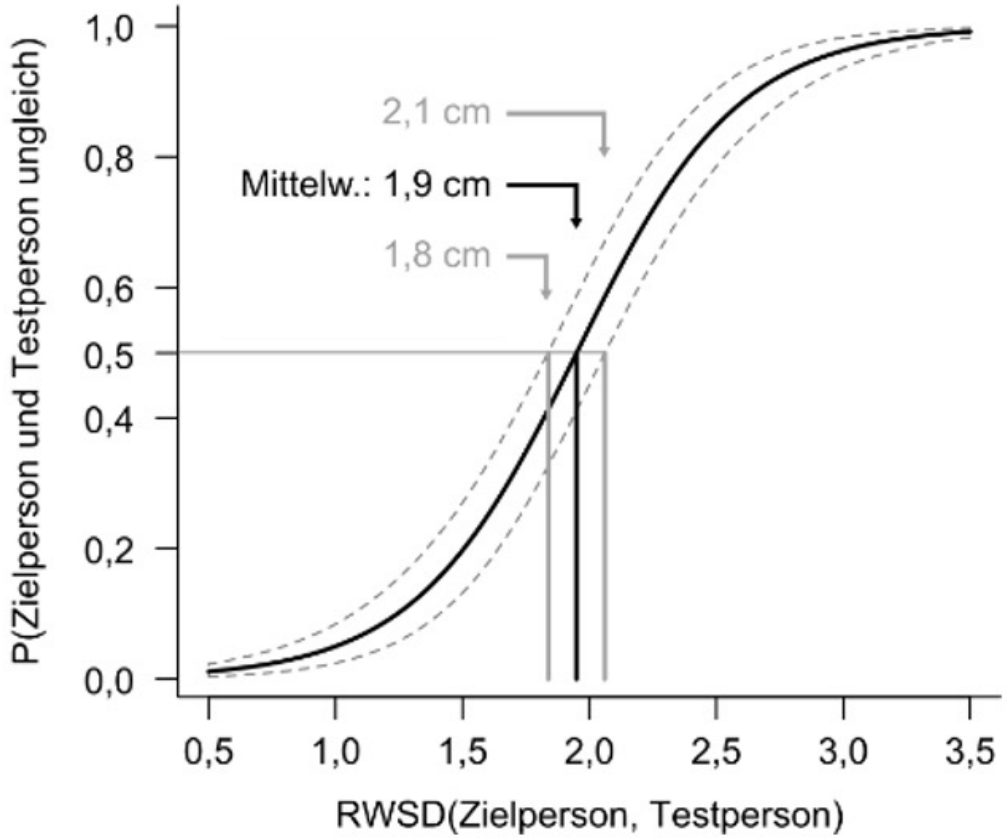
Keywords: Biometric features; anthropometric measurements; duplicate probability

The probability between 10^{-15} bis 10^{-8}, that the values of two individuals coincide in all characteristics considered.



Statistical considerations





The predictive RWSD threshold value lies within a 90% credibility interval of 1.8 to 2.1 cm a posteriori.

The digital skeleton in modern video analysis - inter- and intraspecific comparsion of individual rigs

Elena Pistorius[1], Sabine Richter[2], and Dirk Labudde[3]

Analysing Distributions of Feature Similarities in the Context of Digital Anthropometric Pattern Matching Probability

Florian Heinke[1], Marie-Luise Heuschkel[1] and Dirk Labudde[1]

A frequentist estimation of duplicate probability as a baseline for person identification from image and video material using anthropometric measurements

Florian Heinke[1], Marie-Luise Heuschkel[1], Dirk Labudde[1]

KI - Künstliche Intelligenz (2022) 36:171–180
https://doi.org/10.1007/s13218-022-00761-x

PROJECT REPORTS

COMBI: Artificial Intelligence for Computer-Based Forensic Analysis of Persons

Sven Becker[1] · Marie Heuschkel[1] · Sabine Richter[1] · Dirk Labudde[1]

ELSEVIER

Forensic Science International: Synergy

Volume 8, 2024, 100452

Reconsideration of Bertillonage in the age of digitalisation: Digital anthropometric patterns as a promising method for establishing identity

Marie L. Heuschkel, Dirk Labudde

Labudde, Dirk

Das digitale Rig als intelligentes, bildbasiertes, forensisches Instrument

SIAK-Journal – Zeitschrift für Polizeiwissenschaft und polizeiliche Praxis (4/2023), 28-39.

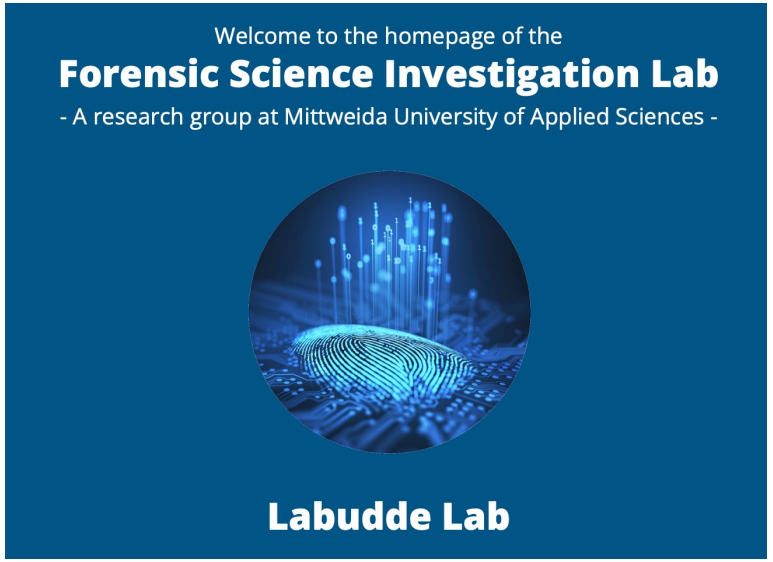
doi: 10.7396/2023_4_C

Potential approach for targeted matching of people in video footage based on 3D human pose estimation

Sabine Richter[1] and Dirk Labudde[1]

Fraunhofer Lernlabor Bundeskriminalamt | HOCHSCHULE MITTWEIDA

Thank you



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Special Issue on Unveiling Truth: Exploring the Frontier of AI and ML in Multimedia Forensics

Revealing the Unreal: Forensic Analysis of AI-Generated Adult Content from Diffusion Models

Lukas Jaeckel*†, Quentin Stickler†, and Dirk Labudde*† ,

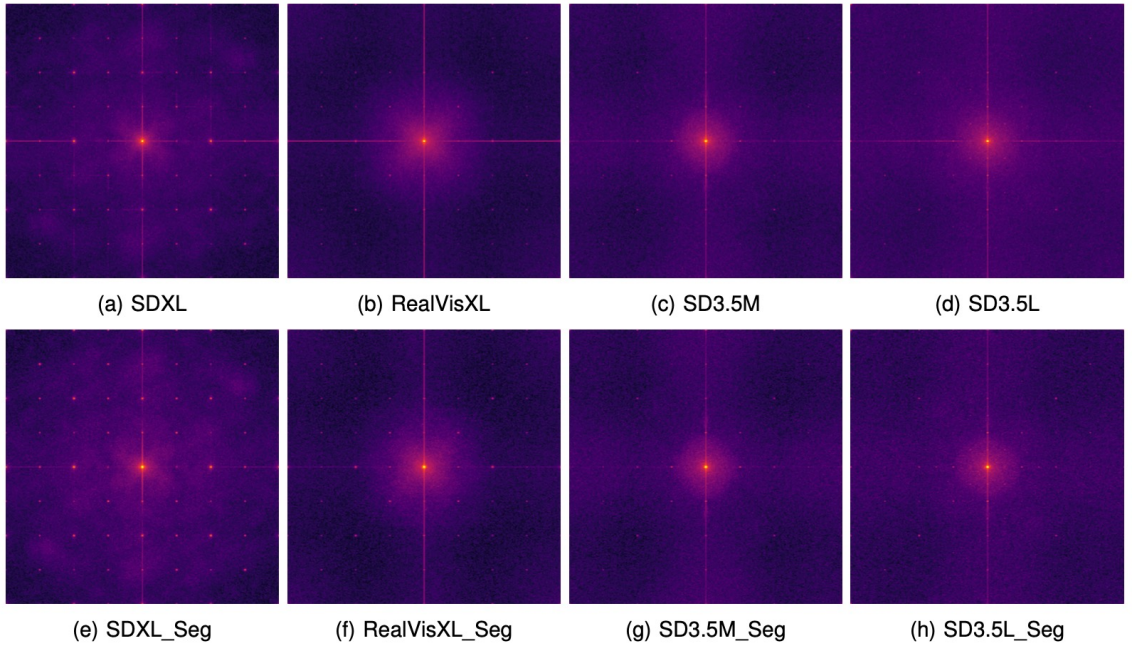
* *Technische Universität Bergakademie Freiberg, Freiberg, 09599, Germany*
† *University of Applied Sciences Mittweida, Mittweida, 09648, Germany*

(a) SDXL (b) RealVisXL

(c) SD3.5M (d) SD3.5L

Text-zu-Bild-Ausgaben der DMs (a) SDXL, (b) RealVisXL, (c) SD3.5M und (d) SD3.5L.

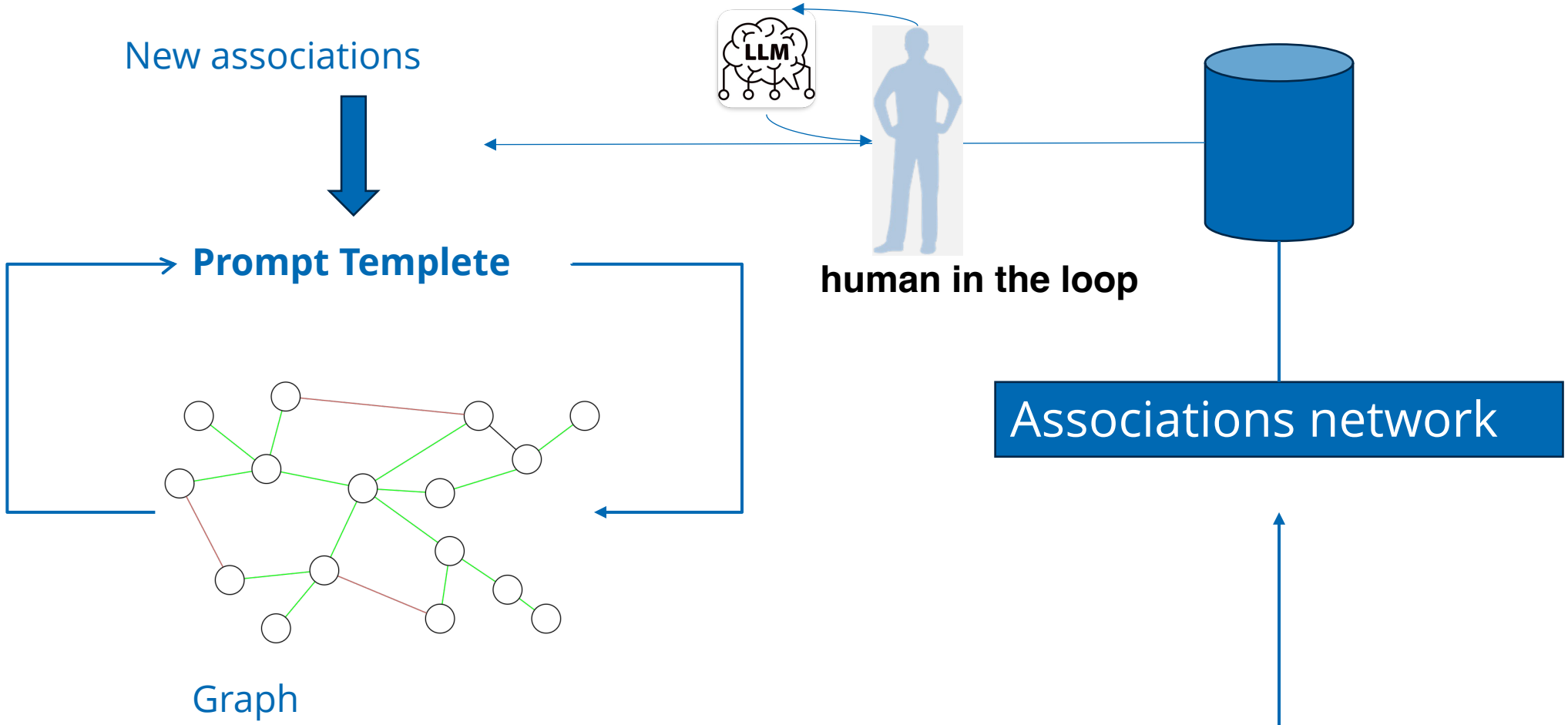
Fourier-Domänen-Wärmekarten von Hautsegmenten aus Bildern, die von den vier ausgewählten Modellen generiert wurden. Jeder Teilplot stellt den Frequenzbereich (Spektrum) für ein bestimmtes Modell dar. Auffällige Gitter- und Linienartefakte ermöglichen Rückschlüsse auf die Modellarchitektur und Trainingsverzerrungen.



(a) SDXL (b) RealVisXL (c) SD3.5M (d) SD3.5L

(e) SDXL_Seg (f) RealVisXL_Seg (g) SD3.5M_Seg (h) SD3.5L_Seg

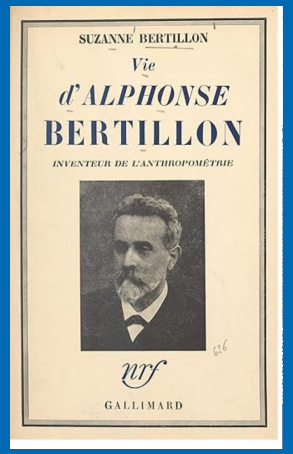
Agent Reinforced Generation – Assoziation Network (Graph)



ARG → Forensic Graph → Graph Analysis

The digital skeleton as an intelligent, forward-looking, image-based (*potential*) forensic tool

1833



Bertillonage worldwide
1895

From poetry to reality

The Digital Rig
2022

COMBI: Artificial Intelligence for Computer-Based Forensic Analysis of Persons