HOCHSCHULE MITTWEIDA
UNIVERSITY OF APPLIED SCIENCES

3D-Crime Scene/Disaster-Site Reconstruction using Open Source Software

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13. April 2016

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Introduction

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San Francisco Plane Crash 2013 (Asiana Airlines)

2004 Indian Ocean Tsunami

30-plus car pileup on Indiana interstate 2013

Introduction

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2013 Fukushima Earth Quake and atomic disaster

Introduction

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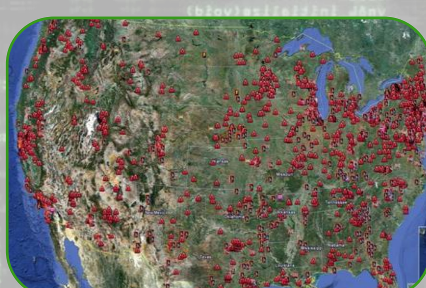
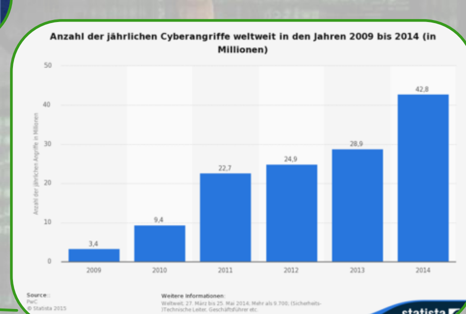


Hacker hits on U.S. power and nuclear targets spiked in 2012



Number of annual cyber attacks in the years 2009 to 2014 (in millions)

Introduction

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Resilience Cycle

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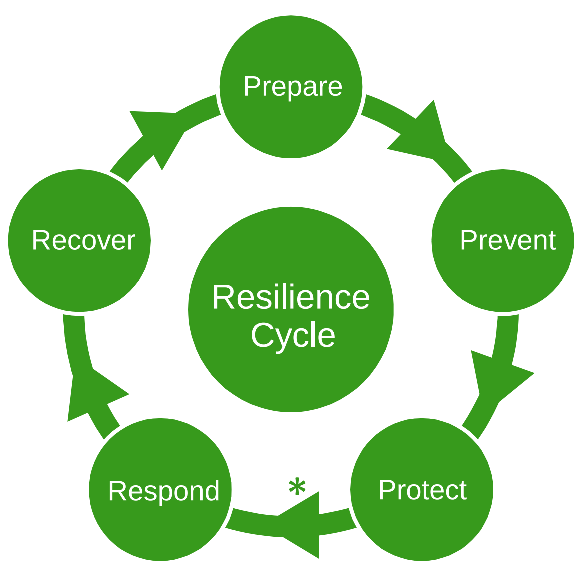
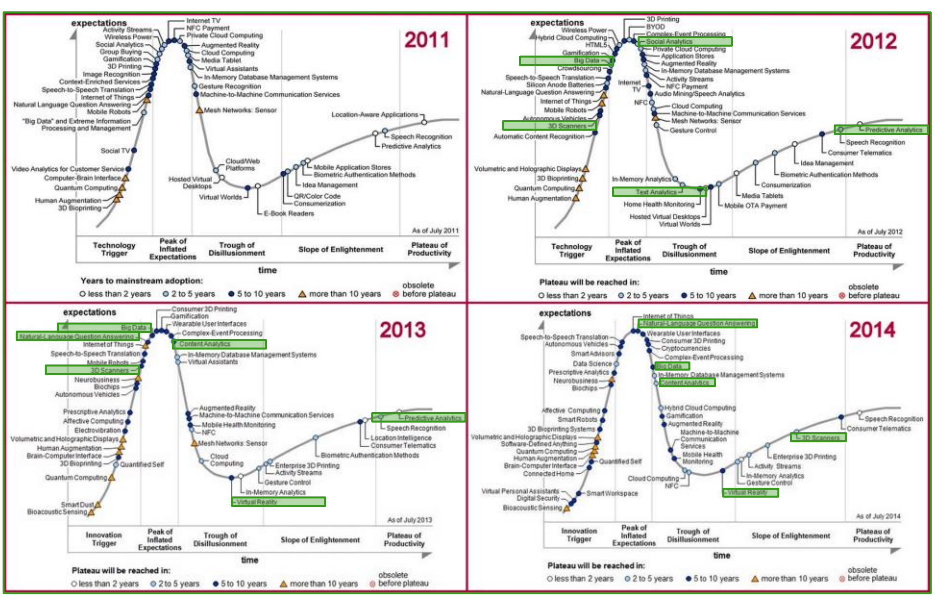


Resilience-by-Design:

Supporting the processes, as a consequence of the introduction and dissemination of new technologies, in the prevention and response phase of the resilience cycle…

Monitoring Emerging Technologies



Gartner Inc.

Phase-Model

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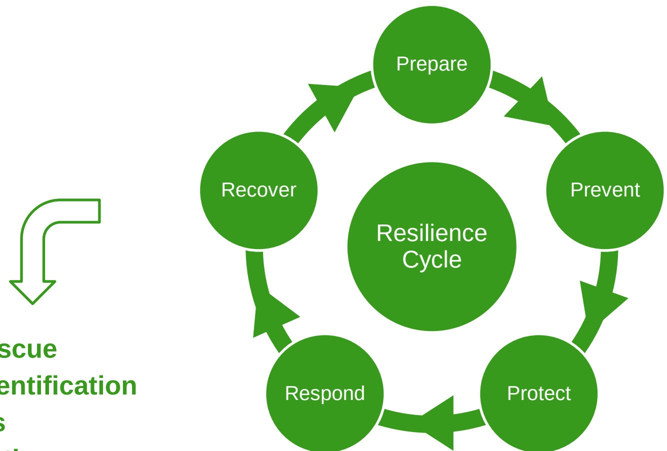
There are generally five phases that follows such an event



1. victim rescue
2. victim identification
3. forensics
4. investigation
5. derivation and implementation of prevention models

Resilience-by-Design:

..utilizing Open Source Software for the development of assistance tools in terms of modeling, visualization and simulation of different resilience scenarios.

Phase 1 – Victim Rescue

Phase 1 – Victim Rescue

- Gathering as much information as possible about the event-site
- Monitoring/observation of unknown environments in a fast and save way
  - Fast -> important for victims to survive
  - Safe -> important for rescue forces

The spatiotemporal data gathered in this way can be used for supporting decision makers with respect to targeted and safe management of rescue teams and the fast locating of victims.

Motivation

Motivation – Germanwings Flight 9525, March 24, 2015

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Video

VIDEO

Motivation – Germanwings Flight 9525, March 24, 2015

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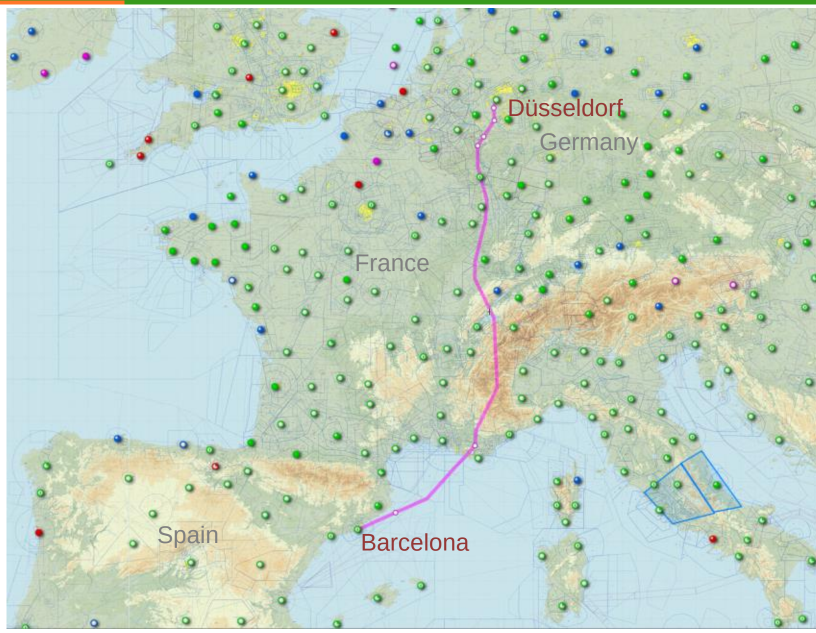

Motivation – Germanwings Flight 9525, March 24, 2015

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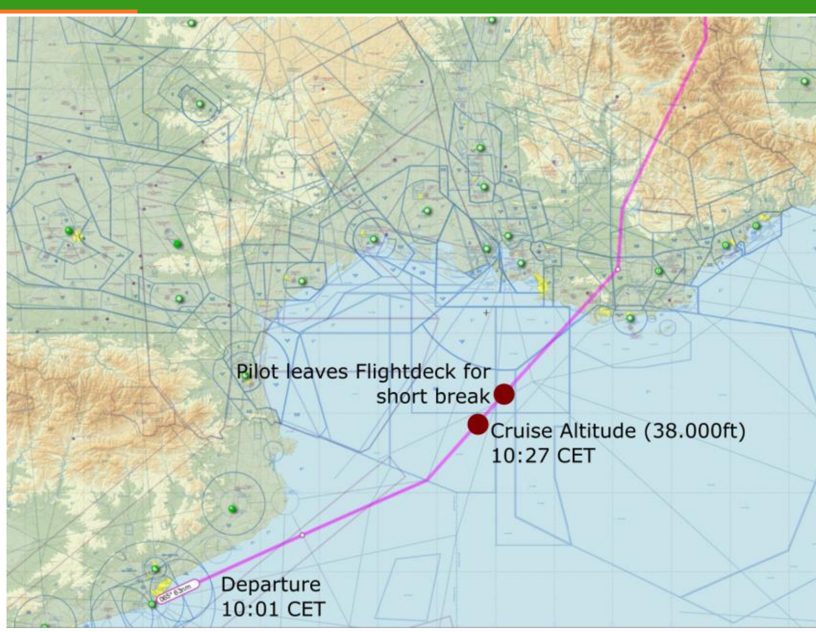

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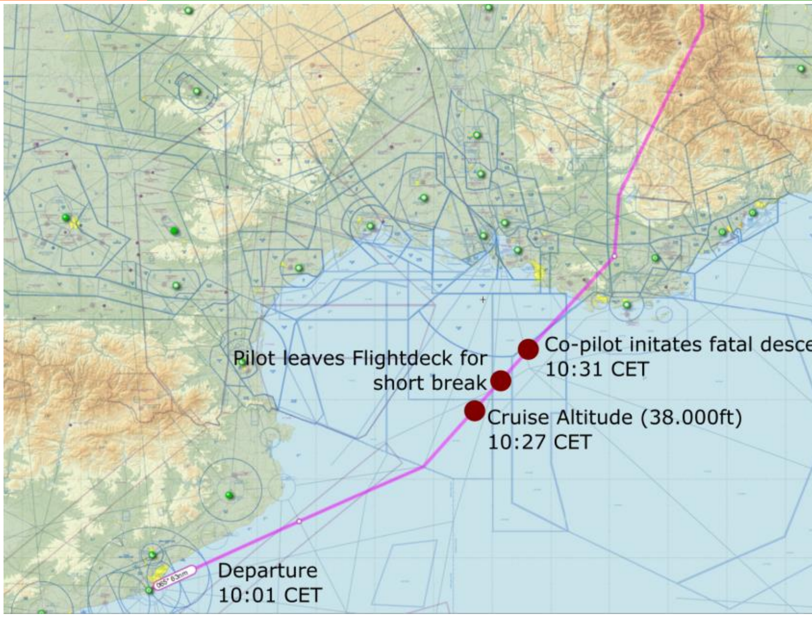

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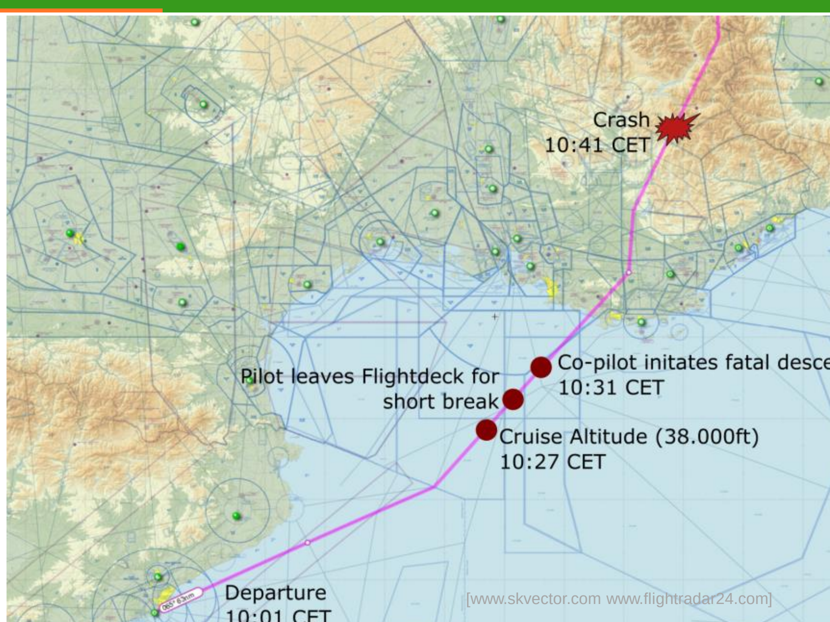

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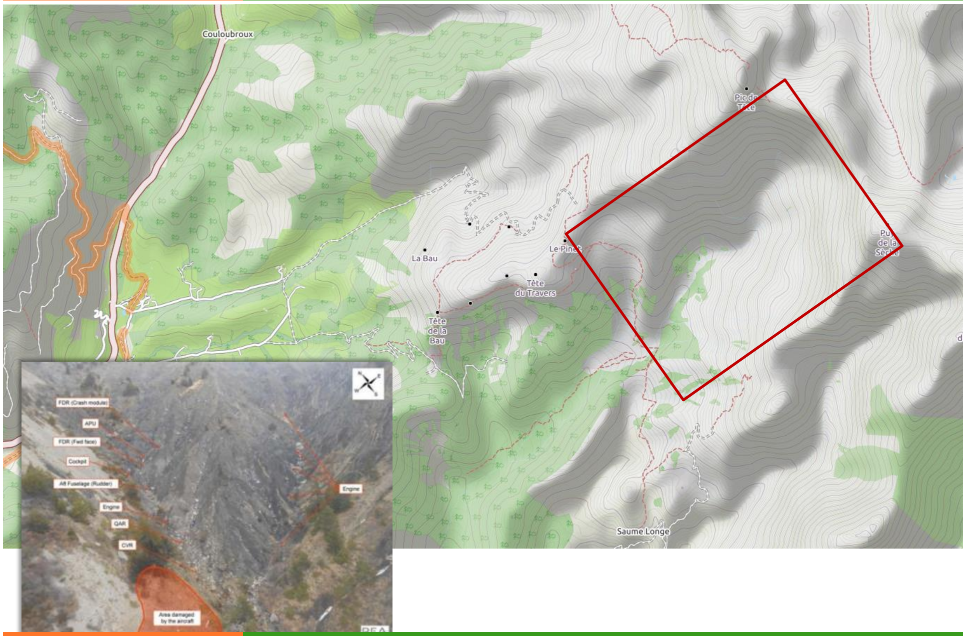

Application of Drones?

Application of Drones (Unmanned Aerial Vehicles, UAV)

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MikroKopter
MK Okto XL 6S12

- small, fast to set-up, easy to fly
- very maneuverable
- capable flight assistance systems
- reasonable flight time and range

- soft- and hardware upgradability
- video downlink (SLR, infrared, …)
- **automated waypoint flight**
- **wireless flightplan uplink**
- …
- affordable!

Nothing new … isn't it?

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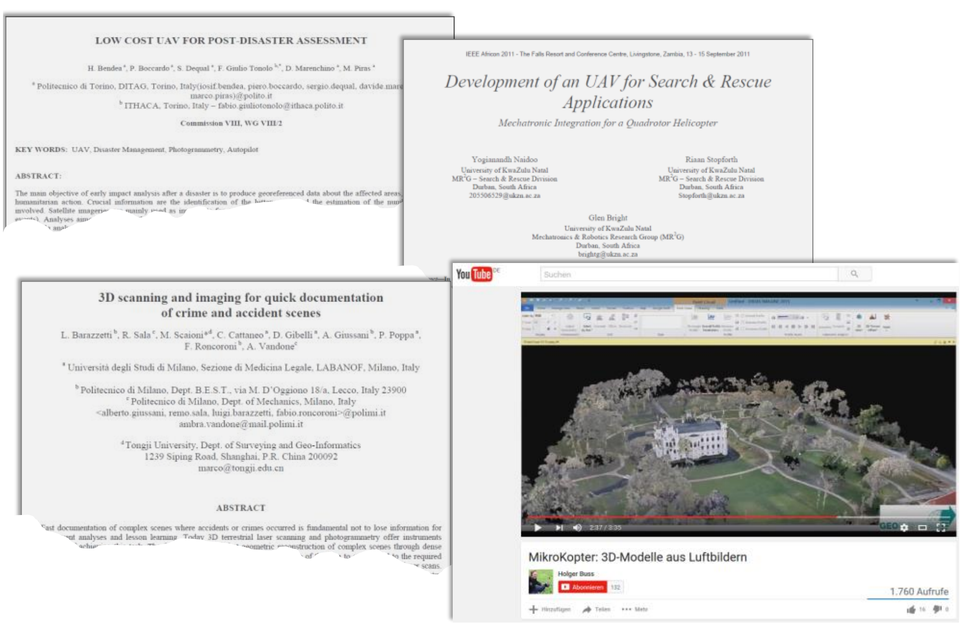

Fast 3D Reconstruction based on aerial Images

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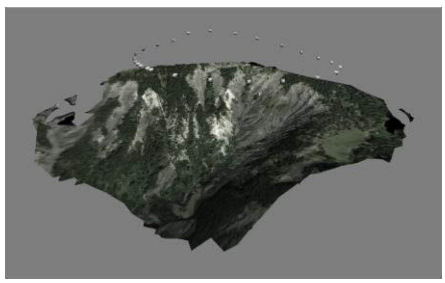

Fast 3D Reconstruction based on aerial Images

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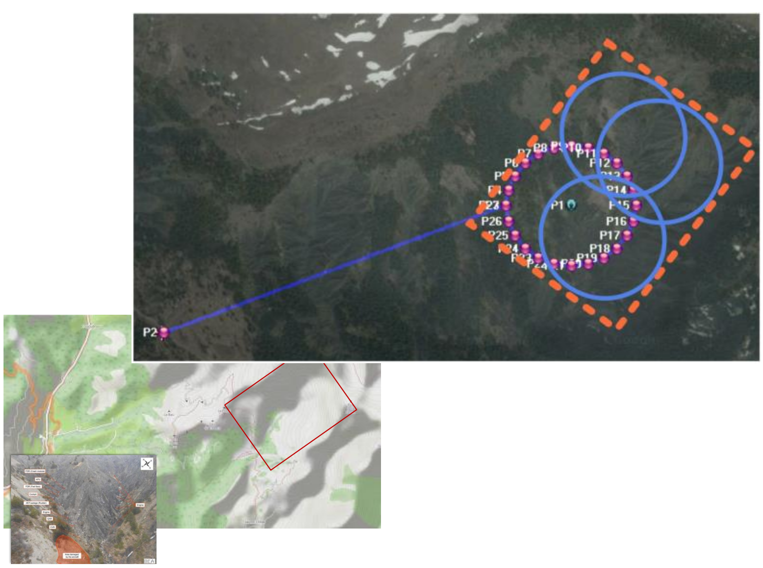

Fast 3D Reconstruction based on aerial Images

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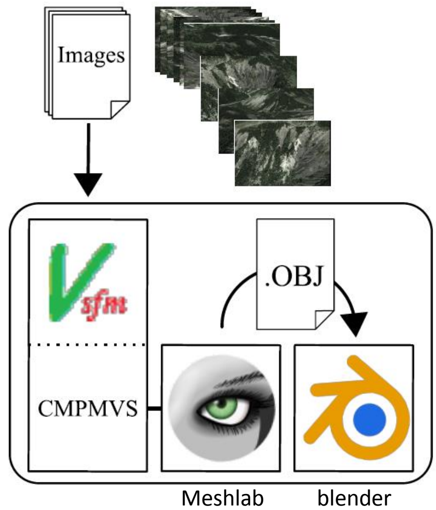
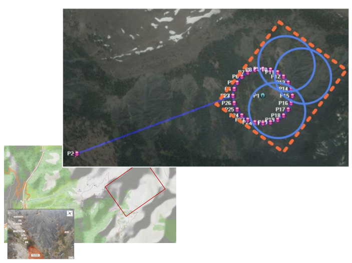
Visual sfm – point cloud
CMPMVS – surface calculation





Modelling

Fast 3D Reconstruction based on aerial Images

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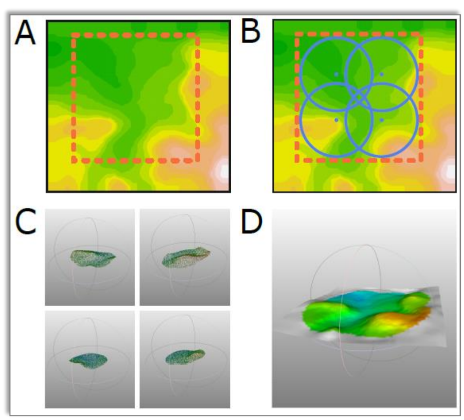

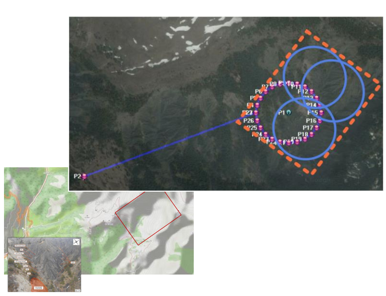

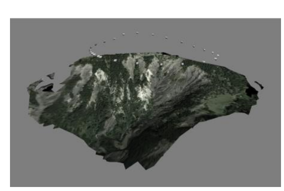

Details talk (M.Spranger) ACCSE1

Fast 3D Reconstruction based on aerial Images

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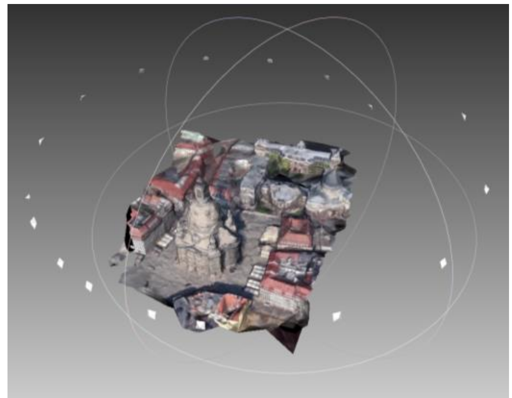
Test of Concept



17 *pseudo-aerial images* of the Frauenkirche in Dresden obtained via Google Earth

Software pipeline

Fast 3D Reconstruction based on aerial Images

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A

- 120 aerial images of the Mittweida water tower extracted from HD video
- **2 hours of computation**

B

- 25 aerial images of the Mittweida water tower extracted from HD video
- **20 minutes of computation**

C

- 55 aerial images of the Mittweida water tower basis
- 6K images (6000x4000 pixels)
- **~ 8-9 hours of computation**

Fast 3D Reconstruction based on aerial Images

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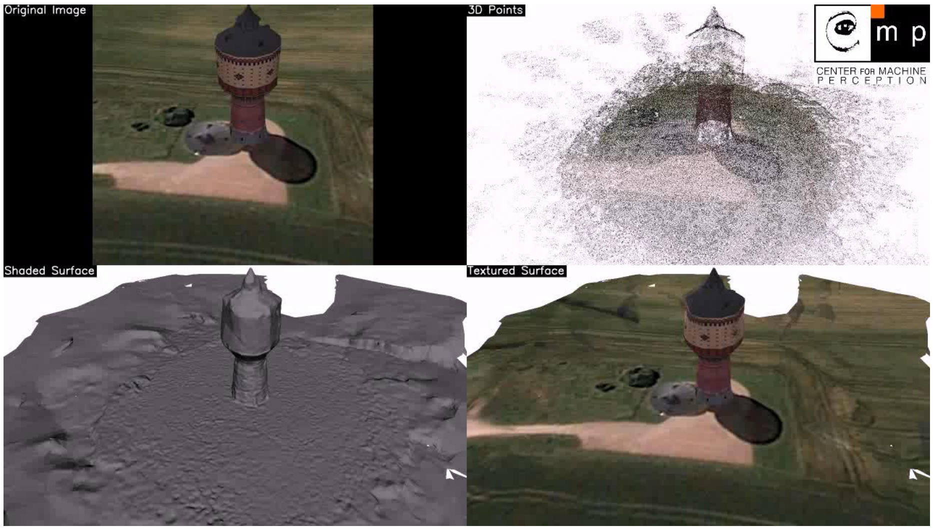

Phase 2 – Victim Identification

Phase 2 – Victim Identification

In Phase 2 the identification of an unknown deceased person is the main priority. Generally, this is an important task in **forensic anthropology**. There are various methods for identification, such as

which presuppose the existence of **reference material** of the missing person; **however**, if there is no evidence of a person's identity the only possibility is often the utilization of **forensic facial soft tissue reconstruction**.

Forensic facial soft tissue reconstruction:

This method is based on the high recognition level of a human face on the basis of **bone** structure characteristics of the skull and its anatomical features.

computer-aided 3D facial soft tissue reconstruction

Facial soft tissue reconstruction :: Classical reconstruction methods

Objectives/aim:

- creating a possible real-life, (three) dimensional model of the face on the basis of:
  - individual bony structures
  - data from medical imaging procedures
  - photographs in conjunction with anatomical findings of forensic medicine

- models are used to support :
  - the authentic reconstruction of the face of a deceased, no longer identifiable person
  - police investigations in identifying unknown remains

- **often last option for heavily skeletonized finds**

Facial soft tissue reconstruction :: Classical reconstruction methods

- **sculptural reconstruction (3D)**
  - creating a plaster cast of the skull (clay, wax , plastics)
  - modeling of muscle and tissue layers

- **hand drawing (2D)**
  - reconstruction on the basis of an image of a skull and tracing paper in scale 1:1
  - used identikit software in Germany: "ISIS" or "Facet"

Sculptural reconstruction

Hand drawing by the use of tracing paper

Facial soft tissue reconstruction :: Classical reconstruction methods

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Problems of classical methods of facial soft tissue reconstruction

- replication of the skull due to ethical limitations
- time-consuming reconstruction of injuries and destruction
- no relation to anatomical points
- conditional flexibility over subsequent changes of models
- comparison of database entries with models only feasible with interim steps

➢ **high costs and expenditure of time**

➢ high costs and expenditure of time

Facial soft tissue reconstruction :: Computer-aided reconstruction methods

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➢ **2D facial soft tissue reconstruction**
  - correlation of skull parameters with existing image files (portrait photos)
  - automated creation of a phantom image

➢ **3D facial soft tissue reconstruction**
  - three-dimensional digital acquisition of a skull
  - virtual modeling of facial soft tissue using anatomical points (so called landmarks)

➢ **allows a faster and more flexible reconstruction process**

➢ allows a faster and more flexible reconstruction process

Facial soft tissue reconstruction :: In the forensic context

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Development and application of a novel, cost-effective and flexible process for computer-aided 3D facial soft tissue reconstruction using open source software.

- suitability test of variety of recording media
- analysis and application of prediction methods for facial features
- identification of time consuming process steps
- automatic placement of anatomical points with manual override
- creation of a model library of variant morphological facial features

Facial soft tissue reconstruction :: In the forensic context

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case examples

unknown corpse, male, 80 years, maximum 83 years missing since: 11/06/2011 dead: 29/06/2014 outdoors skeleton parts.

male, 64 years died on: 05/07/2014 found dead on 6/16/2014 in House, skeletal corpse with a few soft tissue residues, dark brown, smooth, about 10 cm long, *identity clarified molecular genetics*.

commercial anatomical skull model

Facial soft tissue reconstruction :: In the forensic context

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Facial soft tissue reconstruction :: In the forensic context

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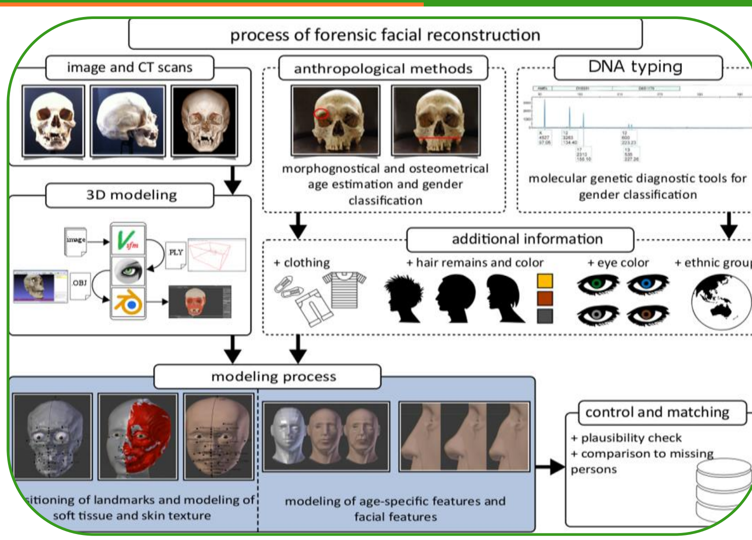

process overview

Facial soft tissue reconstruction :: In the forensic context

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Conditions, collection of facts and research

- **undamaged** and intact **skull**, at best, with existing **mandible**
- **information about** the **appearance** of the remains
- notes of clothing / headgear, life circumstances and **Zeitgeist**
  - photographs, autopsy reports
  - list of evidence, logs
  - database searches
    - Labeled Faces in the Wild
    - Face Base

- **anatomical soft tissue markers** with average soft part thickness

(muscular system and fatty tissue)

Facial soft tissue reconstruction :: In the forensic context

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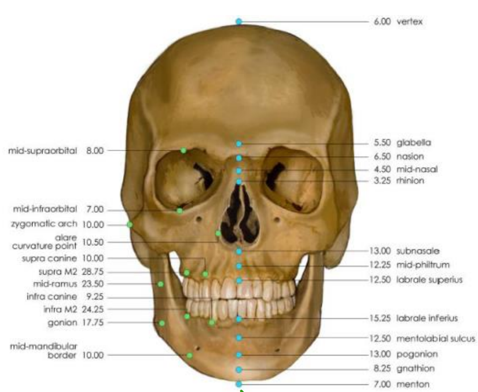
Anatomical soft tissue markers with average soft part



Overview of anatomical landmarks

Facial soft tissue reconstruction :: In the forensic context

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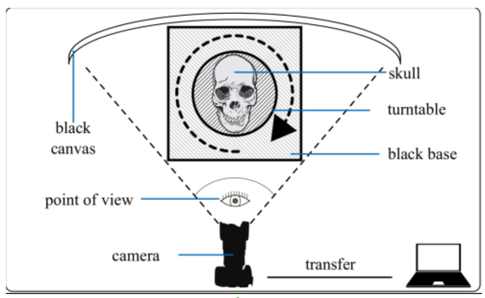
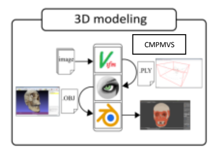
Digitization of the skull

- **Recording media:** SLR Nikon D7100 with two different aperture settings and an iPhone 4 (three photo sets á 96 Images)
- **gapless recordings** with well-defined angles 360° around the skull





Experimental setup to digitize a skull

Facial soft tissue reconstruction :: In the forensic context

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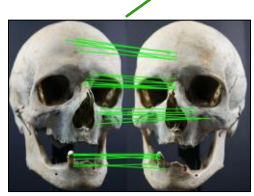
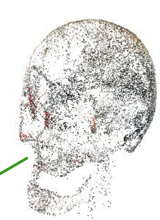
Generating a point cloud using VisualSfM

- **Process steps:**
  - data import
  - *Sparse Reconstruction*
  - *Dense Reconstruction*
  - data export

Example for SIFT features





Calculated point cloud

calculation time

process	time [min]	Dense of point cloud [pt]
generating the point cloud	Ø 1,5	Ø 44.000
point cloud compression	Ø 20	Ø 1.600.000

Facial soft tissue reconstruction :: In the forensic context

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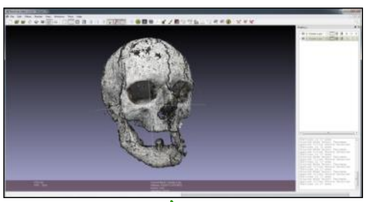
Model surface reconstruction using MeshLab

- **Process steps:**
  - cluster association with *Flatten Visible Layers*
  - *Poisson-Disk-Sampling*
  - surface reconstruction
  - post processing



Imported point cloud

Reconstructed surface

Facial soft tissue reconstruction :: In the forensic context

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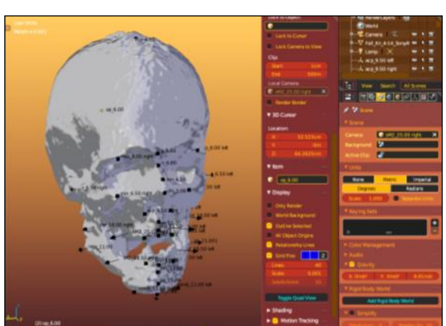
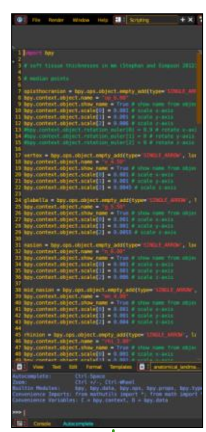
Positioning of anatomical landmarks

- at the beginning, manual modeling, designating and positioning of the 36 anatomical landmarks
- tools: Python Scripts



Modelled and positioned anatomical landmarks in Blender



Associated Python Script in Blender

Facial soft tissue reconstruction :: In the forensic context

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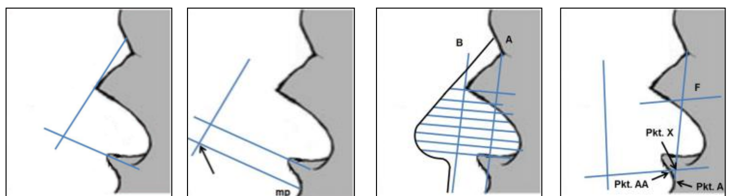
Reconstruction of selected facial features – nose shape

- **Methods** for **predicting facial features**, here the nose shape by:
  - Gerasimov (1955)
  - Krogman (1962)
  - Prokopec & Ubelaker (2002)
  - George (1987)



Overview of prediciting methods for nose shapes: Gerassimow, Krogman, Prokopec & Ubelaker and George (left to right)

Facial soft tissue reconstruction :: In the forensic context

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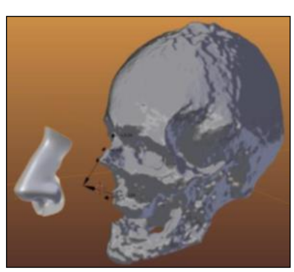
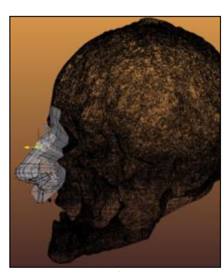
Reconstruction of selected facial features – nose shape

- Reconstruction of nasal forms by the presented methods using Blender
- superposition of the models with a skin texture

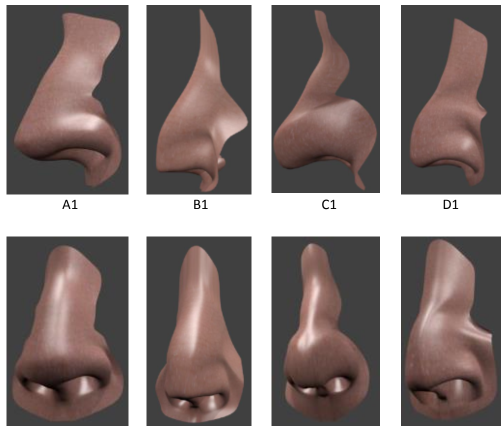


Examples for nose models by Gerasimov



Examples for nose models by Prokopec & Ubelaker (Wireframe Layout in *Blender*)

Facial soft tissue reconstruction :: Reconstruction of selected facial features



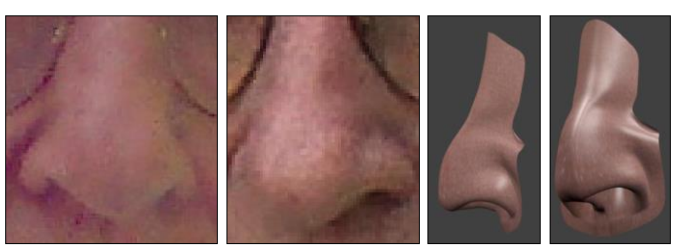
A1 B1 C1 D1

A2 B2 C2 D2

Reconstructed nose models with skin texture by:
A = Gerasimov, B = Krogman, C = Prokopec & Ubelaker, D = George.

Facial soft tissue reconstruction :: Reconstruction of selected facial features

- comparison of 3D models with photographs of the deceased person
- due to insufficient quality only a qualitative comparison was done
- ➢ best modell by method presented from George



A1 A2 B1 B2

Nose of the deceased person (A1 and A2)

Nose model by George (B1 and B2)

Facial soft tissue reconstruction :: Model library

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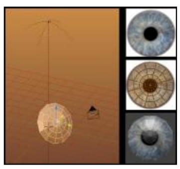
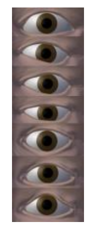
- generating a model library for the optimization of the reconstruction process in terms of:
  - time
  - flexibility



- basis are database researches and literature:
  - *FaceBase database*
  - *Labeled in the Wild* database
  - Wilkinson et al. (2004)
- modeling of various:
  - eyes and eye colors
  - eyes shape
  - nose and ear shapes
  - hairstyles
  - objects



Facial soft tissue reconstruction

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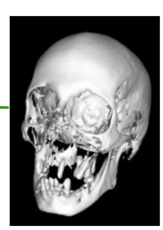
- cost alternative process through the use of open source software
- licence-free software offers great flexibility for the reconstruction process
- confirmed suitability of photographs to create sufficient 3D models
- use of CT data (InVesalius for evaluation of DICOM data)

CT model in *InVesalius*



corresponding 3D model in *Blender*

Facial soft tissue reconstruction

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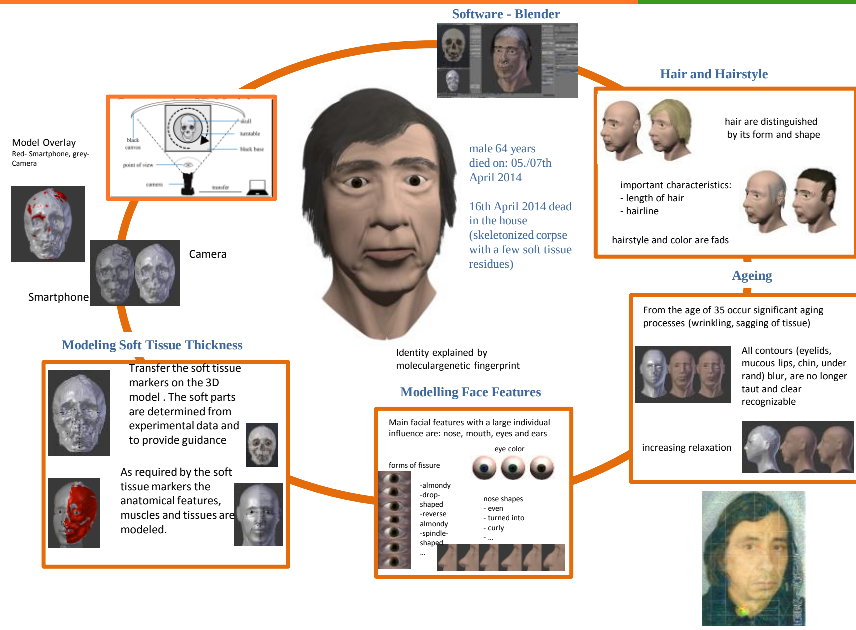

Facial soft tissue reconstruction

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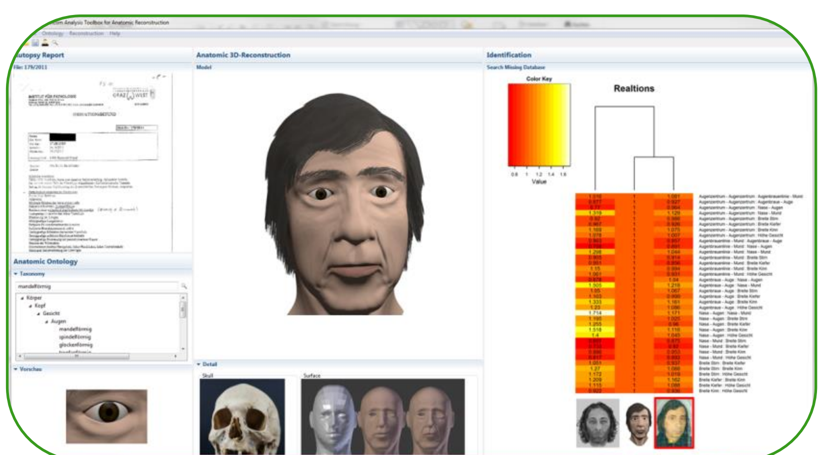

AVATAR
A Victim Analysis Toolbox for Anatomic Reconstruction

Facial soft tissue reconstruction

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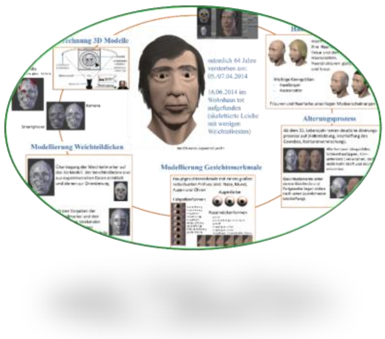
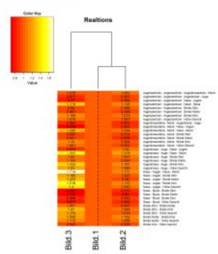


comparison to missing persons



similarity score

Facial soft tissue reconstruction Perspective

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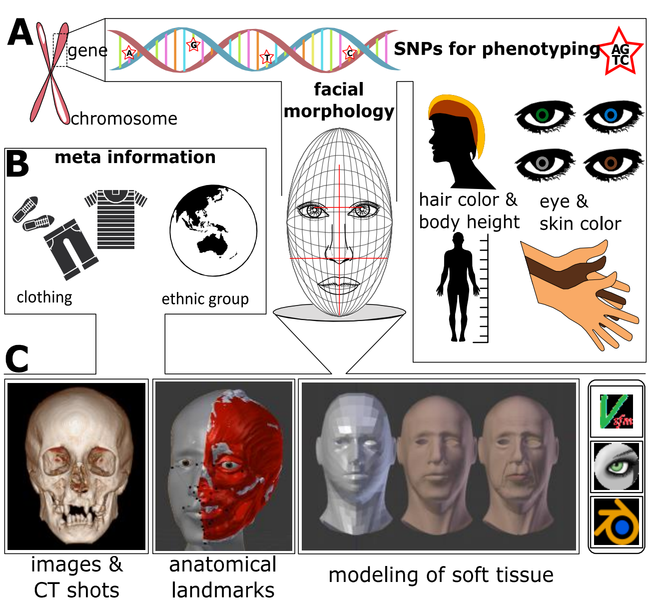

Crime scene reconstruction

CAD-based crime scene reconstruction

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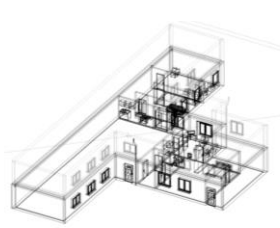
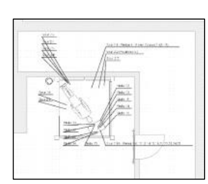
- **background to the selected case**
  - homicide
  - victim: prostitute
  - crime scene: work site of the victim
  - available information:
    - images
    - technical sketches
    - measures





Blender-based reconstruction of crime scenes

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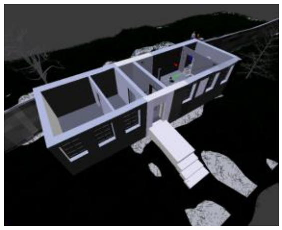

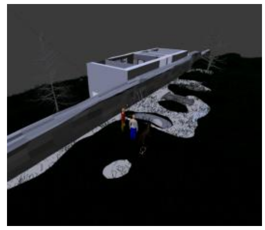

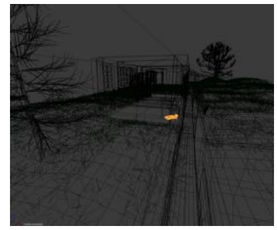

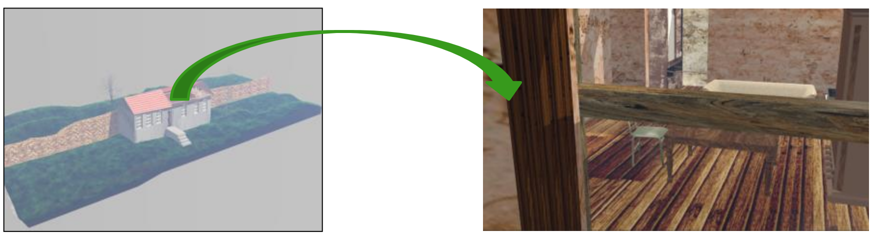

fReconstruction of a crime scene (real case).

Crime Scene Reconstruction

FoSIL

- **background for the selected case**
  - homicide
  - victim: little girl, eleven years of age
  - crime scene: house of the perpetrator, graveyard
  - available information:
    - images
    - technical sketches
    - measures

Simulation Visualization of the house and flat situation …. Crime scene

Blender-based reconstruction of crime scenes

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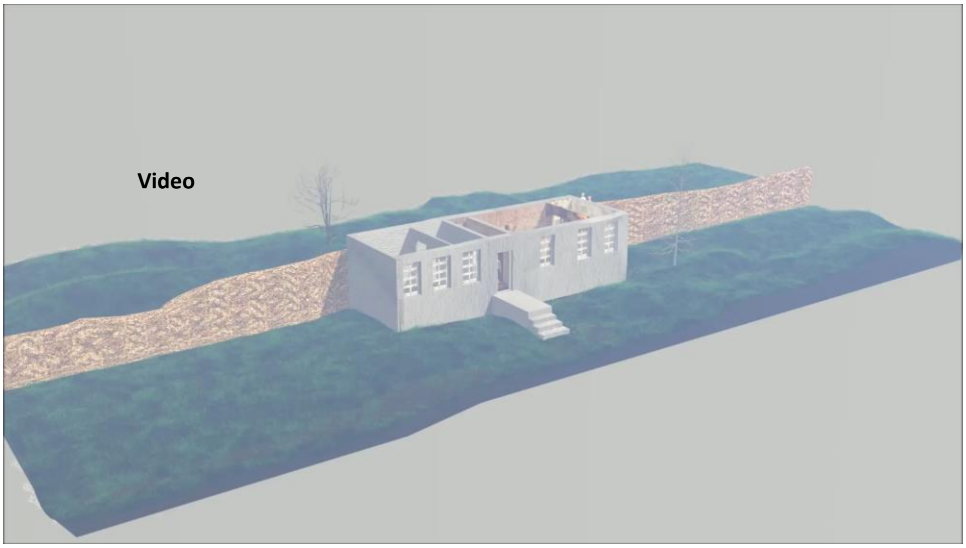

Blender-based reconstruction of crime scenes

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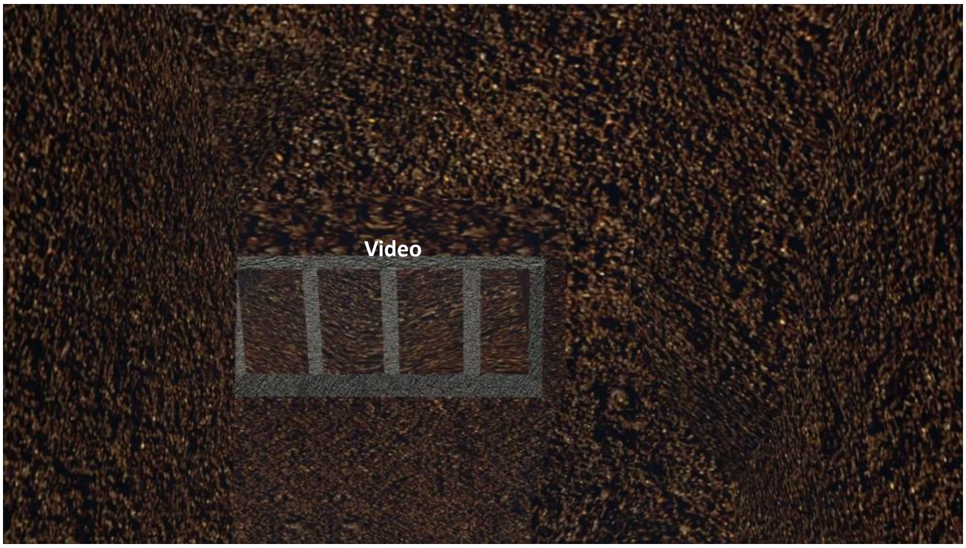
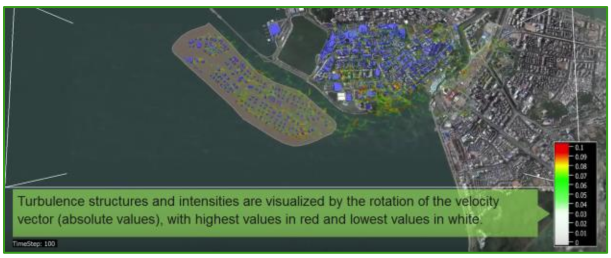
Blender-based reconstruction of crime scenes



Dissemination of particles (gas) in urban systems

Dissemination of particles (gas) in urban systems

How quickly propagate gases in urban structures with a known initial concentration?

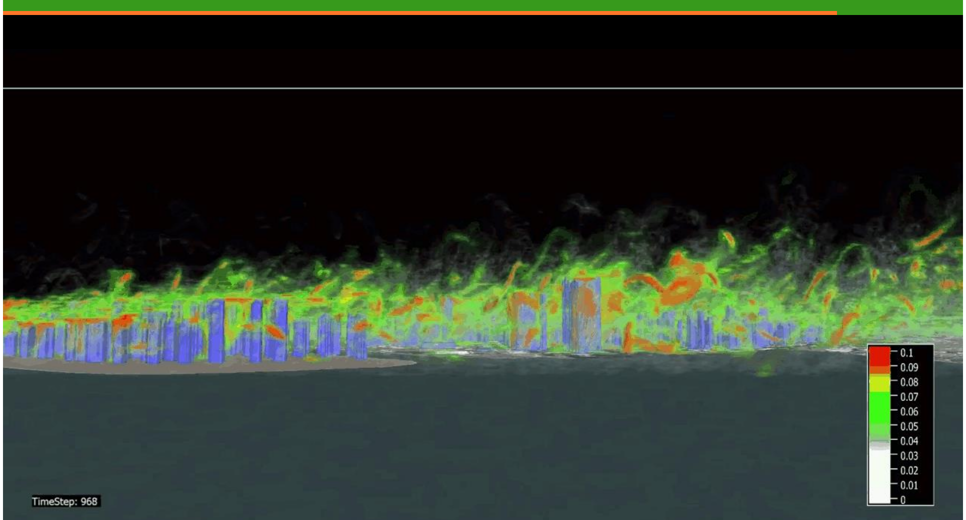


Macau (China)

+

Data collection for phases 4 and 5.

Dissemination of particles (gas) in urban systems



(Knoop et al.)

Pilot project

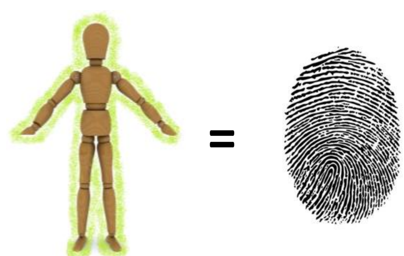
process-based documentation and plausibility consideration of Mantrail-employments in urban and natural systems

Victim Rescue and Search

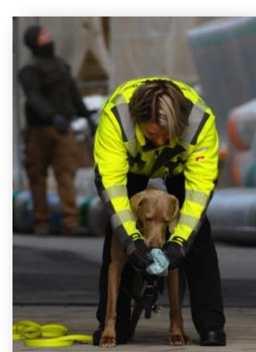
Introduction – Man trailing

FoSIL

Mantrailing is an “art” of following one person’s scent/odor and later identifying that person or the end of the trail.



- supporting the policing and to search missing (individual) persons
  - trained on the human odor
  - recognize individual human odor from clothing or tissue



Introduction

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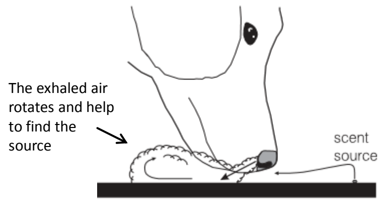
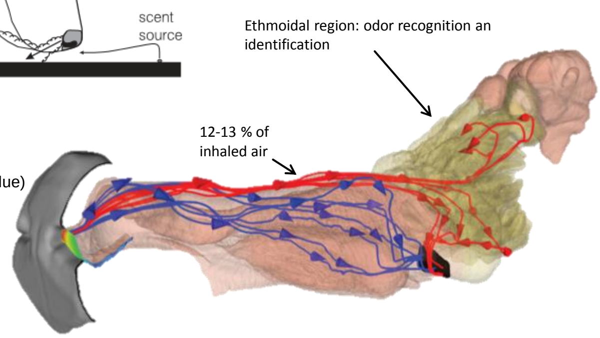
- Dogs have an amazing nose and a keen sense of smell
  - They perceive smallest amounts of odor (odor molecules) an follow the trail





- The dog has an respiratory (blue) and olfactory (red) airstream
- in the nasal cavity, the air is humidified and heated

Situation in Germany

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Information from man-trails are not accepted in (*all*) courts

Aim of the Project

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- We are interested in the behavior of the dog and the odor distribution
- Roll of the odor receptors (membrane proteins) → biological mechanisms

- Implementation of the information for odor distribution in urban and natural systems in a software
- Simulate the trail to created legal usable probability
- documentation an plausibility consideration
- Influence of weather conditions

The Layer Concept

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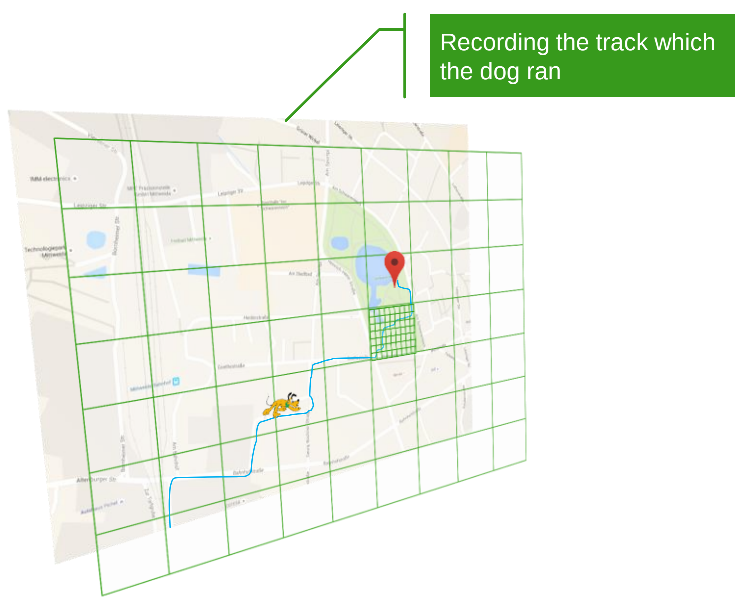


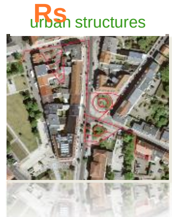
The Layer Concept

Calculate the likelihood for the change of direction of the dog

Factors, Statistics and Layer Concept

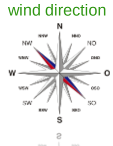
FACTORs

urban structures



temperature an humidity

wind direction



Urban turbulence and particle simulations (Knoop et al.)

BigData – Predictive Policing

FoSIL

Towards Predictive Policing: Knowledge-based Monitoring of Social Networks

Michael Spranger, Florian Heinke, Steffen Grunert and Dirk Labudde
University of Applied Sciences Mittweida
Mittweida, Germany
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Abstract—Increasing the resilience of the society against disorders, such as disasters, attacks or threatening groups, is one of the biggest challenges. Recent events highlight the importance of a resilient society and steps which are required to be taken in resilience engineering. *A priori* the optimal way to handle such

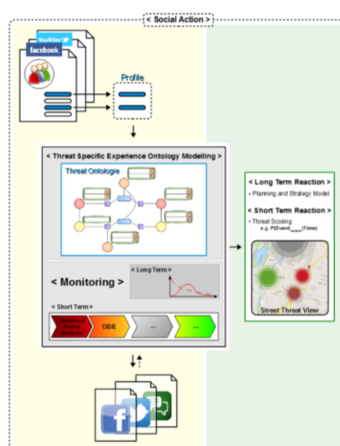
- Extraction of profiles for monitoring
- Extraction of post or comment content relating to the threat ontology and a sentiment analysis

→ enables short-term reaction

- Simulation of temporal development of groups and hot-spots

→enables long-term resource and strategic planning

- Increasing resilience



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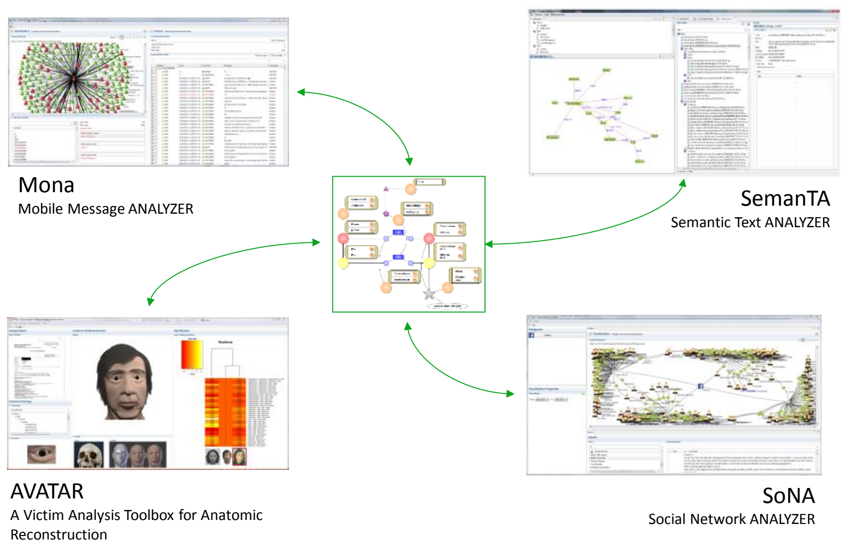

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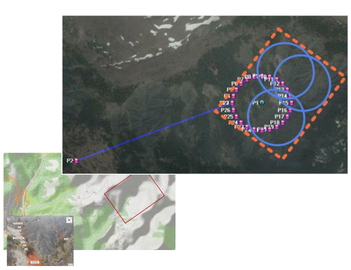
Resilience Cycle

Phase model



Open Source Software for different (sub) processes in the resilience cycle

FEEL FREE TO ASK QUESTIONS

VISIT US AT: www.bioforscher.de/FoSIL