Near-Real Time Post-Disaster Damage Assessment with Airborne Oblique Video Data

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Overview

- Background, motivation & objectives
- Enschede & Golcuk/Marmara (Turkey) disasters
- 3D reconstruction of post-disaster scene
- Texture-based damage mapping
- Video processing results
- Vision of comprehensive video-based method
- Conclusions and follow-on

Background & Motivation

- Following a disaster, timely, comprehensive & reliable information is required
- Challenging particularly after unexpected events
- Frequently inadequate disaster response, because of
  - Unreliable or insufficient information from the site
  - Limited access
  - Organizational reasons (e.g. limited preparedness)
- Clear potential of remote sensing data, but there are also limitations, especially of satellite data
  - Orbit- and sensor-dependent response time
  - Potentially insufficient spatial resolution
  - Limited to (near-)vertical view
  - Cost & access

Objectives of the study

- Investigate the potential of airborne video data for damage assessment
- Acquired by media or law enforcement agencies
- Easy acquisition, difficult use

- **Research issues:** Overall goal is a comprehensive video-based damage assessment methodology

i. Partial video-based 3D reconstruction of the damaged terrain, using extracted positional data or ground control

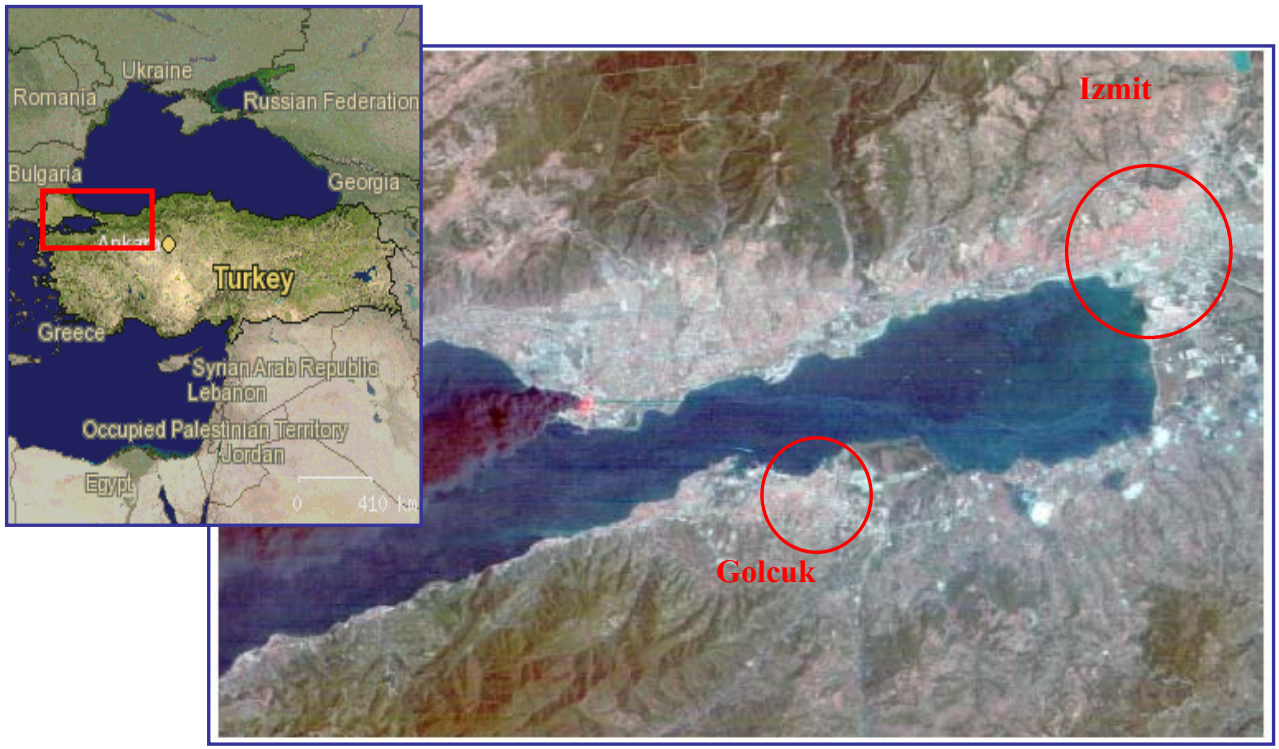
ii. Texture-based damage assessment, using Local Binary Patterns

iii. Apply automated damage mapping on a video stream rather than individual frames

iv. Provide a processing environment for the above steps

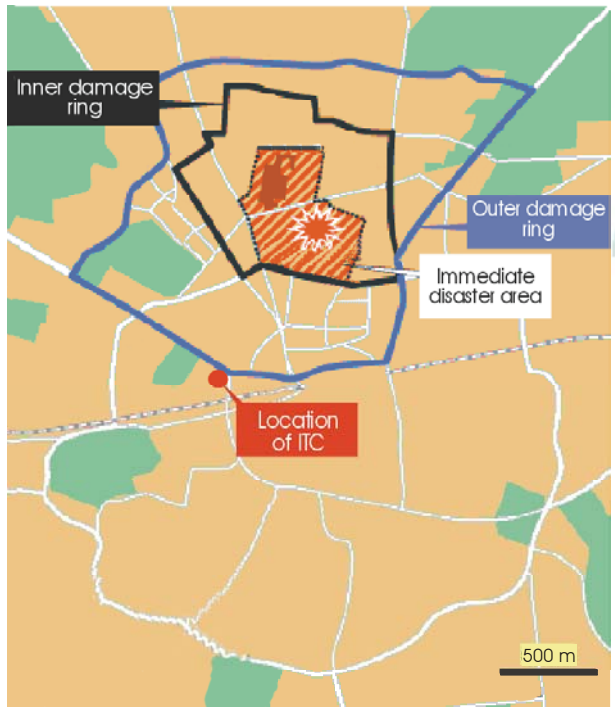
The Marmara Disaster

- 7.4 magnitude earthquake on 17 August 1999
- 15.000 fatalities and 40.000 collapsed or heavily damaged buildings
- Golcuk was one of the most affected towns (ca. 5.000 fatalities)



The Enschede Disaster

- A fireworks factory exploded on 13 May 2000 in Enschede, eastern part of the Netherlands
- Close to 500 buildings were several damaged or destroyed, 22 people killed, in an area of more than 40 ha
- Rapid decline of damage severity away from the blast site



Data availability

- In addition to substantial image archives compiled for both disaster cases (pre- and post imagery, maps, satellite images, etc.), video data were obtained from the media (Turkey) and the police (Enschede)
- Both sets are of relatively low quality (VHS; 360 x 576)

Video processing

3D-reconstruction

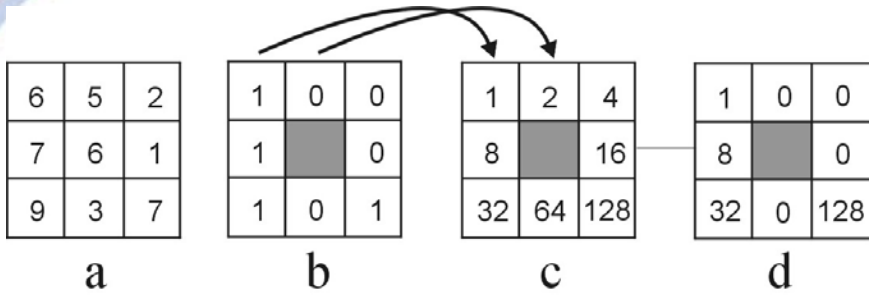
- Sequence of 200 frames of Enschede sequence
- MatchMover used to extract 2D points suitable for tracking
- Point matching in consecutive frames
- Calculation of approximate exterior and camera parameters (focal length)
- Exterior orientation values used for bundle adjustment in Bingo
- Result: relative camera and point positions, from which a partial surface is calculated

Video processing

Texture-based damage mapping

- In previous steps we used image-derived colour and edge characteristics to map damage (sequence processing)
- Here we move to more generic descriptors – Segmentation based on Local Binary Patterns (LBPs; Pietikaeinen & Ojala)
  i. Hierarchical splitting
  ii. Agglomerative merging
  iii. (Pixelwise classification)
- Segmentation into homogeneous areas based on information on the spatial structure of local texture
- So far only texture, no colour information used

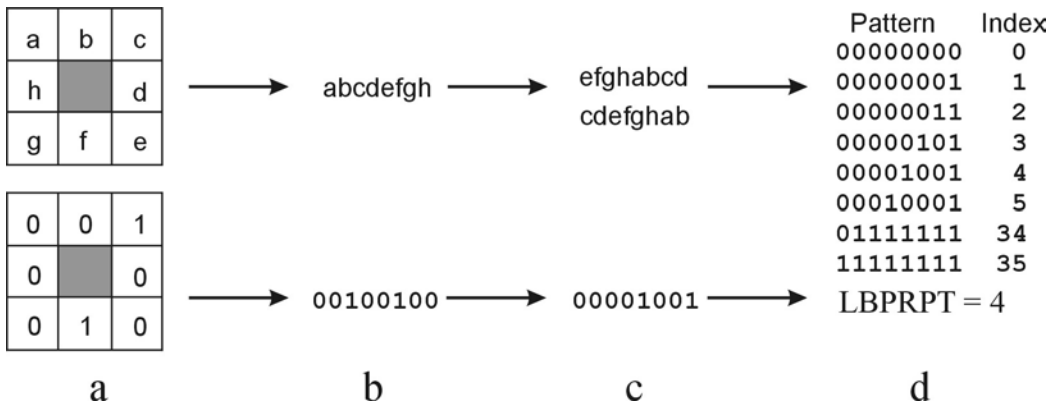
Local Binary Patterns and Contrast/Variance



LBP = 1+8+32+128 = **169**

C = (6+7+9+7)/4 - (5+2+1+3)/4 = **4.5**

- LBP/VAR and LBP/C are calculated, and their distribution approximated by a 2D histogram
- Extension to rotation-invariant implementation is possible (Pietikaeinen et al., 2000)

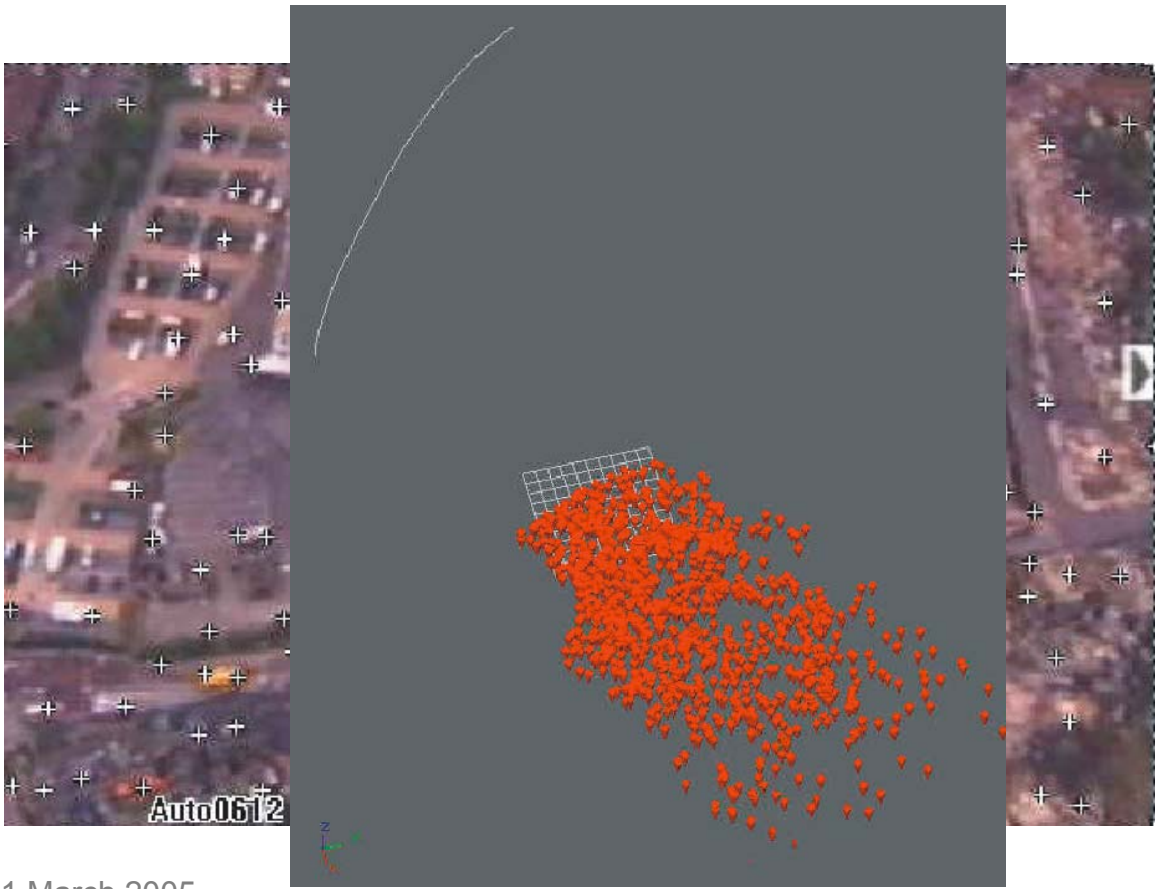


Video processing

Results – 3D

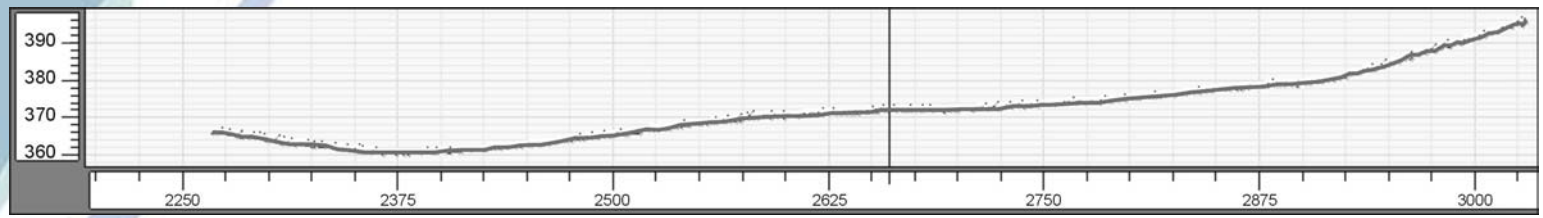
3D reconstruction

- Sequence of some 200 frames was processed, and >1000 points extracted (<100 points tracked per frame)
- Focal length and flying height (above terrain) estimated
- Relative exterior orientation and position of tracked points

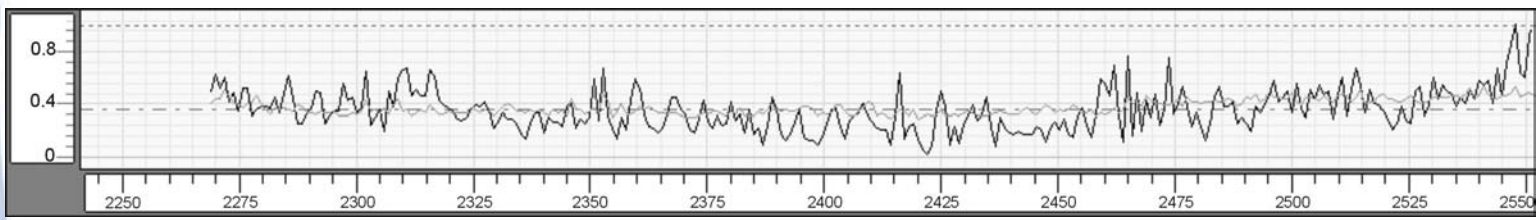


Results – 3D

- **Flying height (relative, since no GPSdata /GCPs used)**

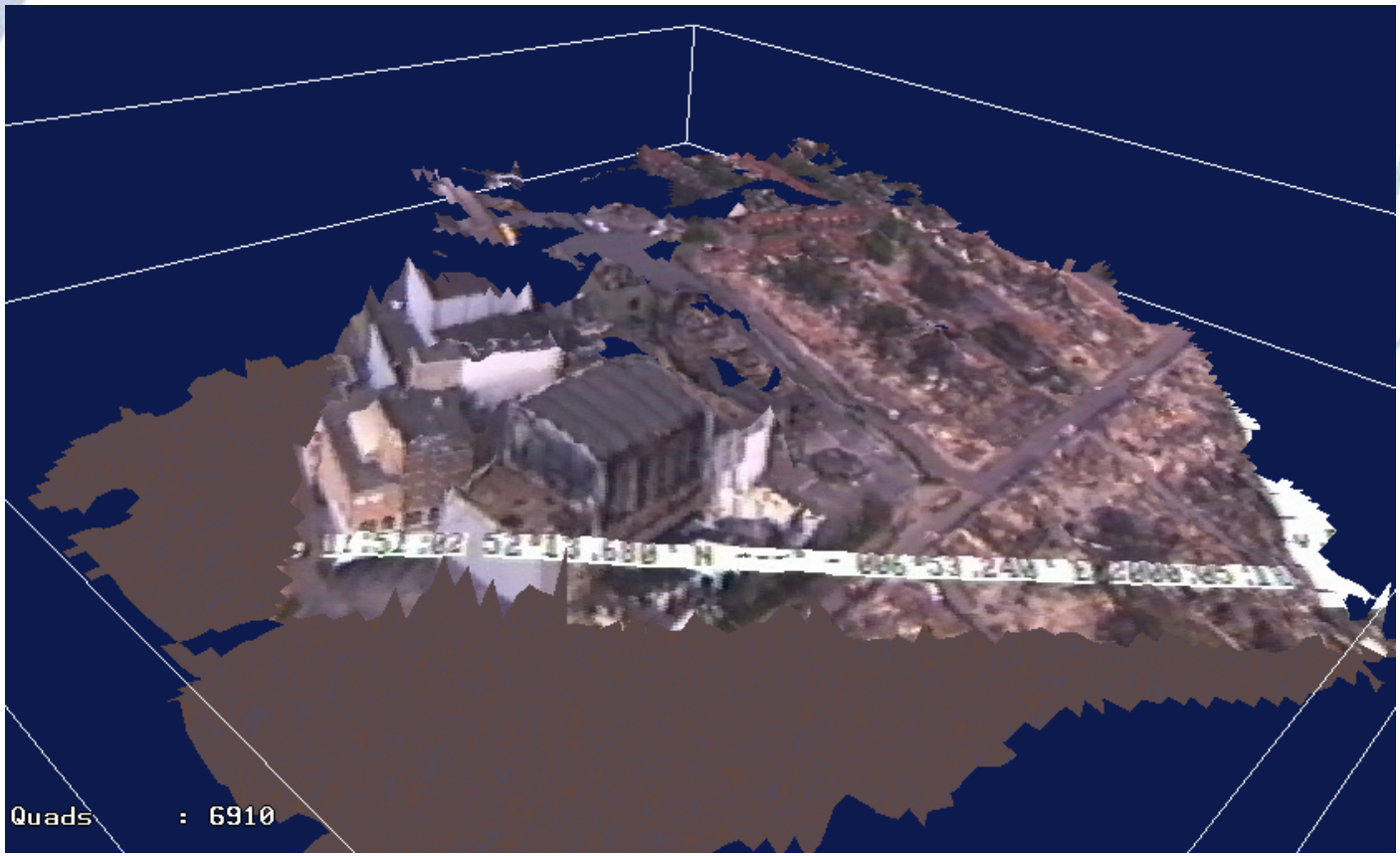


- **Point accuracies: RMS of xyz of 1.3-1.5 m (max. 5.7m [xy] and 3.8m [z])**
- **Residuals computed per point, ca. 1 pixel**



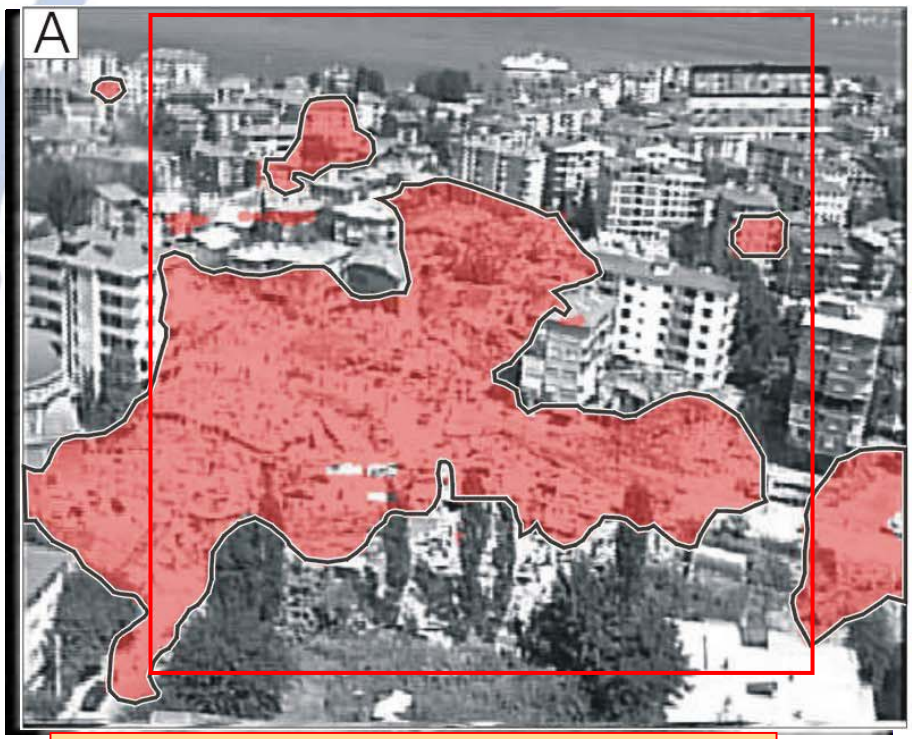
Results – 3D

- Surface reconstruction is limited, because of
  - Poor video resolution and quality (interlacing)
  - Allows limited extraction of points
  - Model incomplete due to reduced distal resolution and occlusion

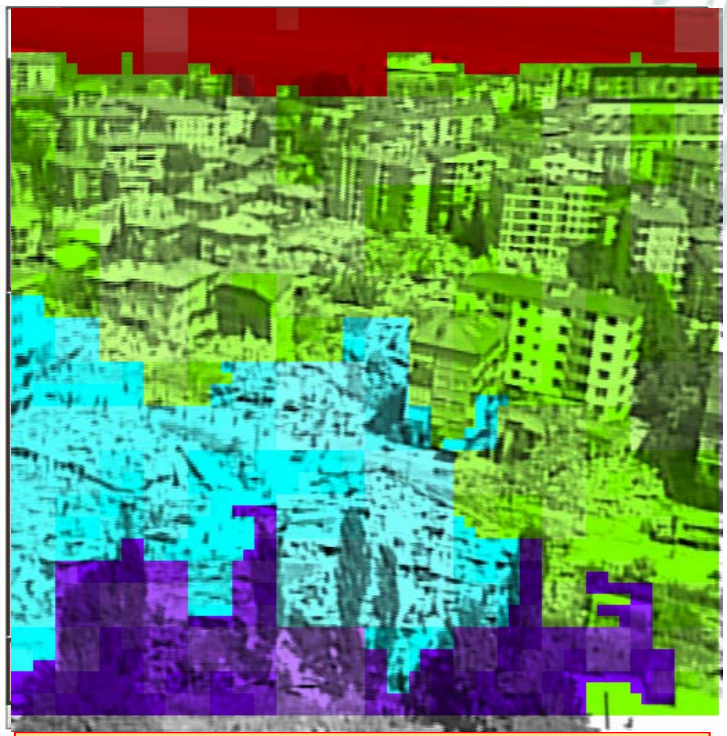


Results – Segmentation

- Segmentation implementation worked well for synthetic images
- Success for video scenes was limited (limited resolution constraints the minimum block size)



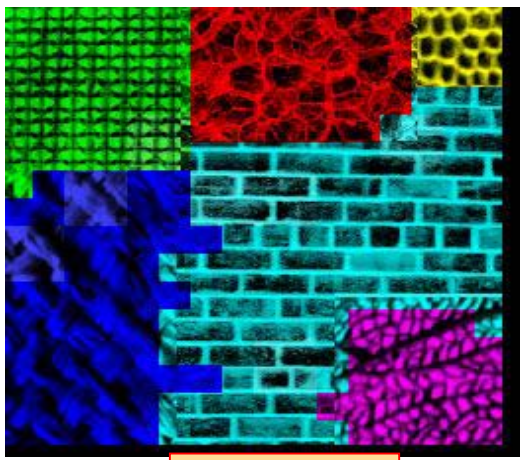
Colour/edge-based assessment



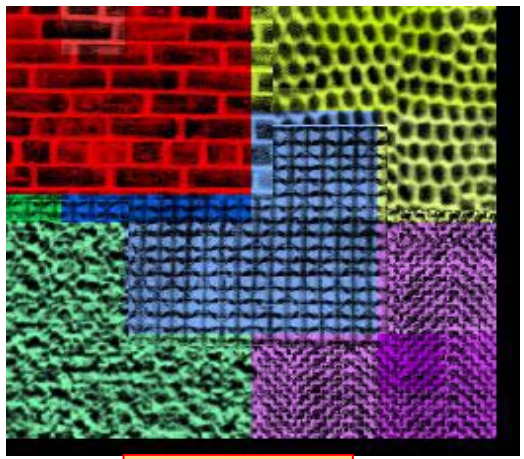
Split & merge (without colour)

Results – Segmentation

- Simple, single-scale LPC was extended to a multi-scale approach (HVD (Horizontal Vertical Diagonal lines), whereby differences between the centre and the surrounding 3x3 and 5x5 matrix are determined (Abs(O-x) + Abs(O-X))



LBP/VA
R 5x5



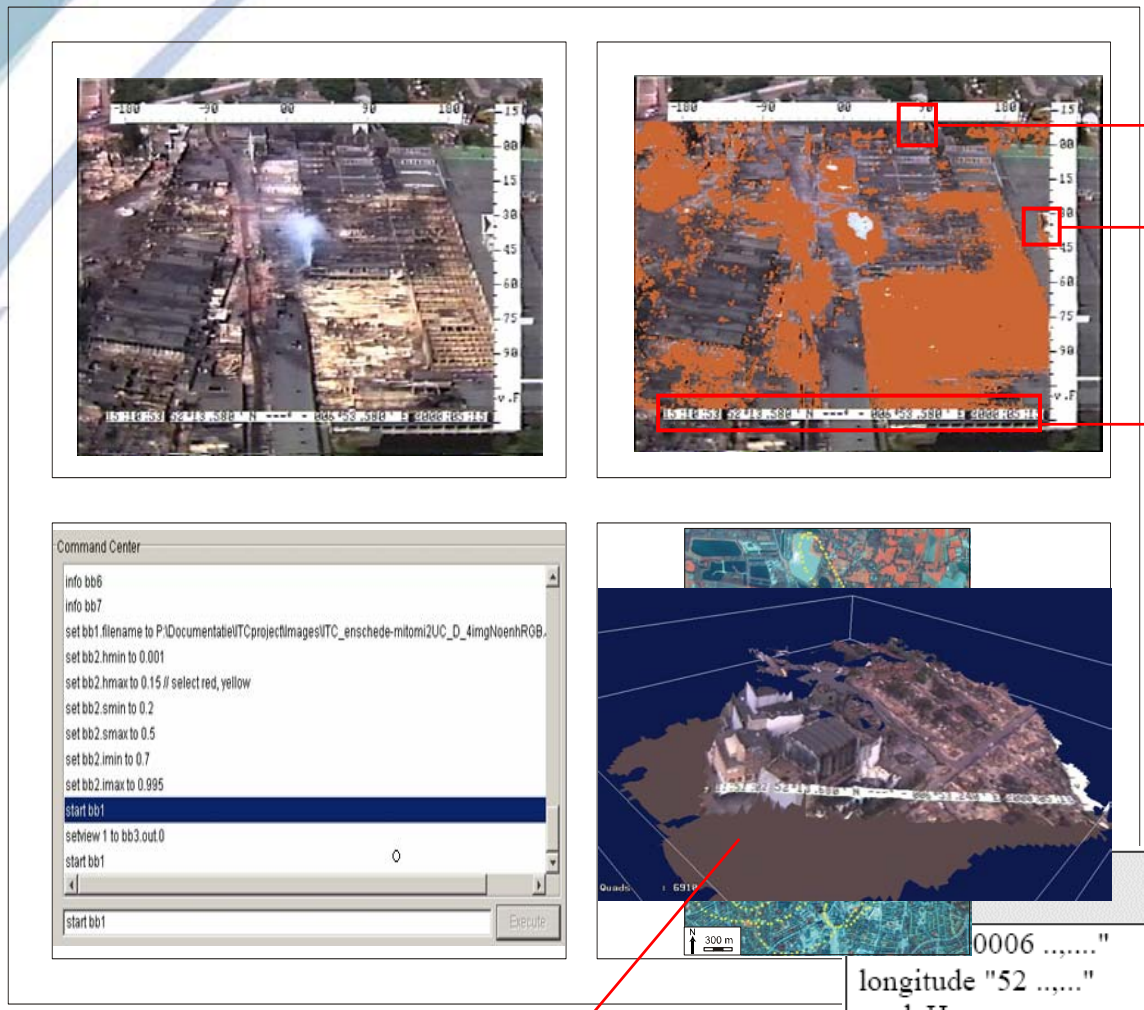
HVD
9x9

- Matched performance of LBP, but no significant improvement
- Next step incorporation of colour

Summary & follow-up

- 3D coordinates and exterior orientation parameters of the Enschede site were extracted for partial 3D reconstruction
  - **Follow-up:** point densification, tests on higher resolution data, calculation of absolute surface, integration of auxiliary data
- Texture-based segmentation (without colour) can work on higher resolution data and on homogenous artificial textures; The LBP implementation on low-quality grey-scale video is not encouraging, and is still very threshold-dependent
  - **Follow-up:** colour integration, true multi-scale segmentation, and work on within-frame scale variation

The comprehensive solution



Azimuth

Inclination

GPS & time

	Example output string
0006 .,....."	Latitude 0006 54.900
longitude "52 .,...."	longitude 52 13.000
angleH ….,..	angleH -14.23
angleV ….,..	angleV -33.97
time "1.h..m..s"	time 17h18m23s
date "2000:05:1."	date 2000:05:13

3D-reconstruction (resulting in frame footprint location)

Summary & follow-up

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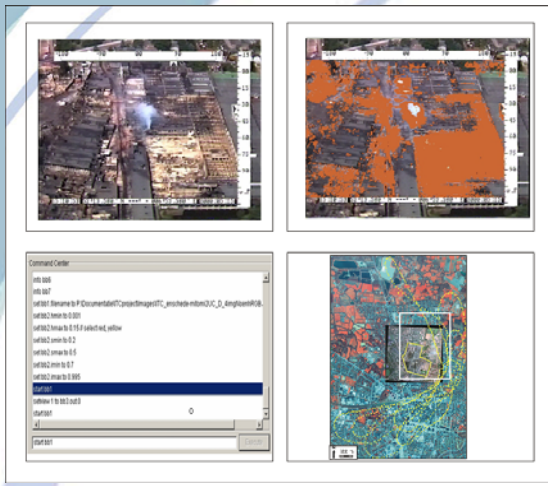
The comprehensive solution



Requirements:

- Versatility (work with all kinds of video data)
- Modularity (depending on data available, situation requirements)
- Scalability (allow nested integration of more detailed work in a general damage assessment)
- Allow some user interaction, since variability in damage types is unlikely to allow fully automated system
- Open source/low cost
- Easy to operate

Acknowledgments

Thank you

The video data of Enschede were made available by the police's TOL Team. In particular we thank Hans Kamperman for his assistance, and for making additional aerial photographs available. The Golcuk data were provided by Show TV.