

3D Reconstruction of a Collapsed Historical Site from Sparse Set of Photographs and Photogrammetric Map

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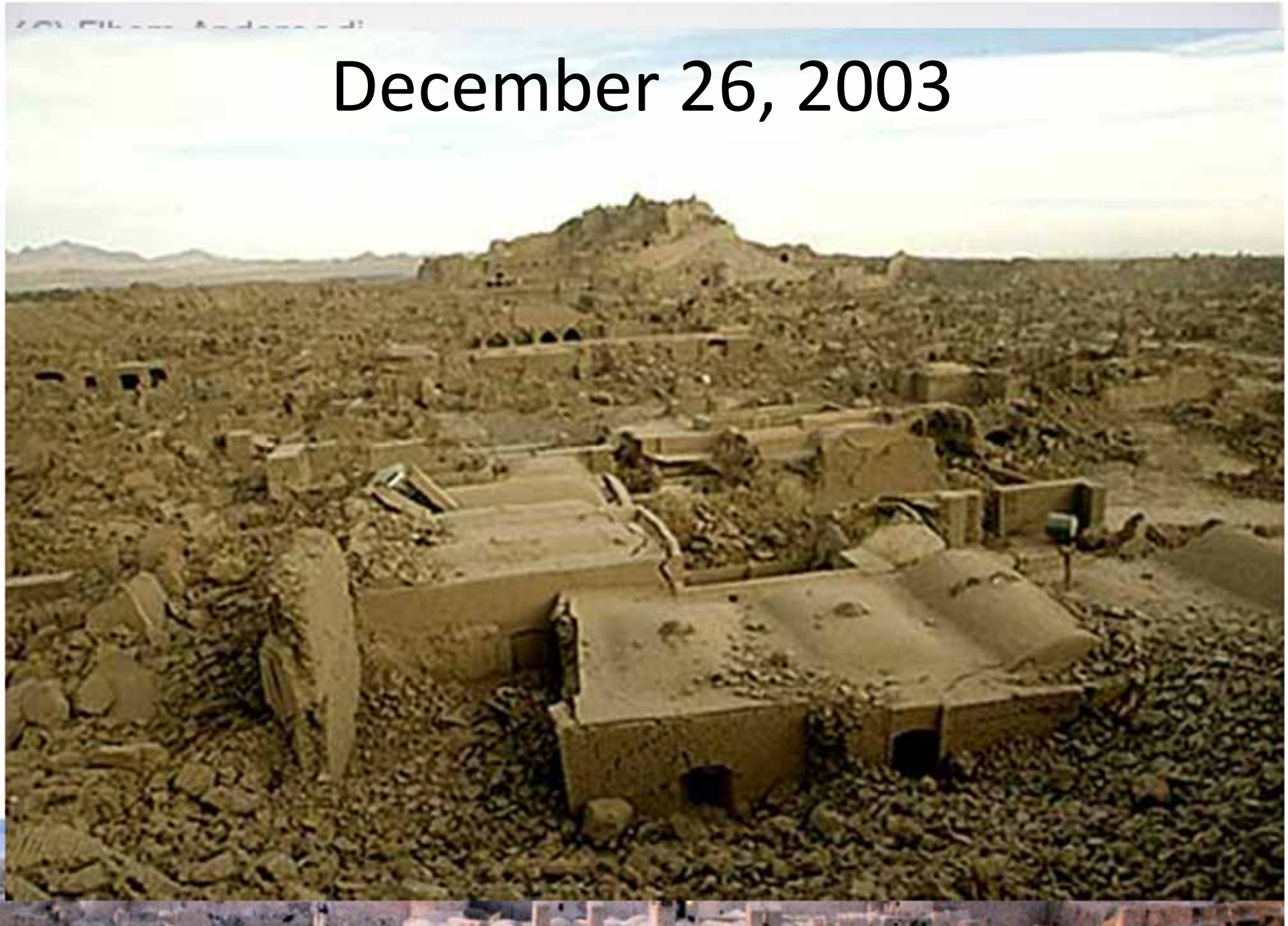
University of Yazd

Kinji Ono

National Institute of Informatics



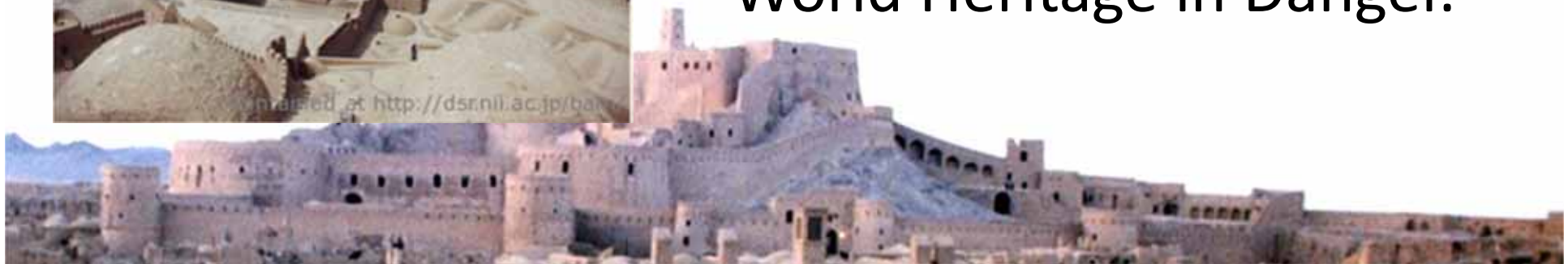
December 26, 2003



Citadel of Bam

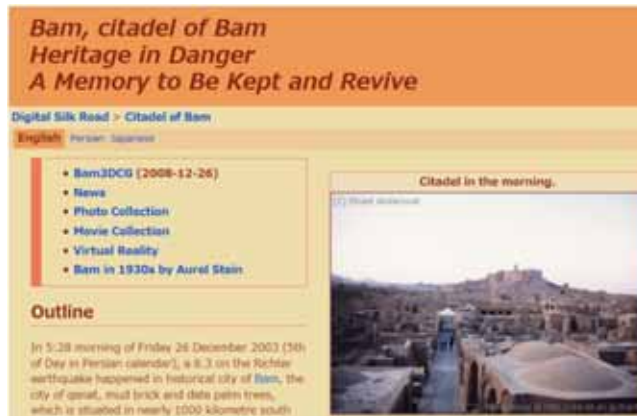


- One of the biggest mud brick complex in the world.
- Most of the citadel was collapsed by the quake.
- One year later, “Bam and its Cultural Landscape” was inscribed on the list of World Heritage in Danger.



Bam Project History

December 31, 2003



January 2004



April – June, 2006



December 26, 2008



3D Reconstruction of a Collapsed Site



New data cannot be captured from now!



Laser scanning

Image: Wikipedia

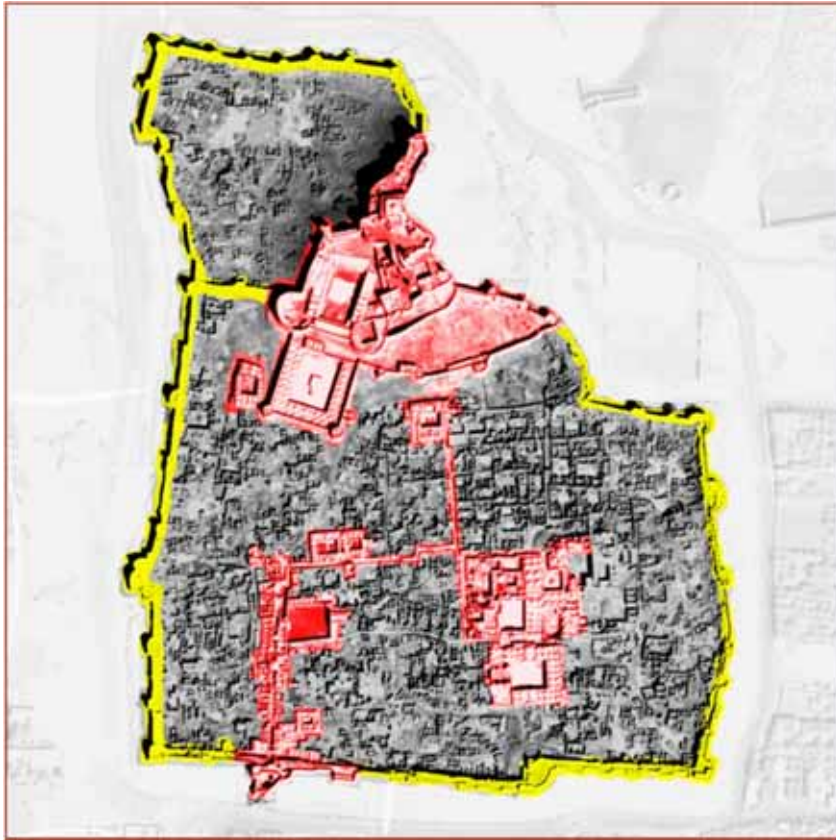


Structure from Motion

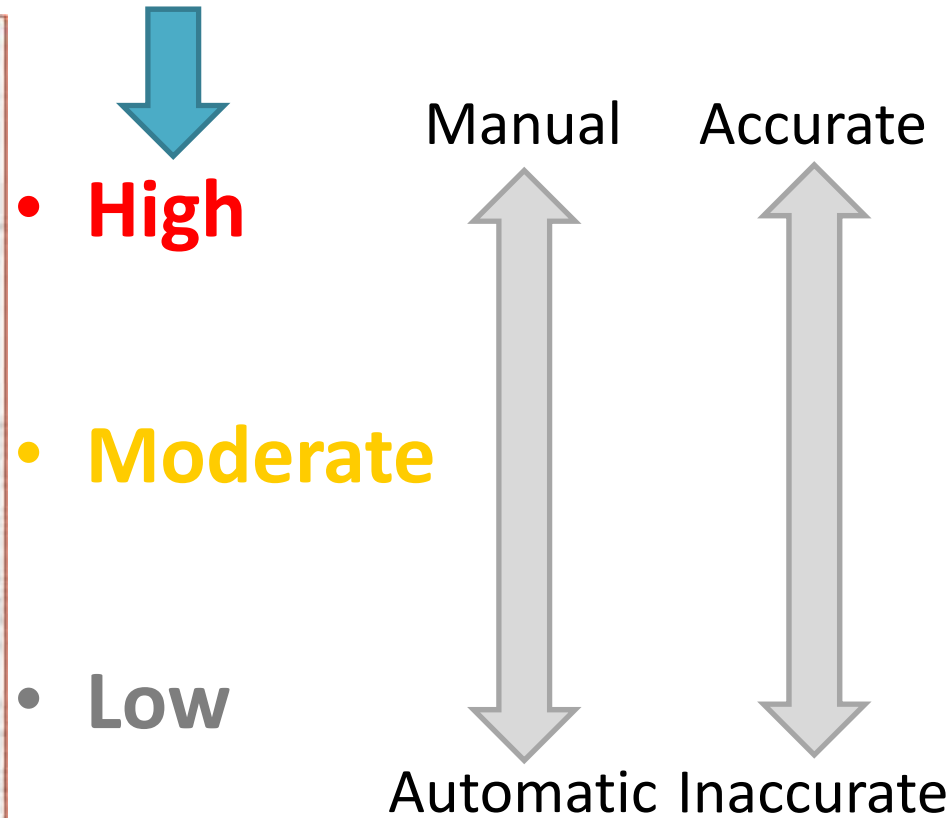
Image: Building Rome in a Day



Levels of Architectural Importance



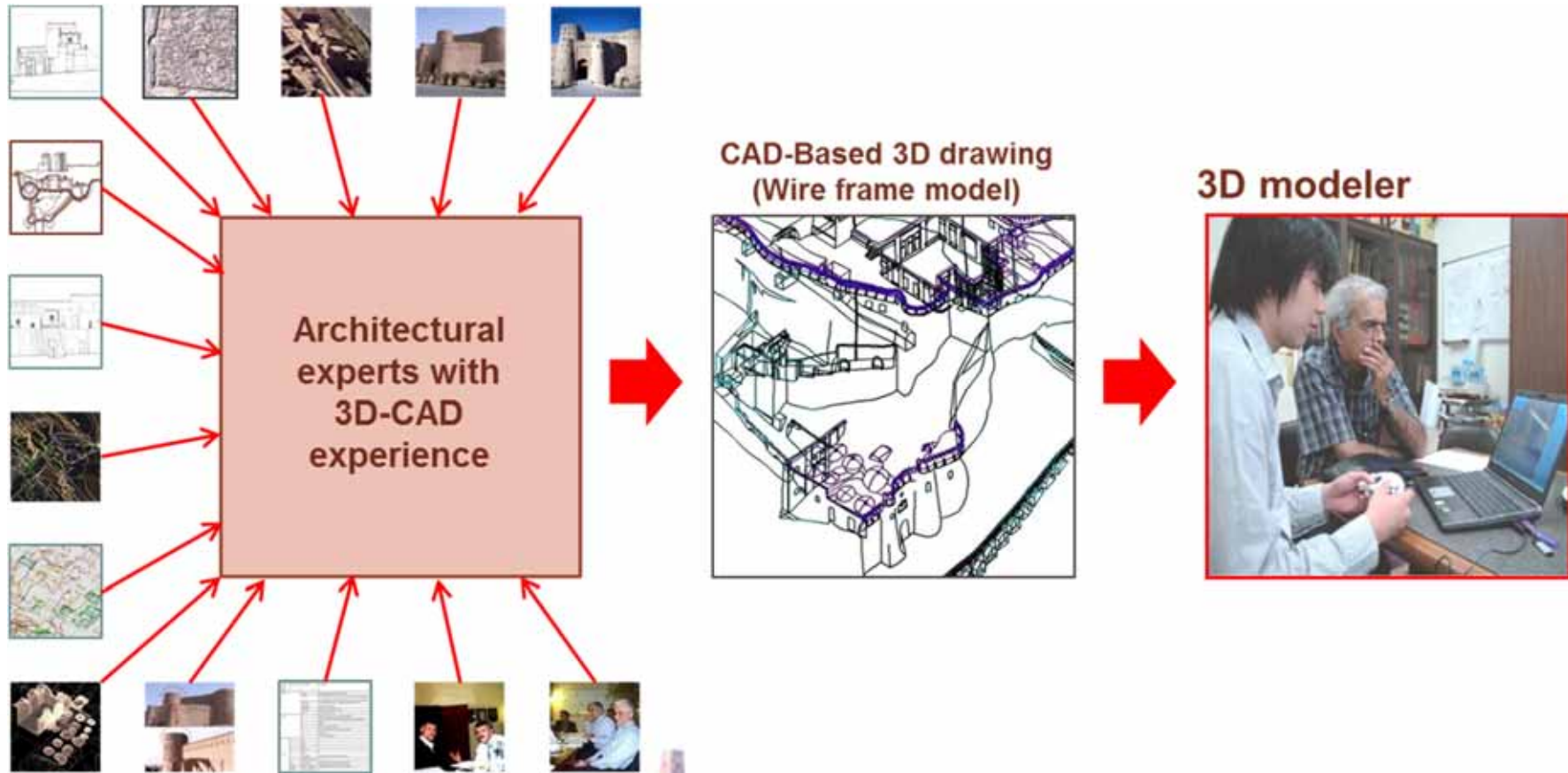
Original image: Digital Globe



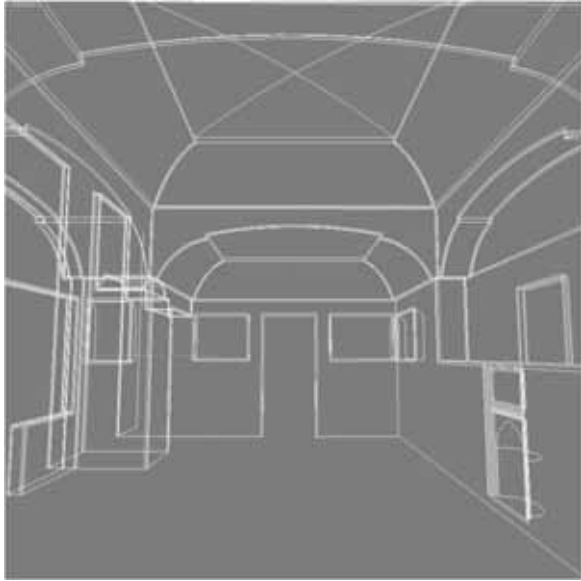
Good balance of accuracy and cost



High Importance Areas



Interior Space



CAD-based 3D drawing:
Dr. M.R. Matini (NII)

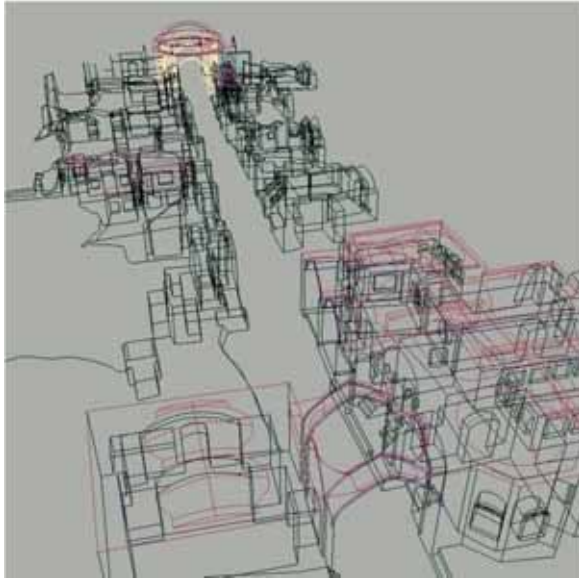
3D modelers:
Raazahang, University of Tehran, Iran



one room of Sistani house

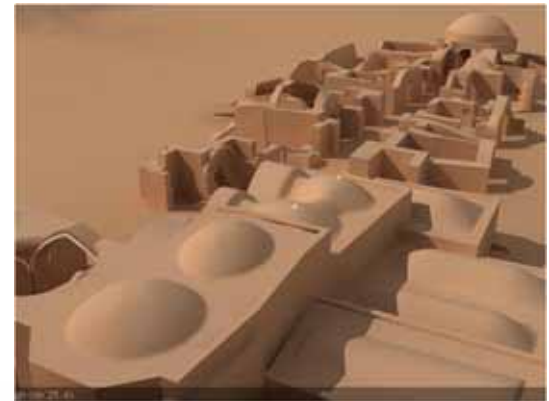
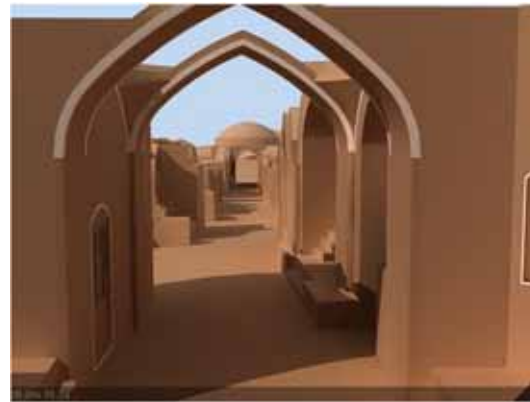


Exterior Space



CAD-based 3D drawing:
Dr. M.R. Matini (NII)

3D modelers:
Global Information and Telecommunication
Institute (GITI), Waseda University, Tokyo



one part of Bazaar



Low Importance Areas



Using point correspondences and projective geometry fails due to the lack of photographs, variety of cameras, and temporal change due to renovation.



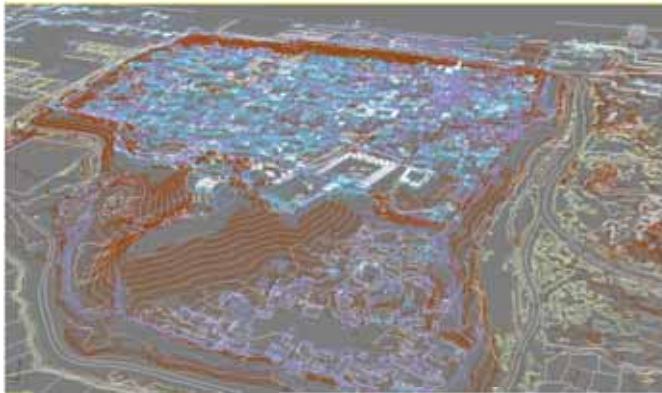
7-minute video taken from a helicopter by NHK in 1981 has potential for the automatic reconstruction of a 3D model, but not yet completed.



Work by Mr. Tiago da Silva

Proposed Method

Photogrammetric Map
From CNRS and ICHHTO

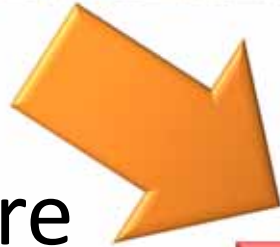


Photographs
From experts and tourists



Overlay

Structure



Texture



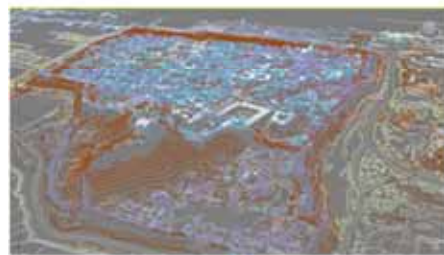
Simple 3D Model



Workflow



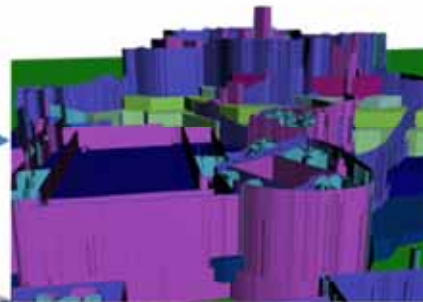
Tourist Photos (before earthquake)



Cartography map

Map Optimization

Mesh Interpret

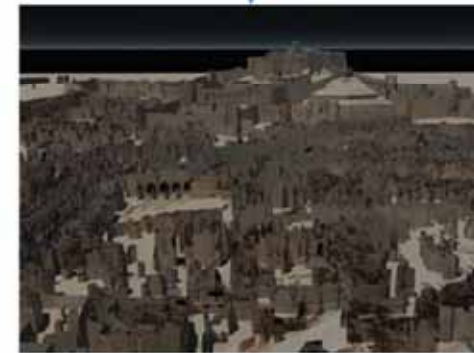


City's 3DMesh

Photo adjustment

Photo Registration

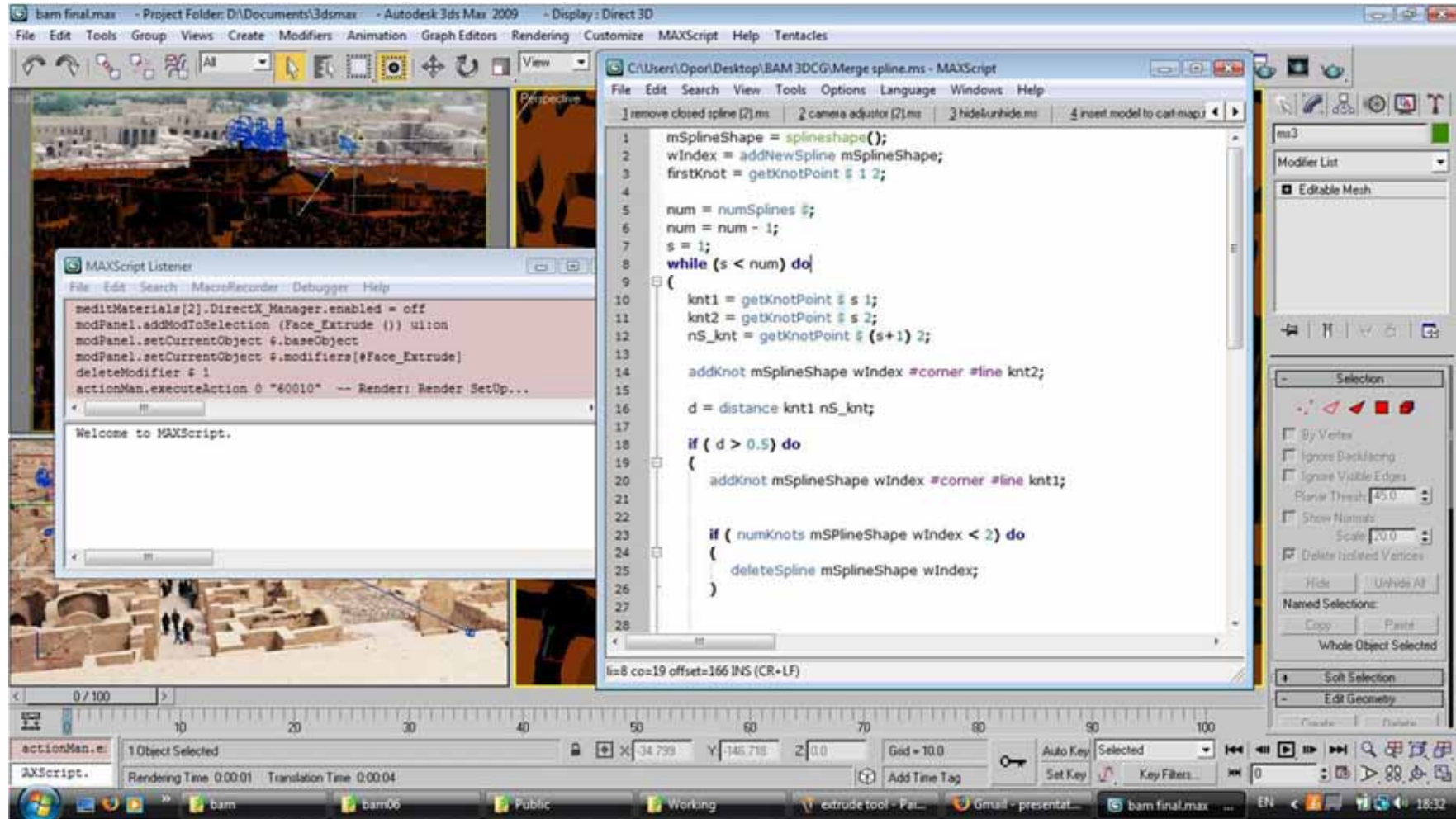
Post Processing



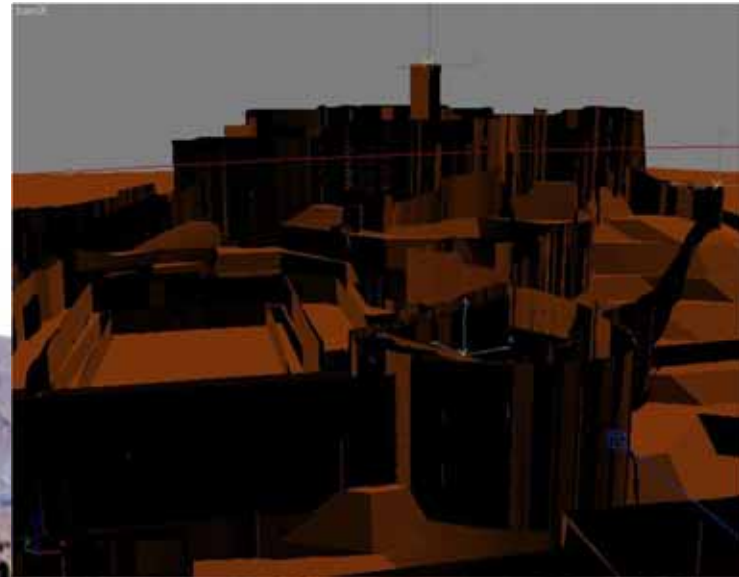
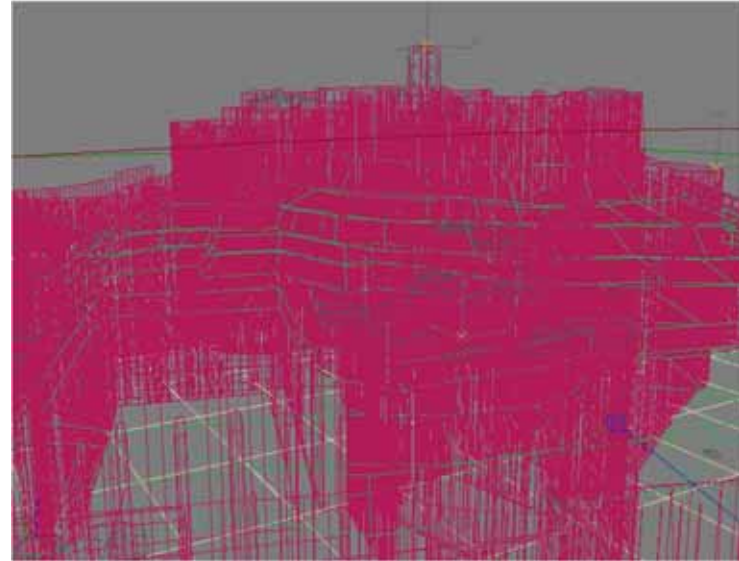
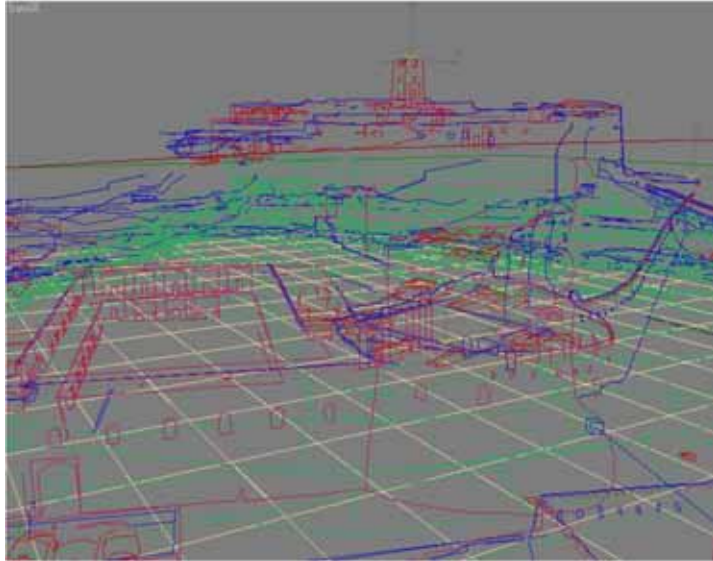
Final Result



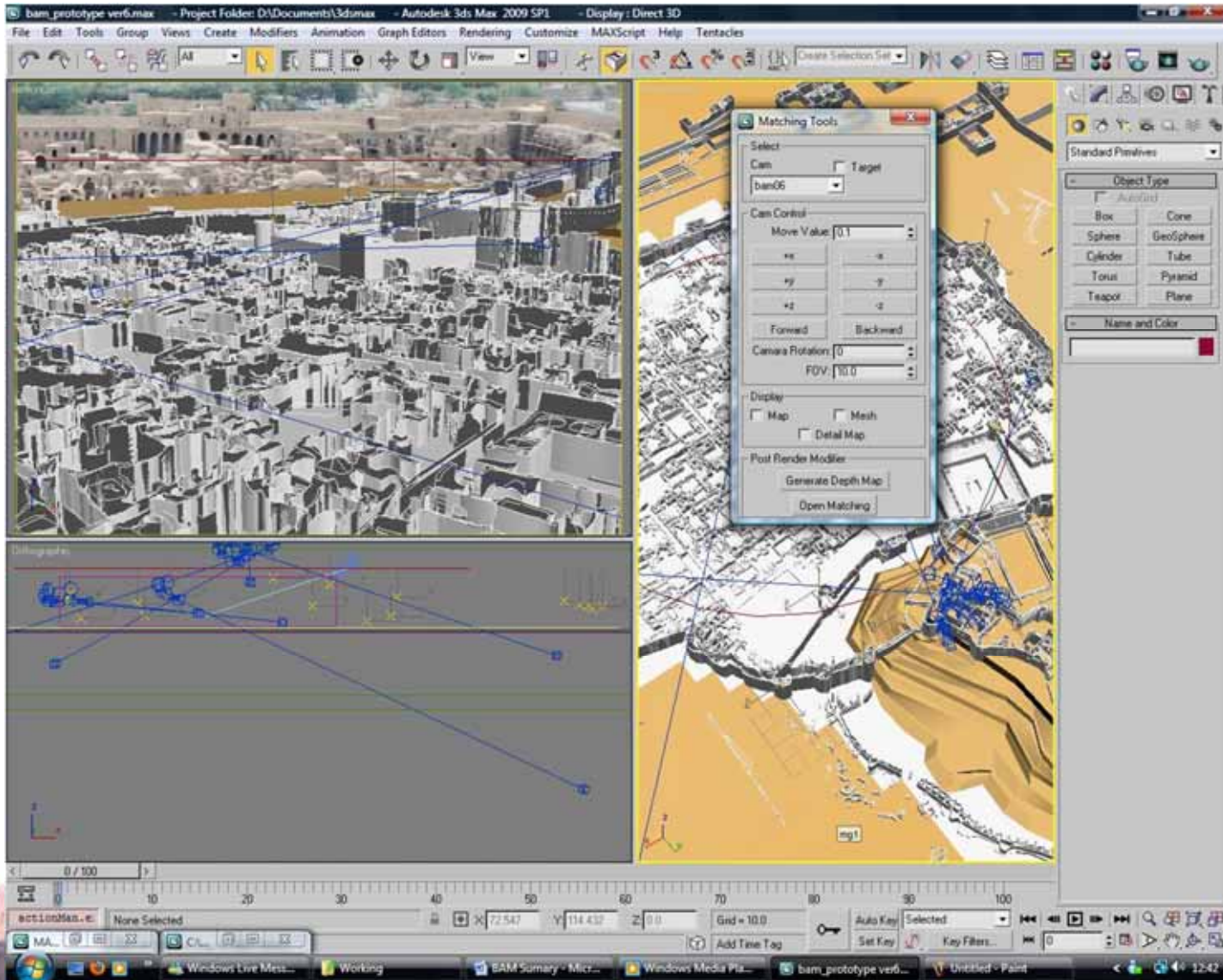
Autodesk 3ds Max Framework



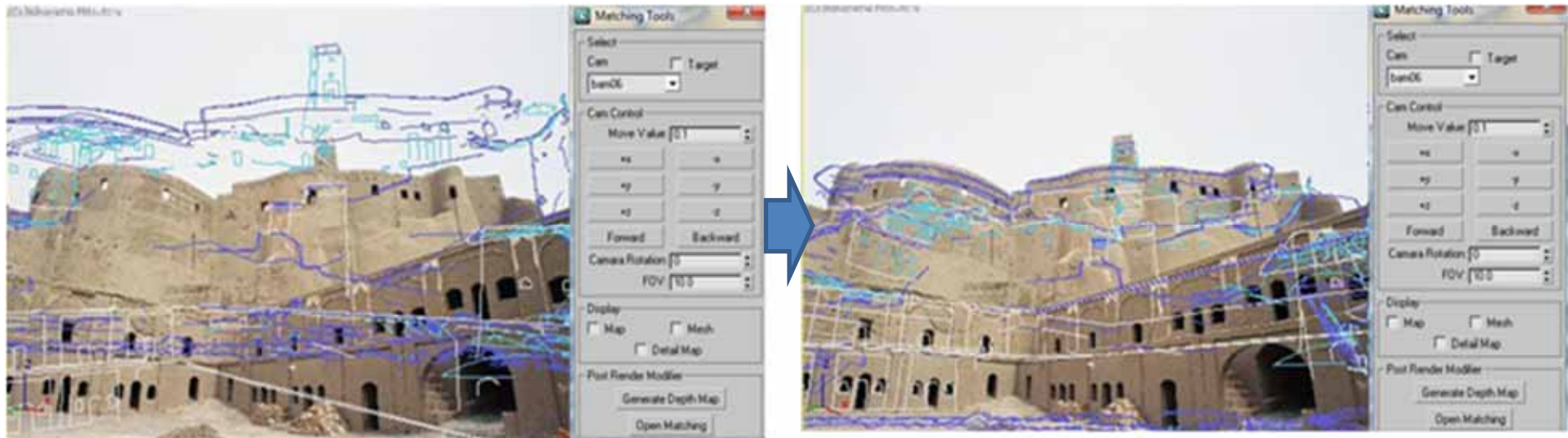
Building Mesh from Splines



Camera Matching Tool



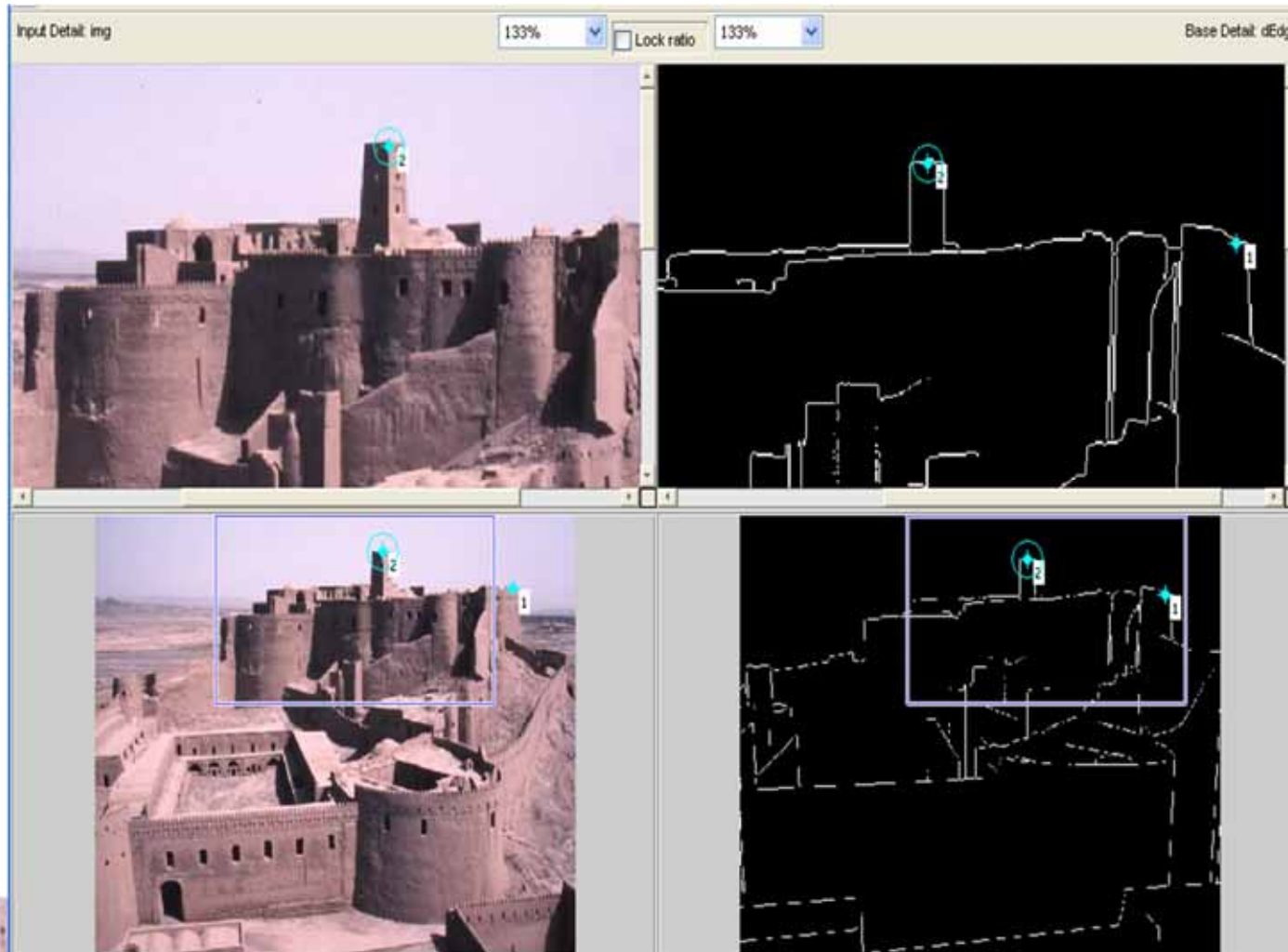
Estimating Camera Parameters by 3D Matching



- The crucial step for better accuracy but a manual, time-consuming step due to the large degree of freedom.
- Matching feature points between the photogrammetric map and images should work across multiple scales.



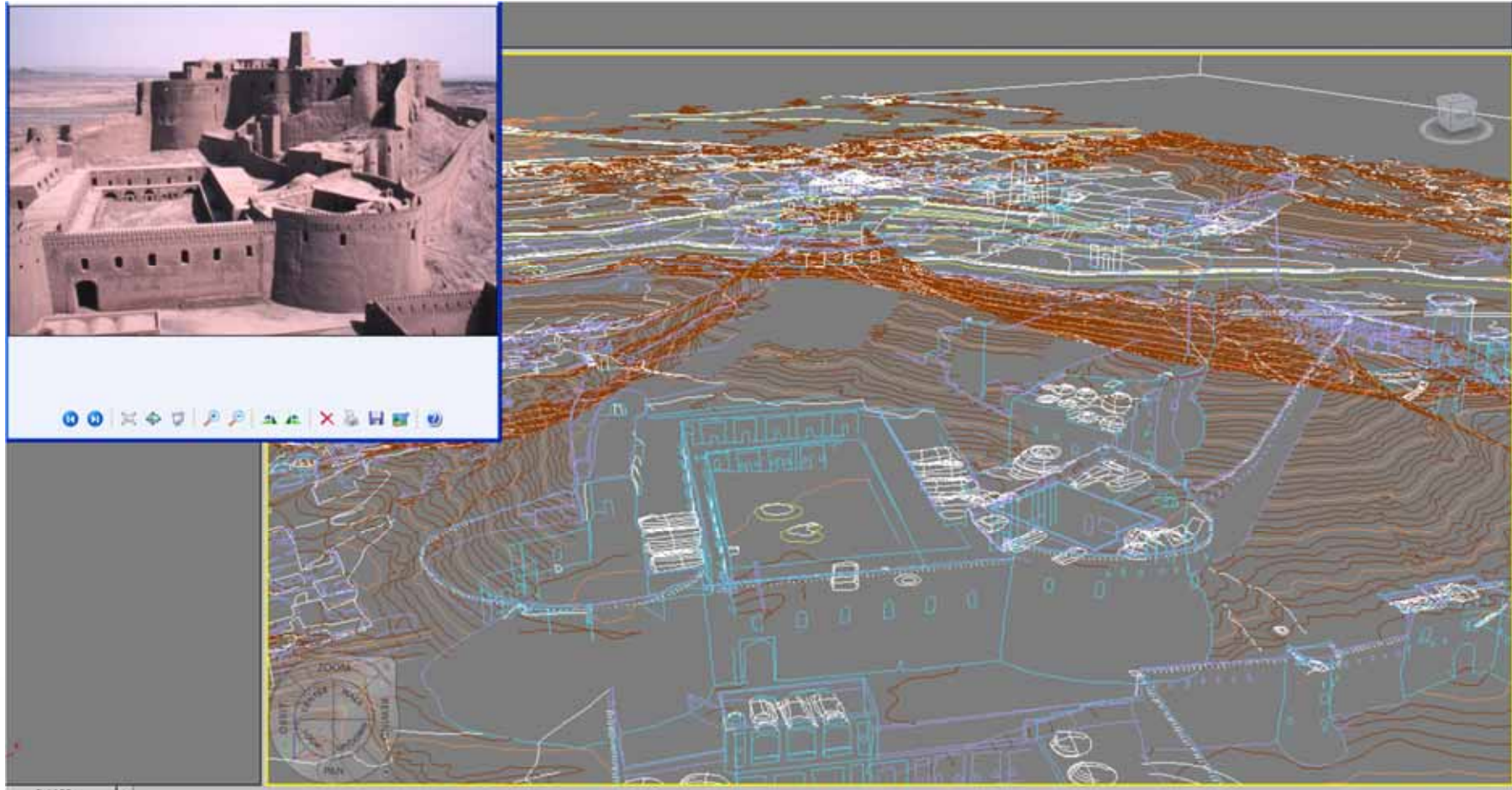
Estimating Transformation Matrix from Control Points



Result of Image Transformation

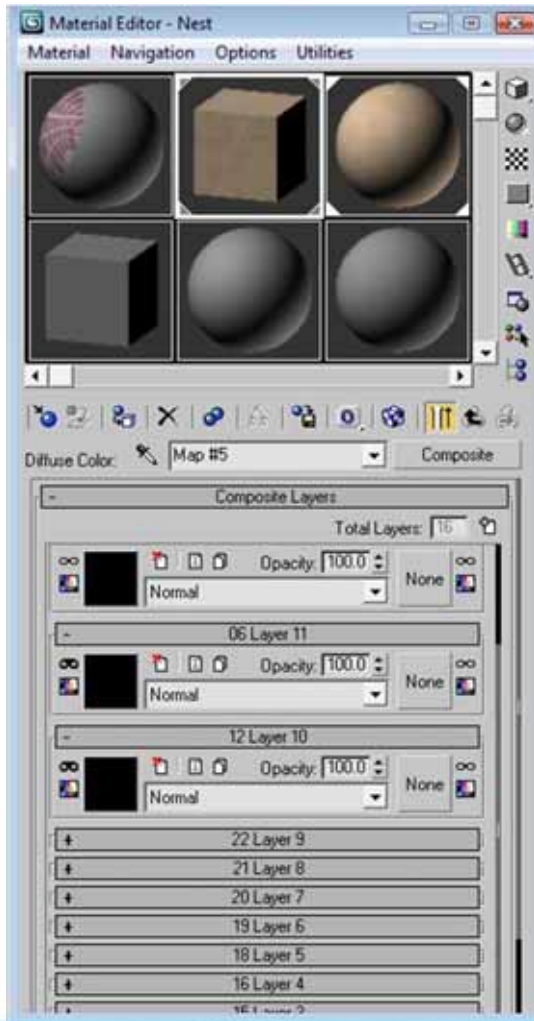


Result of Photograph Registration

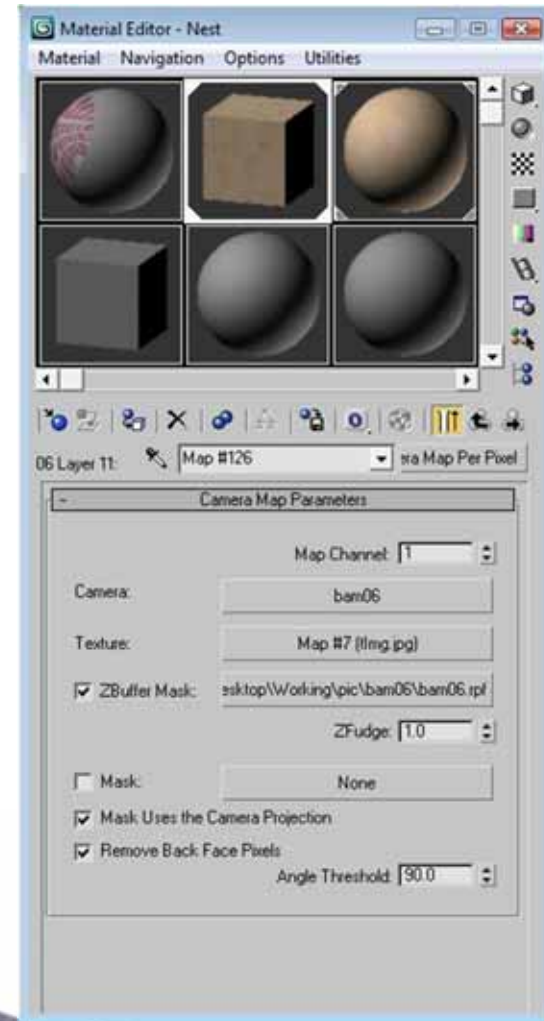


Texture Mapping Tool

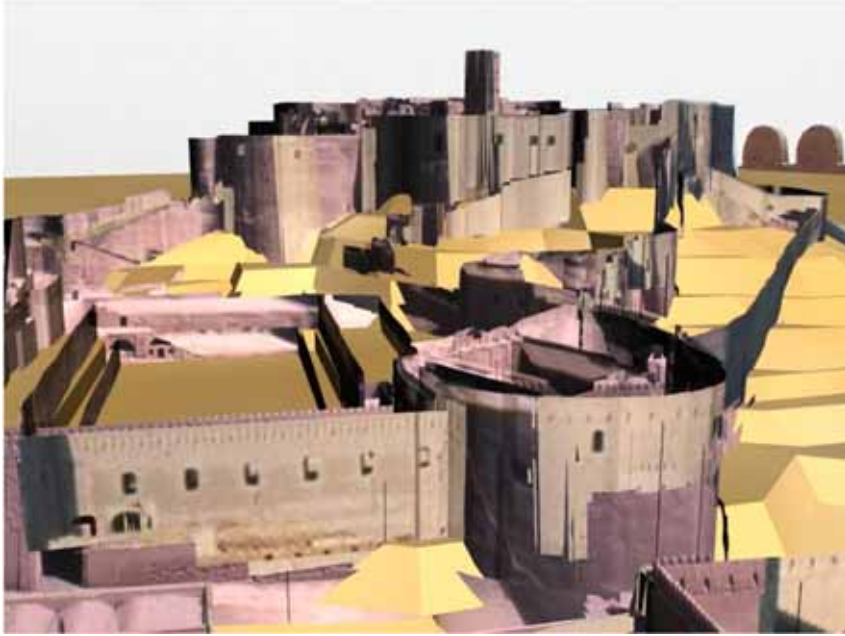
Composite Map



Camera Map



Post Processing



Filling occluded texture, modifying the ground level, and changing the illumination with a new lighting system.



Selecting Photographs



(a)



(b)



(c)

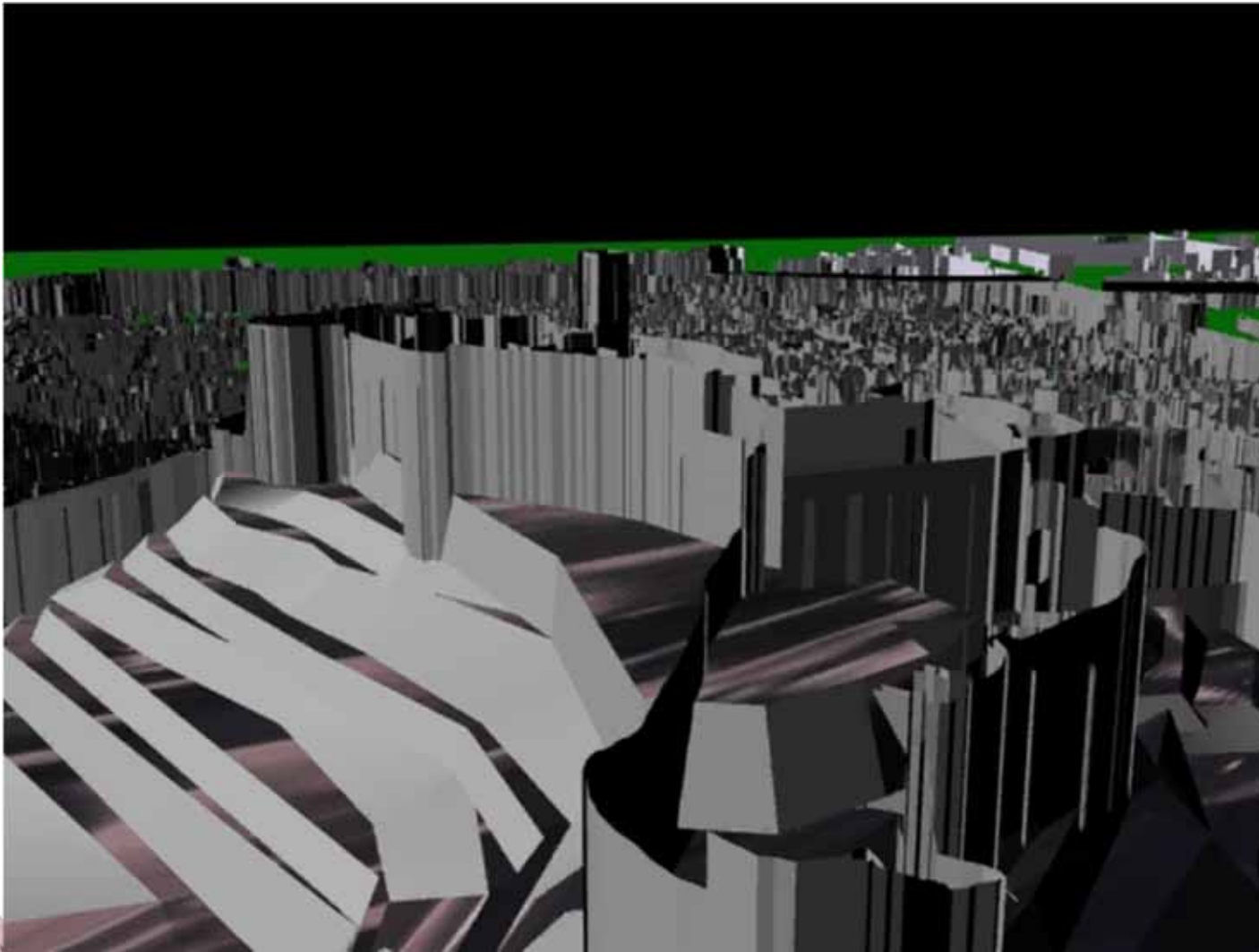


(d)

- Out of 200+ photographs, only 22 were used.
 - Many tourist photographs are from popular views.
 - Some close-up photographs are difficult to match.



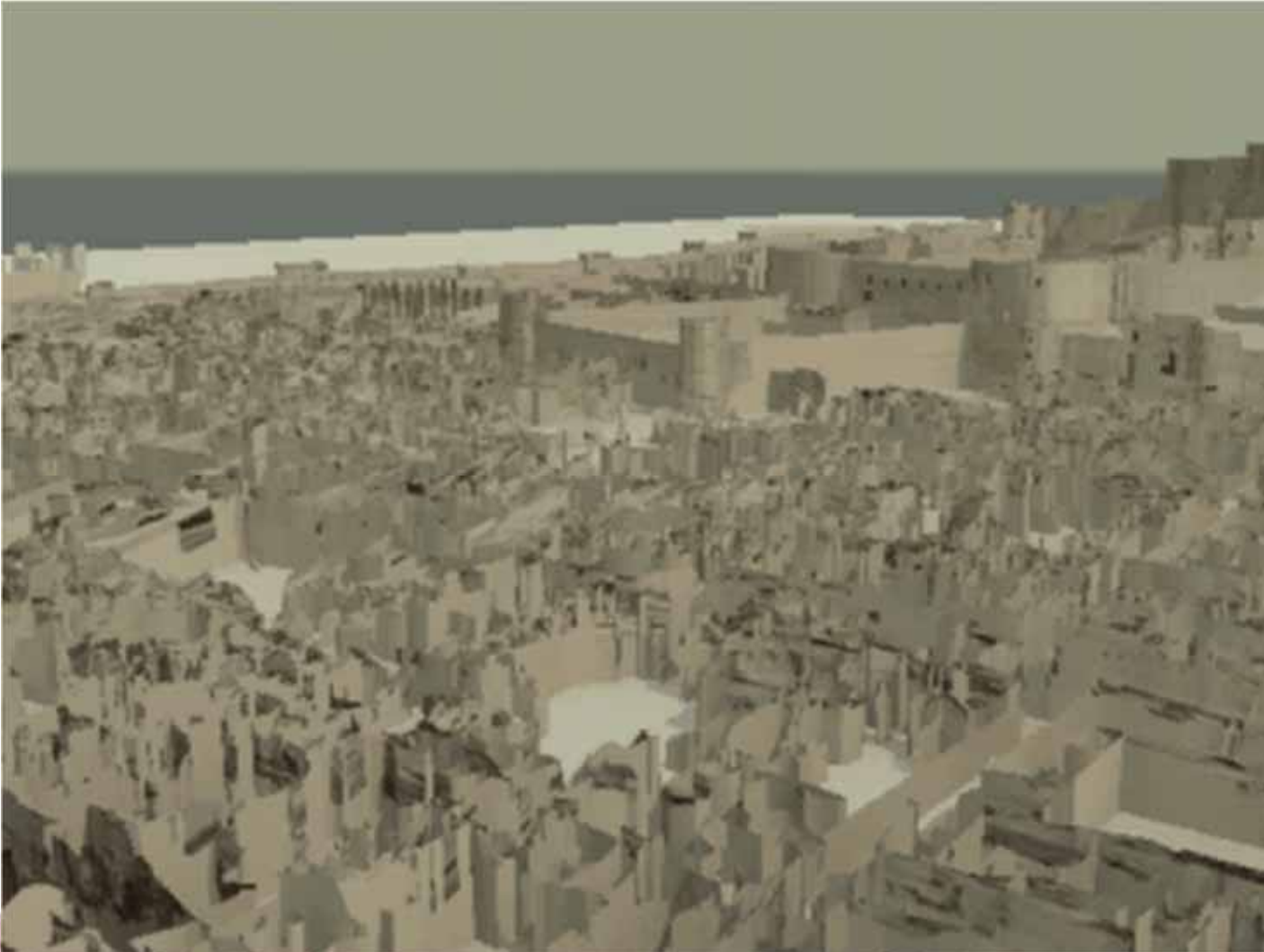
3D Model



General View of Bam (1)



General View of Bam (2)



Discussion

- A 3D model of the city was created quickly by integrating structure and texture.
- Surface of the photogrammetric map was added as wall, roof, slope and flat ground. This needs better interpretation of splines.
- Photograph registration requires a costly semi-automatic process. This needs more powerful automated tools.



Future Work

- Improve surface by characterizing splines.
- Improve texture by generating more realistic texture using context or database.
- Calibrate the variation of illumination in multiple photographs taken at different times.
- Combine results of automatic, semi-automatic, and manual methods to a city-scale 3D model.



Acknowledgment

The supporting research project, 3D CG reconstruction of the Citadel of Bam is a collaborative project between Digital Silk Road Project of NII and Iranian Cultural Heritage, Handicraft and Tourism Organization (ICHHTO). The 3D photogrammetric material is provided to NII by Professor Chahryar ADLE from CNRS and ICHHTO.

- Digital Silk Road Project
 - <http://dsr.nii.ac.jp/>
- Bam Project
 - <http://dsr.nii.ac.jp/bam/>
- Bam3DCG
 - <http://dsr.nii.ac.jp/Bam3DCG/>

