APPLICATIONS OF OPEN AND FREE SOFTWARE: FROM UNDERWATER TO THE SKY

D. Skarlatos, S. Kiparissi

ISPRS Working Group V/2 Conference,
"Cultural heritage data acquisition and processing"
17th –19th August 2011 - University of York, UK

Why don't we use commercial s/w

- Expensive respectively
  - Sometimes they are over-complicated to justify their price tag
- Cannot be customized
  - like GIS packages, so they are black boxes…
- Portability issues
  - Common heritage recording workflow
  - Inexperienced personnel trained once
  - Direct exploitation of data by final user
- Its "strange" to use 25K € s/w for simple tasks

Free Web Services Available

- ARC 3D Webservice
  - A Family of Web Tools for Remote 3D Reconstruction (http://www.arc3d.be/)
  - EPOCH – European Network of Excellence in Open Cultural Heritage (http://www.epoch-net.org)
- Microsoft Photosynth
  - http://photosynth.net/
- Autodesk Photofly
  - http://labs.autodesk.com/technologies/photofly/

So, why don't we use them ?

- Image copyright issues
  - Archaeologists do not like to share their precious photos
- Completely black box
  - No customization
  - No parameterization

End users (ie archaeologists) want a

-CHEAP

-VERSATILE

-EASY TO USE,

-UNIVERSAL solution

...with data they can access by themselves without elaborate s/w

Standard Photogrammetric Workflow

- Image pre-processing
- Camera calibration
- Bundle adjustment
- Image matching
- Surface reconstruction
- Orthophoto production
- Mosaicking
- ~~3D~~ or 2D plotting
- Structured light scanners

- Imagemagick, GIMP, IrfanView
- OpenCV, GML, Matlab Toolboxes
- SIFT, SBA, Bundler
- CMVS & PMVS
- Meshlab, Scanalyze
- ZPR, and our own extension
- Smartblend, Enblend, Hugin
- VeCAD
- David Laser scanner

Image Pre-processing

- Common a decade ago
  - when scanned photos were still in use…
- SLR and digital aerial cameras overcome the necessity for that, as quality boosted
- Still necessary if photographic conditions are not optimal

➢ Irfanview (http://www.irfanview.com/)

➢ GIMP (http://www.gimp.org/)

➢ ImageMagick (http://www.imagemagick.org/script/index.php)

Camera Calibration 1/3

- FAUUCAL (MatLab)

(http://portal.survey.ntua.gr/main/labs/photo/staff/gkarras/fauccal.html)

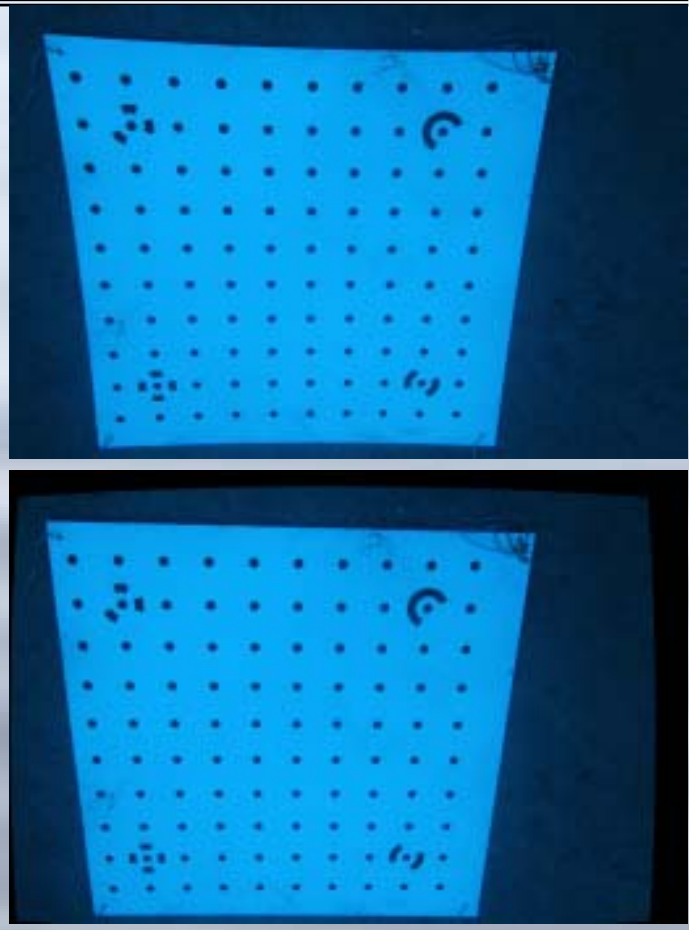
  - V. Douskos, G. Karras et al

- Bouguet calibration toolbox (MatLab) (http://www.vision.caltech.edu/bouguetj/calib_doc/)
  - GML extension (http://graphics.cs.msu.ru/en/science/research/calibration/matlab)
- OpenCV (http://opencv.willowgarage.com/wiki/)
  - Calibration & Undistort functions

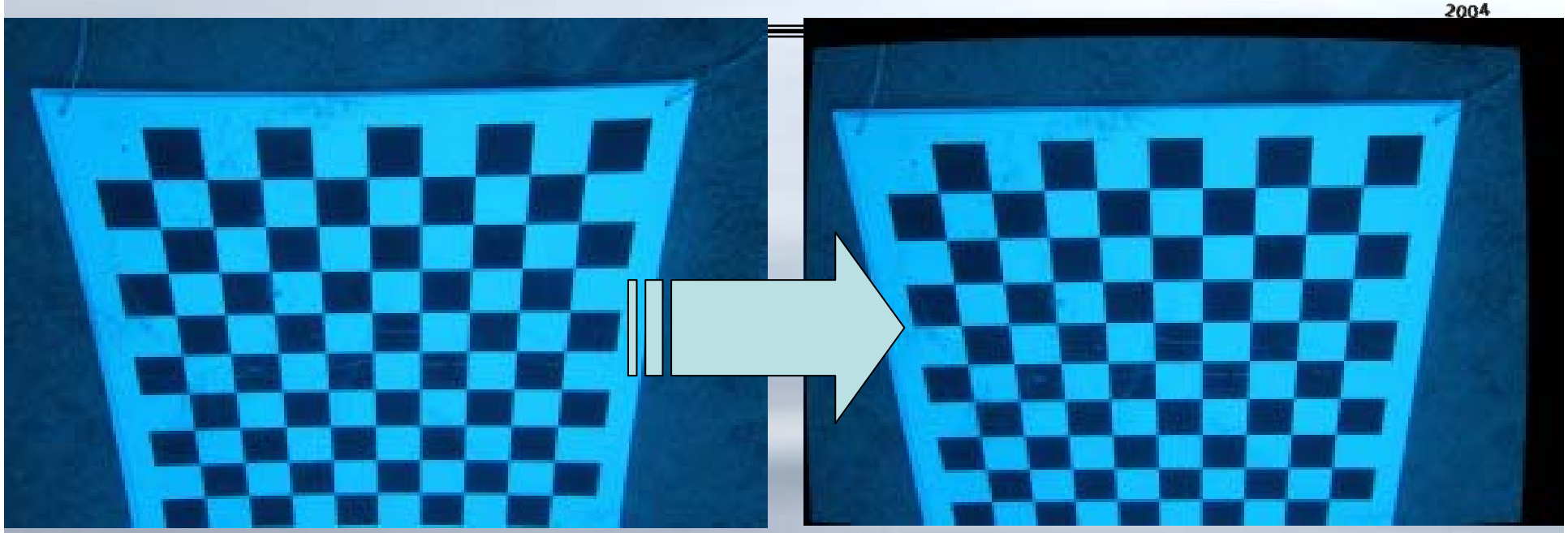
- Octave (www.gnu.org/software/**octave**)
- Open source IDE like Code Blocks (http://www.codeblocks.org/),

Camera Calibration 2/3

- Cheap replacement for full 3D calibration fields
- Planar check boards or similar patterns
- Carefully apply estimated values as corrections on images
  - Different parameters as output
  - Large differences among different solution, even with similar parameters



Camera Calibration 3/3



- Bouguet calibration + OpenCV undistort
  - www.cut.ac.cy/en/staff/dimitrios.skarlatos/
- Pre-processing might be necessary for the s/w to accurately & robustly locate corners
- Post-processing to crop image

Bundle Adjustment

- SIFT – Scale Invariant Feature Transform
  - D. Lowe, 1999. (http://www.cs.ubc.ca/~lowe/keypoints/)
- SURF - Speeded Up Robust Feature
  - Herbert Bay et al., 2006 (http://en.wikipedia.org/wiki/SURF)
- SBA – Sparse Bundle Adjustment
  - Lourakis - Argyros 2009 (http://www.ics.forth.gr/~lourakis/sba/)
  - C/C++ package, GNU-GPL license
- Bundler
  - Bundle adjustment with self calibration of multiple images
  - N. Snavely et al, 2006 (http://phototour.cs.washington.edu/bundler/)
  - C/C++ package, GNU-GPL license

Comments on bundler

- Not all images can be adjusted – experience in coverage & layout issues necessary
- Even worst, images may be adjusted erroneously
  - Therefore, some measures on bundle quality adjustment are necessary
- Very good camera self-calibration
- Simple, fast, with some parameters
- **CAN BE CUSTOMIZED !!!**

CMVS & PMVS

http://grail.cs.washington.edu/software/cmvs/

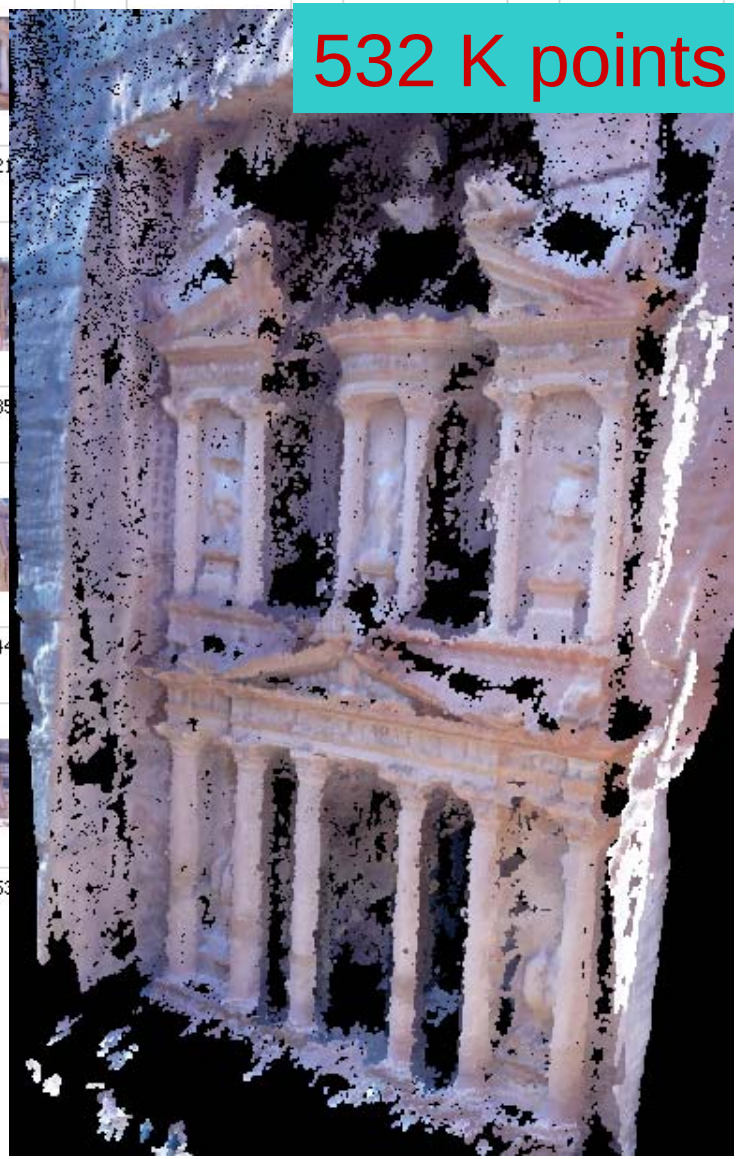
- Multi image matching for dense full 3D color point cloud generation
  - Y. Furukawa and J. Ponce (2009)
  - C/C++ package, GNU-GPL license
- Accepts Bundler solution as input
- Aimed to optimize computer speed & memory, but these factors need to be taken into consideration
- NO moving objects
- NO SCALE on the point cloud
- NO measures of accuracy on 3D points

Examples 1/5

Amphora (#72u@~1m – SONY a350 18mm)

Examples 2/5

Touristic handheld photos (#32/40u@20-60m – Panasonic DMC-LX2 zoom lens)



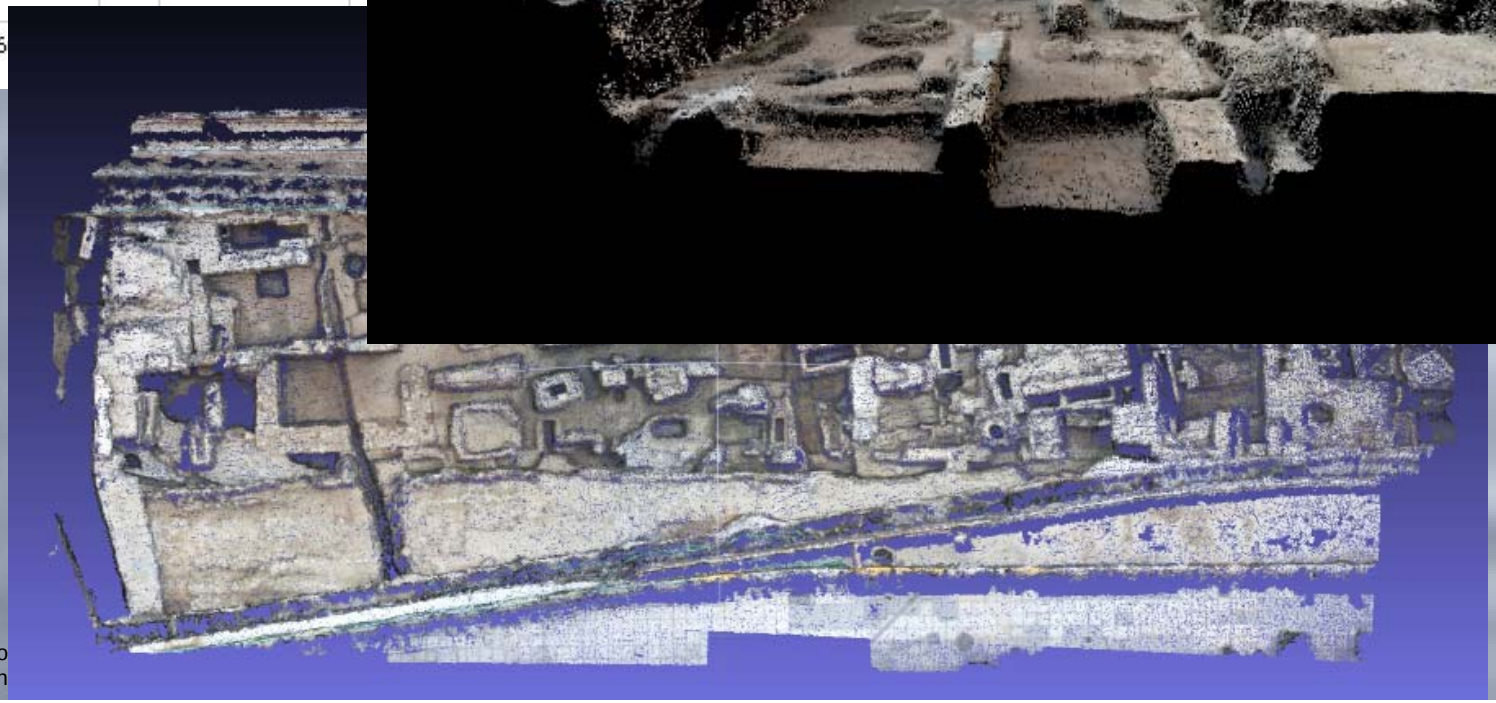
Examples 3/5

Archaeological site recording from RF helicopter (#8u@20m Canon EOS 5D 24mm)


IMG_2679.JPG


IMG_2681.JPG


IMG_26

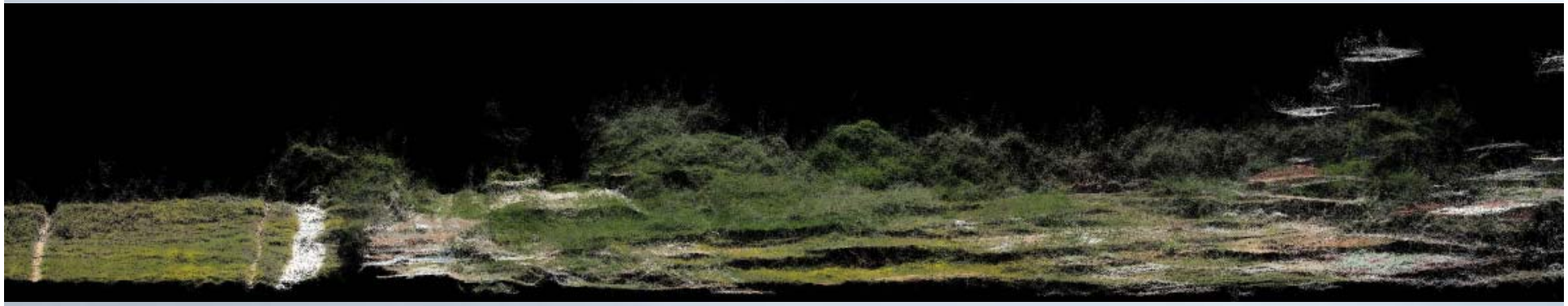


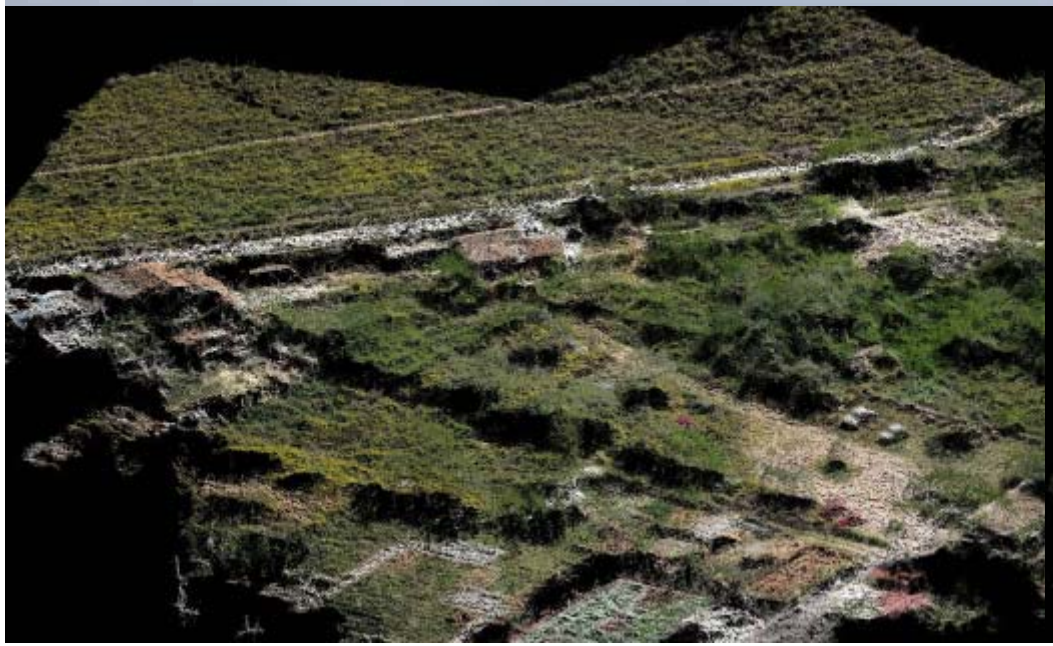
Examples 4/5

UAV Aerial photography (#9u@60m – Canon IXUS 120IS 5mm)

Swinglet airplane UAV

1.13 M points

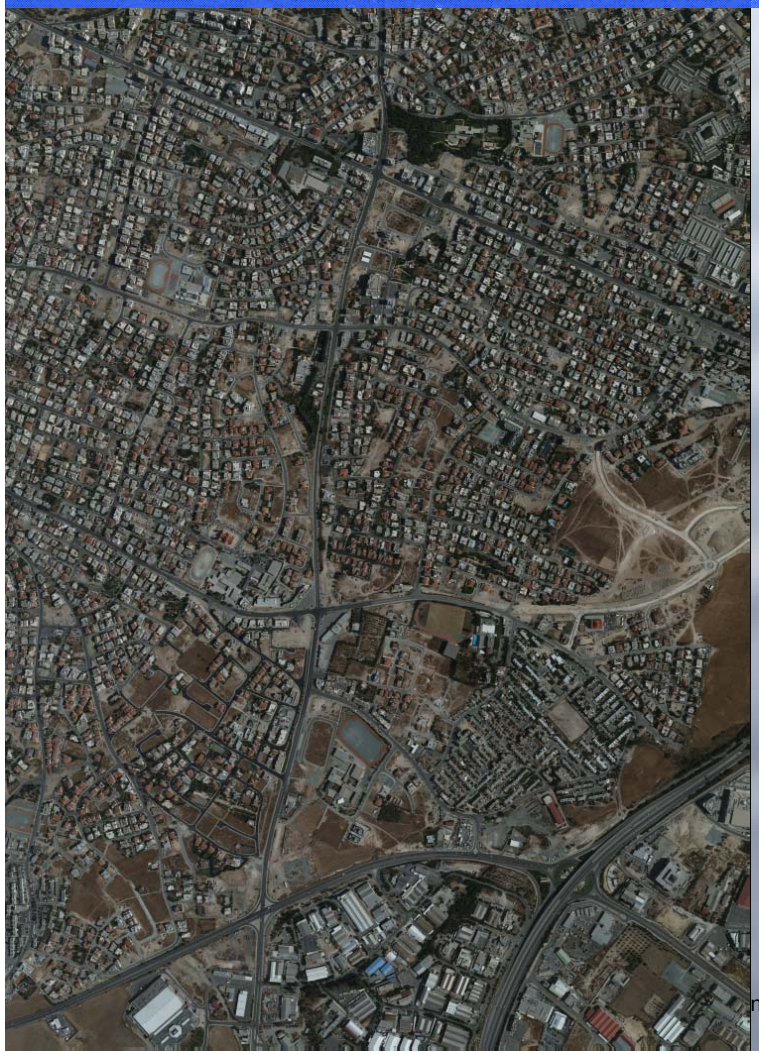




Examples 5/5

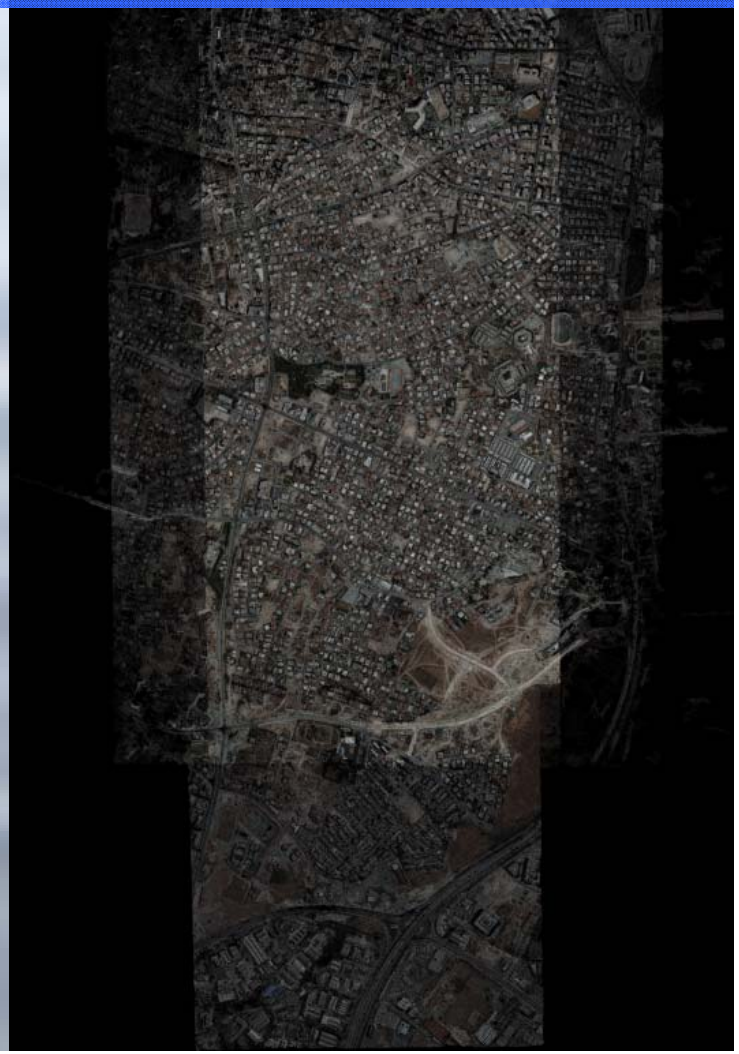
Aerial photos (#6u@2900m - Vexcel 100mm)

3x2 block – 14430x9420 pixels – 80/60% along/across overlap



3.5 M points
(best case)

31 M in total



Surface reconstruction

- Meshlab (http://meshlab.sourceforge.net/)
  - a tool developed with the support of the 3D-CoForm project
  - GNU-GPL license
  - Excellent import-export features & exceptionally fast viewing facilities
  - In some aspects better that commercial s/w
- Scanalyze (http://graphics.stanford.edu/software/scanalyze)
  - a system for aligning and merging range data
  - GSL-BSD license

Orthophoto production

- ZPR (http://zpr.sourceforge.net/)
  - by S. Natsis, 2007, diploma thesis at NTUA
  - Assigns colors to laser scanner point clouds and orthographicaly projects the point cloud to the requested plane.
  - Does not depend on surface reconstruction, hence avoids undercuts easily
  - Simple concept, easy implementation
  - Quality not like orthophotos or wrapped images on meshes
  - Final results, heavily depends on density, many holes
- Our own implementation (www.cut.ac.cy/en/staff/dimitrios.skarlatos/)
  - Based on the previous concept
  - Improved gap filling
  - Using directly multiple color ply files and projects them in the XY plane

Examples of orthophoto from dense color point clouds 1/5

On dense part of the test area (0.2 m pixel size)

Examples of orthophoto from dense color point clouds 2/5

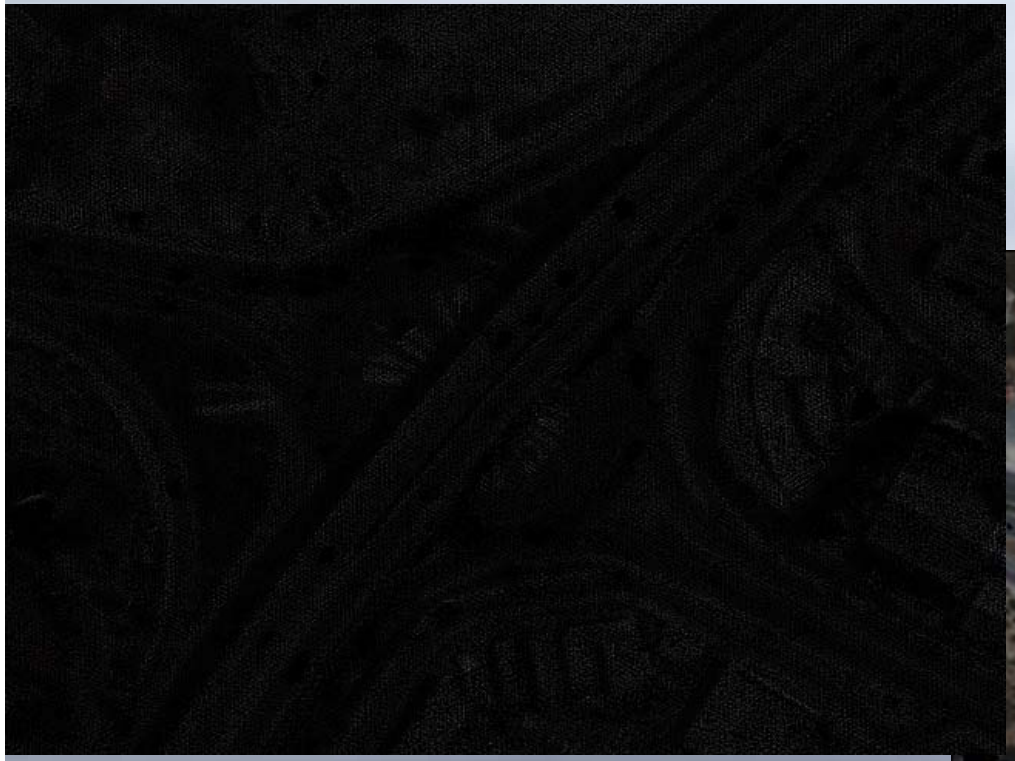
On dense part of the test area (0.2 m pixel size)

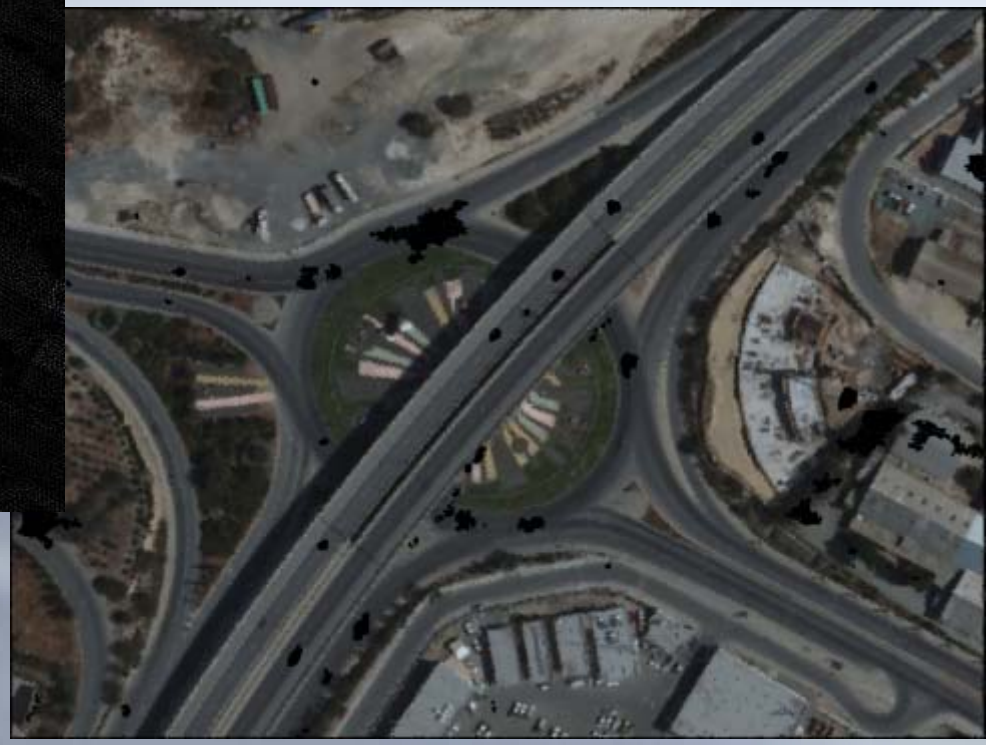
Examples of orthophoto from dense color point clouds 3/5

On dense & coarse part of the test area (0.2 m pixel size)

Examples of orthophoto from dense color point clouds 4/5

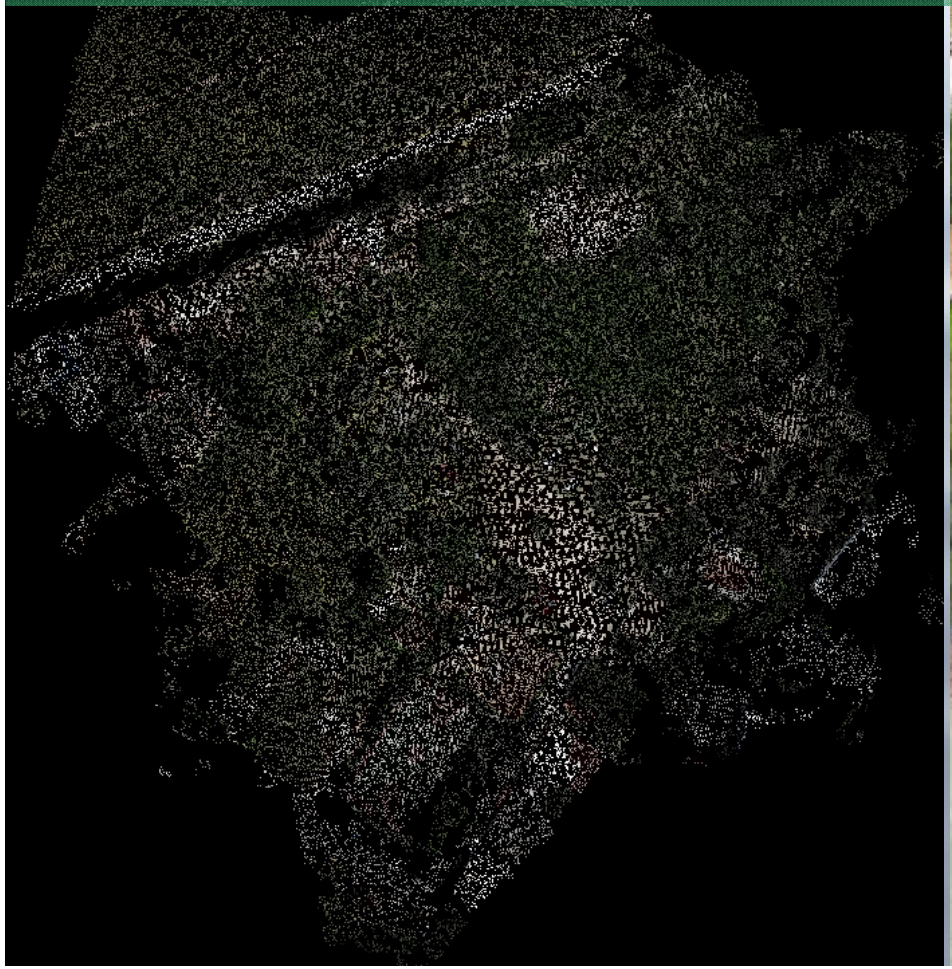
On coarse part of the test area (0.2 m pixel size)





Examples of orthophoto from dense color point clouds 5/5

Swinglet test data (0.05m ortho pixel size - 0.07m original pixel size)



Mosaicking

- Smartblend
  - M. Norel (http://wiki.panotools.org/SmartBlend)
- Enblend/Enfuse
  - http://enblend.sourceforge.net/
- Hugin
  - http://hugin.sourceforge.net/
  - Parameters that are similar to photogrammetry for internal geometry (1+2+3) and "positioning" of images (6)

Direct mosaicking

Orthophoto mosaicking

Scanning of small objects

- David Laserscanner
  - http://www.david-laserscanner.com/
  - Line laser, a web cam and a calibration box
  - Free s/w for scanning
  - Registration at extra cost, but alternative s/w might be used
  - All together ~350€

New troubles or new opportunities ??

Think LINUX

Think Android

Think Google Earth

Think OPEN

Evolve or disappear ?

Thank you