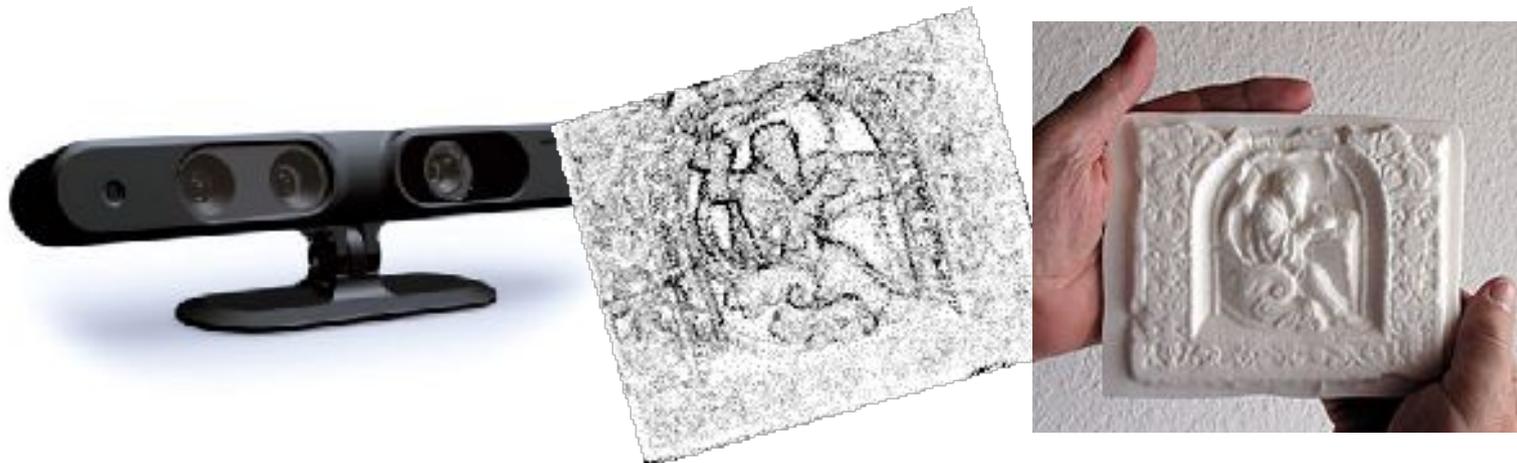


# Scannen mit Digital- und Tiefenkamera - der Workflow bis zum 3D-Druck

*Günter Pomaska*

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# Scanner Technologie

**Laserscanning**

**Time of Flight Kameras**

**Streifenprojektion, Strukturiertes Licht,**

**Tiefenkameras**

**Structure from Motion, Structure from Stereo**

# Laserscanning

**Puls- oder Phasen-Laserscanner**

**Messvolumen 1 – 1000m**

**Genauigkeit 1 - 10 mm**

**Kosten ca. 50 TEuro**



# Time of Flight Kameras

**Laufzeitmessung bis 10m**  
**Genauigkeit im Zentimeterbereich**  
**100 fps 200x200px**  
**CamCube PMD Technologies**  
**Kosten ca. 10TEuro**



# Time of Flight Kameras

**Laufzeitmessung bis 10m**  
**Genauigkeit im Zentimeterbereich**  
**100 fps 200x200px**  
**CamCube PMD Technologies**  
**Kosten ca. 10TEuro**



# Strukturiertes Licht

**Strukturiertes Licht / Streifenprojektion**

**Messvolumen 0 - 3m**

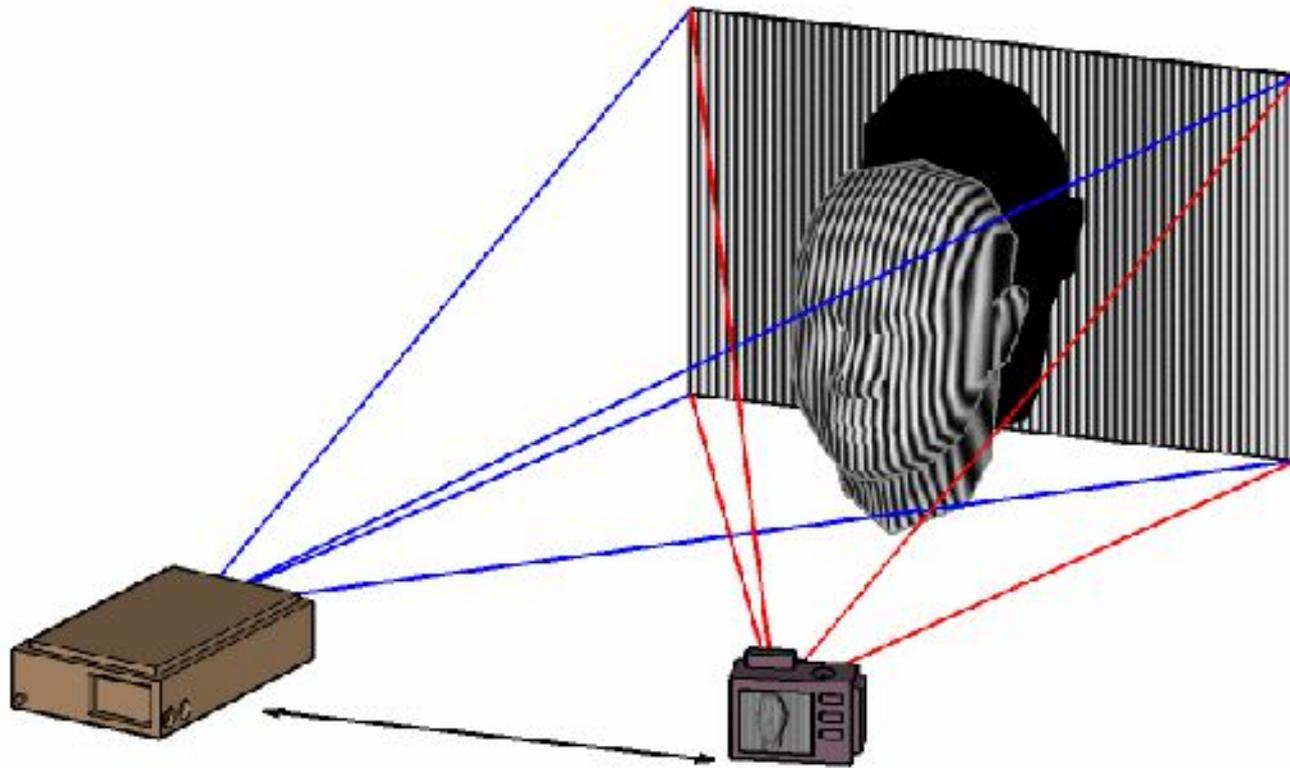
**Genauigkeit 0,3mm – 0,003 mm**

**DAVID, GOM, Breuckmann**

**David ca. 2TEuro, andere um 10TEuro**



# Scannen mit strukturiertem Licht



# Demo DAVID Laserscanner

DAVID-LASERSCANNER Version 3.5.1

Hardwarekonfiguration  
Kamerakalibrierung  
3D Laser-Scannen

Scannen:  
Laserfarbe: Rot

Start Stopp Löschen

Ergebnis-Filterung:  
Interpolation: 4  
Glättung: Median: 2  
Glättung: Mittelung: 0

Zur Liste Speichern

Shape Fusion

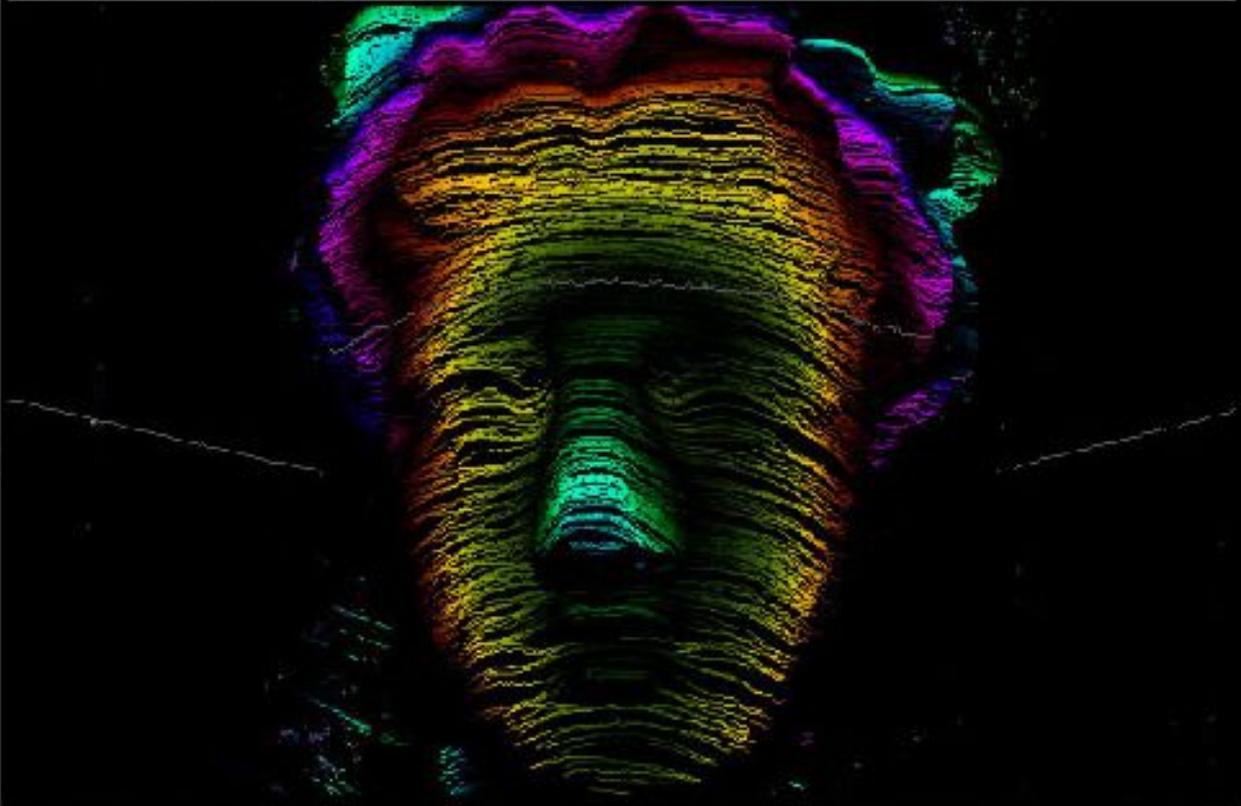
Fliege zu: Alt Live Tiefte Scan  
Sichtbarkeit: Kamera zeigt: Depth Map Update rate:  
Belichtungszeit: 1/756 s  
Scan: Kamerareisigensch.

Einstellungen Hilfe

Scanliste

Scaneigenschaften

Arbeitsverzeichnis  
C:\Dokumente und Einstellur  
Scan.obj  
Scan2.obj  
Scan3.obj



DAVID LASERSCANNER  
LASERLINIE NICHT DETEKTIERT AUF DER LINKEN SEITE

5.1.1

# Tiefenkameras

**Messvolumen 0,4m – 10m**

**Genauigkeit 0,3cm - 1cm**

**Auflösung 640x480px**

**30fps, Realtime Oberflächenvermaschung**

**Primesense, Kinect, Asus Xtion**



# Structure from Motion, Structure from Stereo

**Photogrammetrie, Computer Vision**

**RGB Kamera**

**Flexibles Aufnahmeverfahren**

**ARC 3D, 123DCatch, Photo-to-3D**



# Auswahlkriterien für ein Scanverfahren

**Was soll gescannt werden?**

**Oberfläche, Messvolumen, Bewegung**

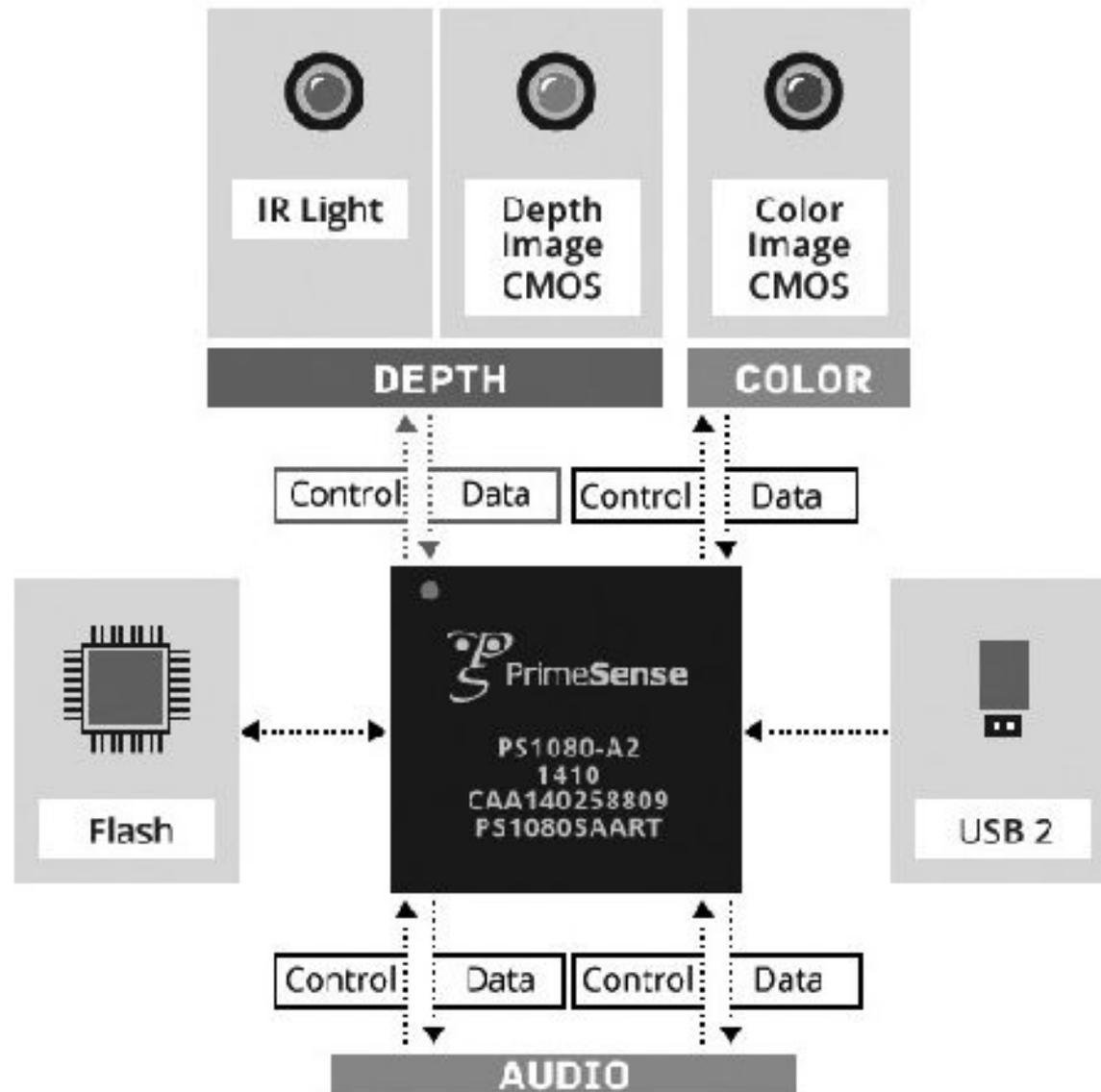
**Tiefengenauigkeit, Auflösung**

**Geschwindigkeit, Umgebung, Lichtverhältnisse**

**Datennutzung CNC, Visualisieren**



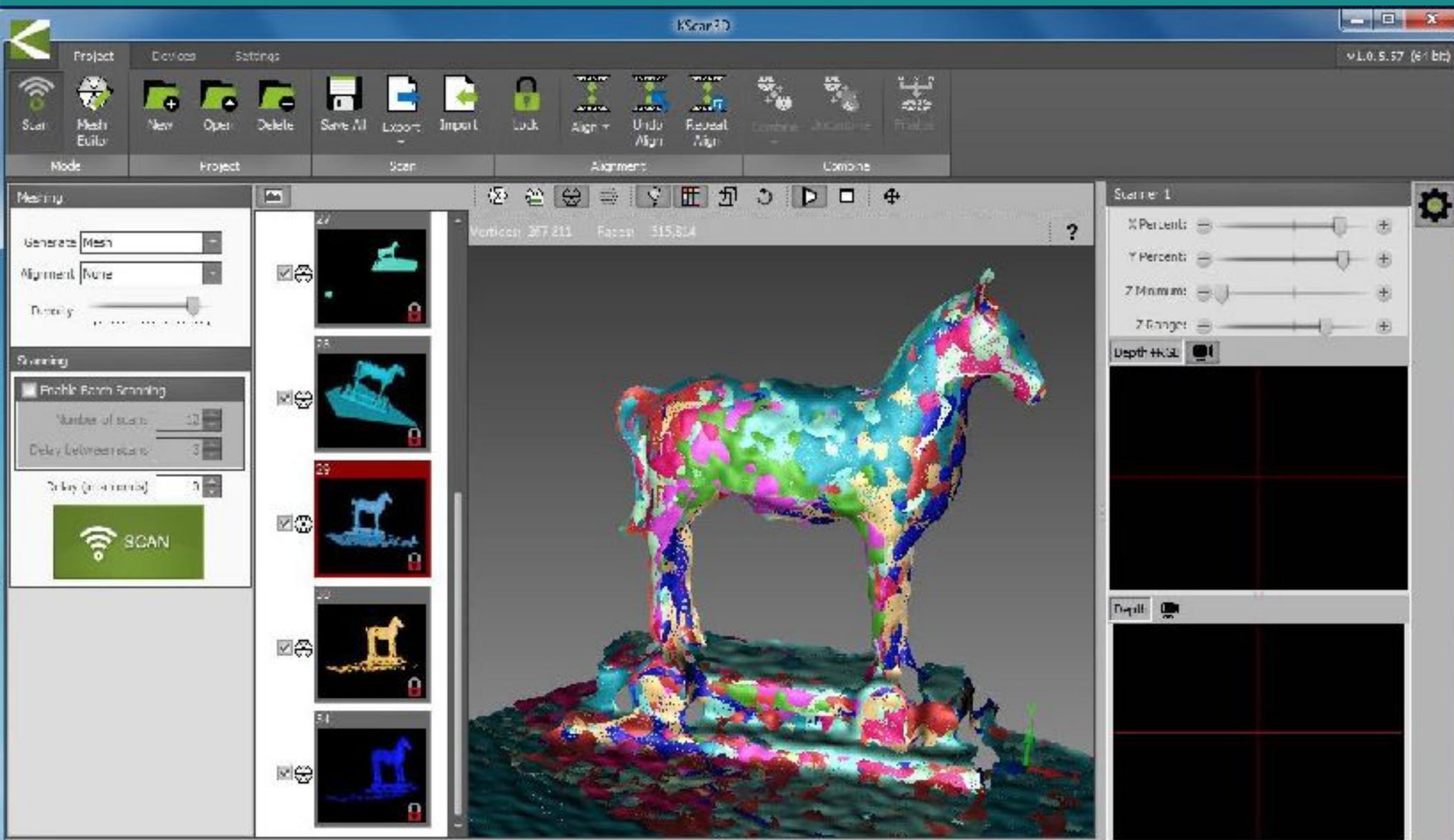
# Scannen mit der Tiefenkamera



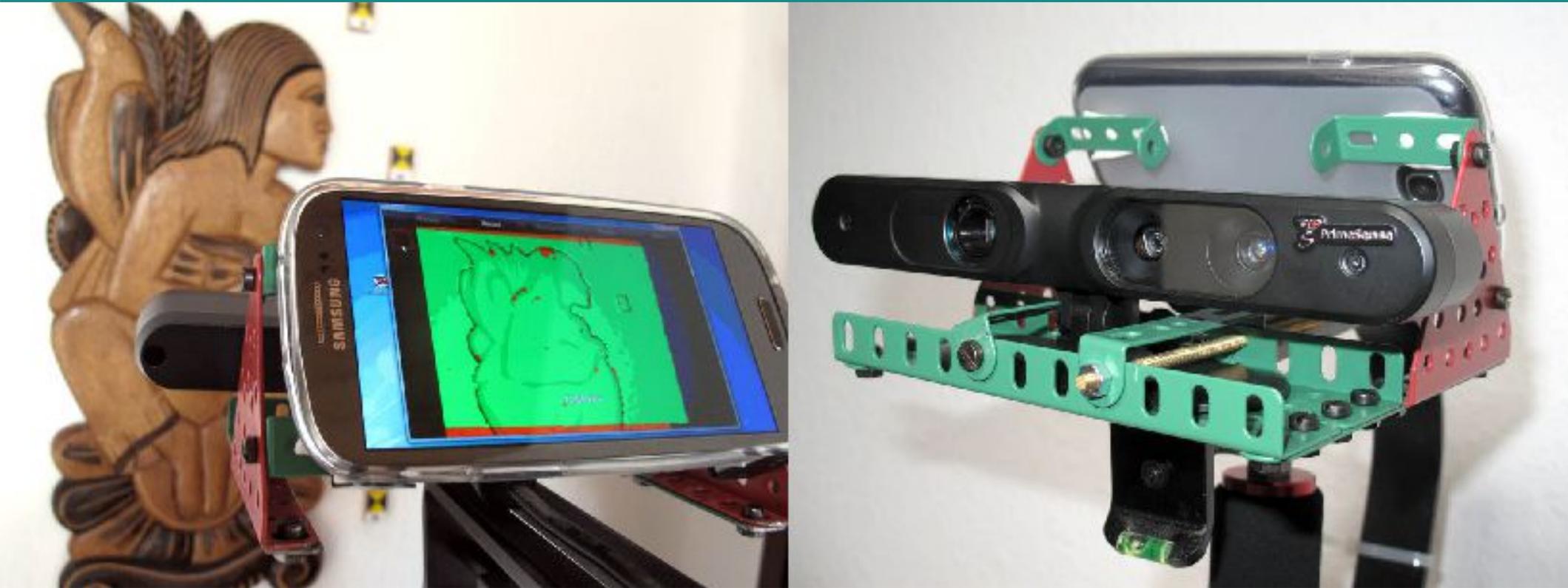
# Infrarot-Tiefenmuster



# Scansoftware für Tiefenkameras



# Steady Cam und Smartphone



**VNC Server – Android VNC Viewer, mobile Hotspot  
USB Verlängerung, Kontrollpunkte zur Skalierung**

# Demo Skanect – KScan3D



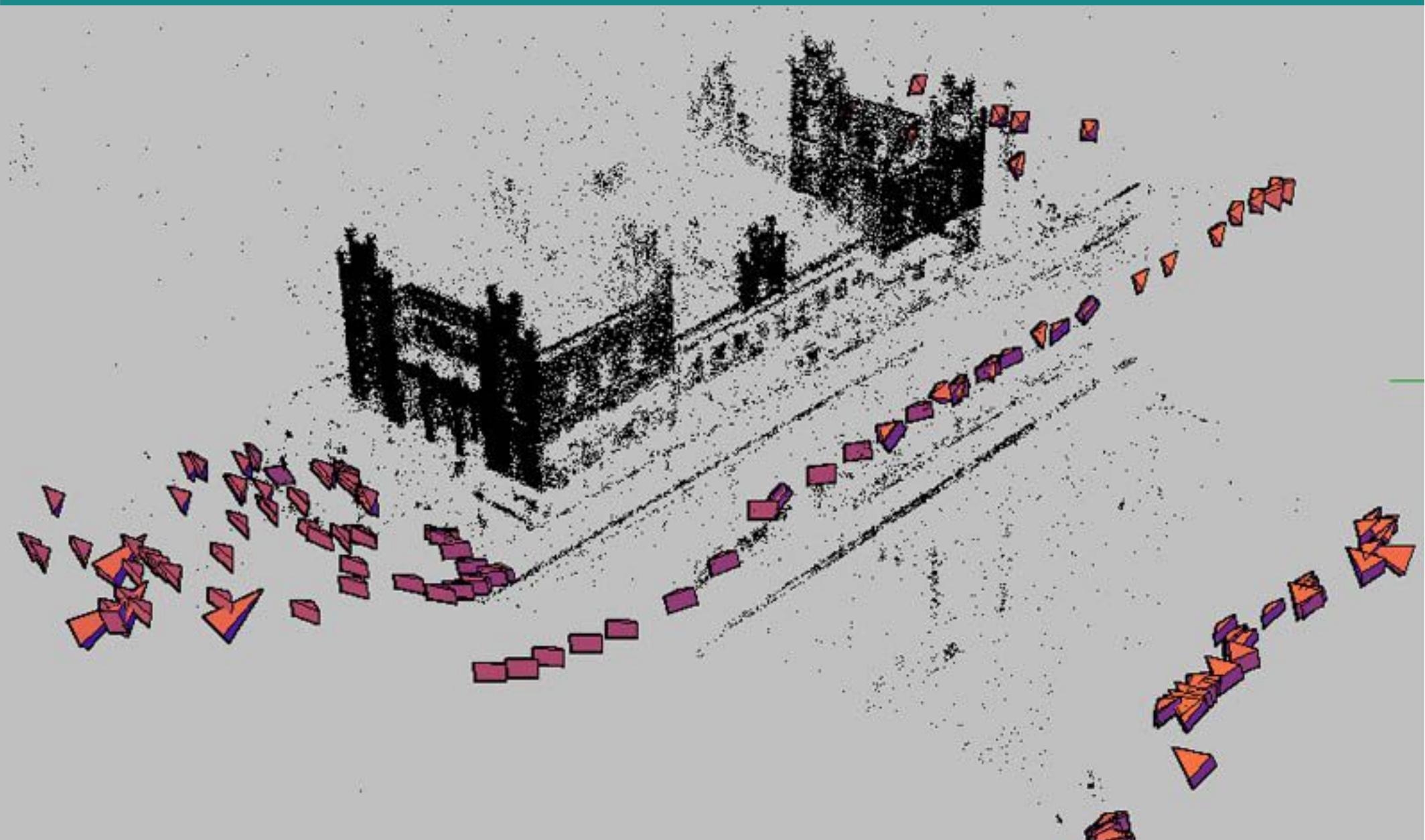
**Vergleich der Tiefenauflösung**

**Primesense Carmine 1.09, Kinect, DCC, WebCam**

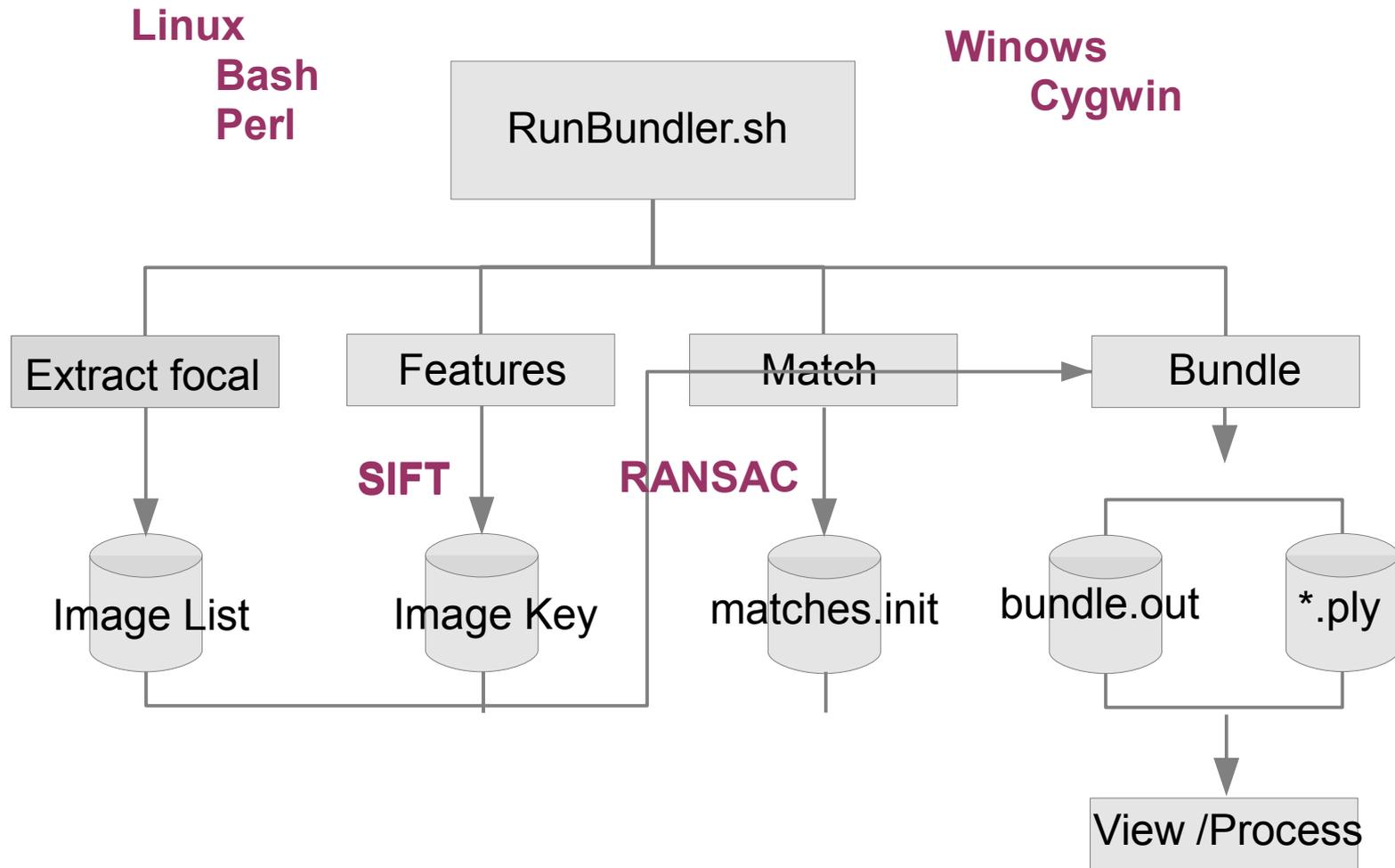
# Structure from Motion SfM

**In Computer Vision wird mit Structure from Motion ein Prozess bezeichnet, der die räumliche Struktur von Objekten aufgrund korrespondierender Merkmale in Bildern erkennt.**

# Structure from Motion SfM



# SFM / Bundler Prozesskette



# SIFT Keypoint Detector

**Scale invariant feature transform SIFT ist ein Algorithmus zur Beschreibung und Erkennung von Merkmalen.**

Autor David Lowe, University of British Columbia, US Patent, 1999.



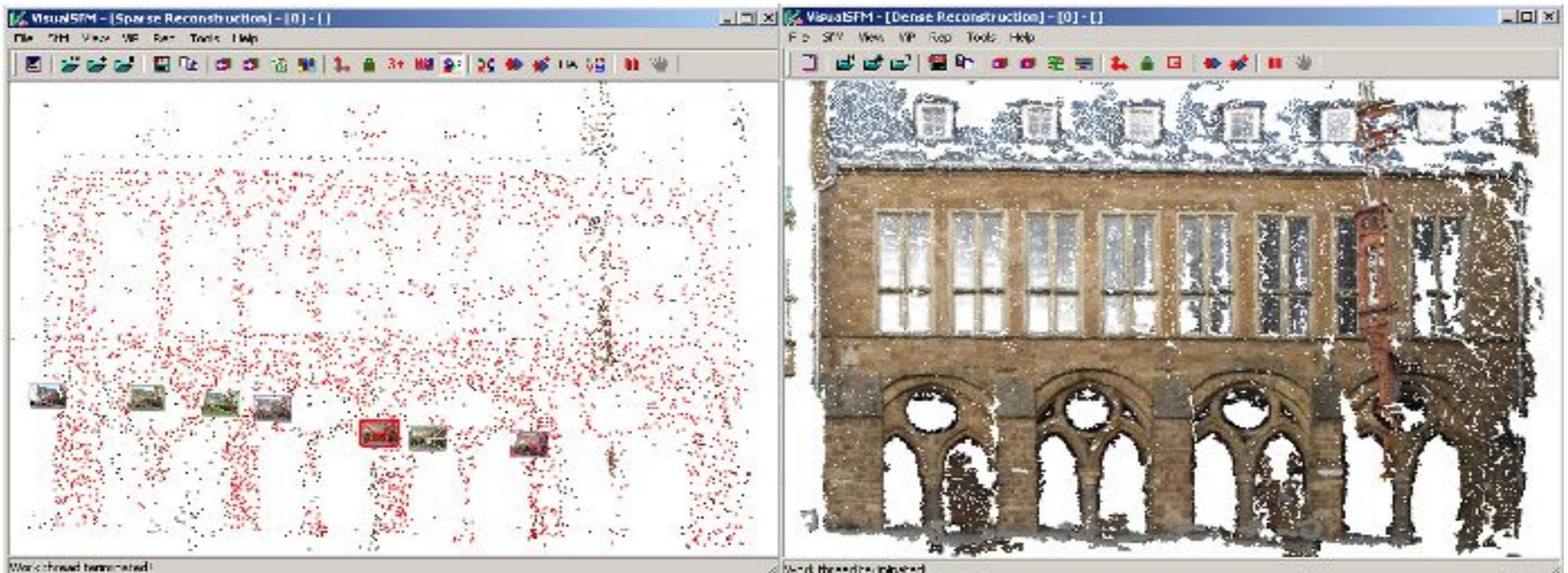
# PMVS / CMVS

**PMVS erzeugt dichtere Punktwolken**

**CMVS Preprocessor für PMVS Clustering**

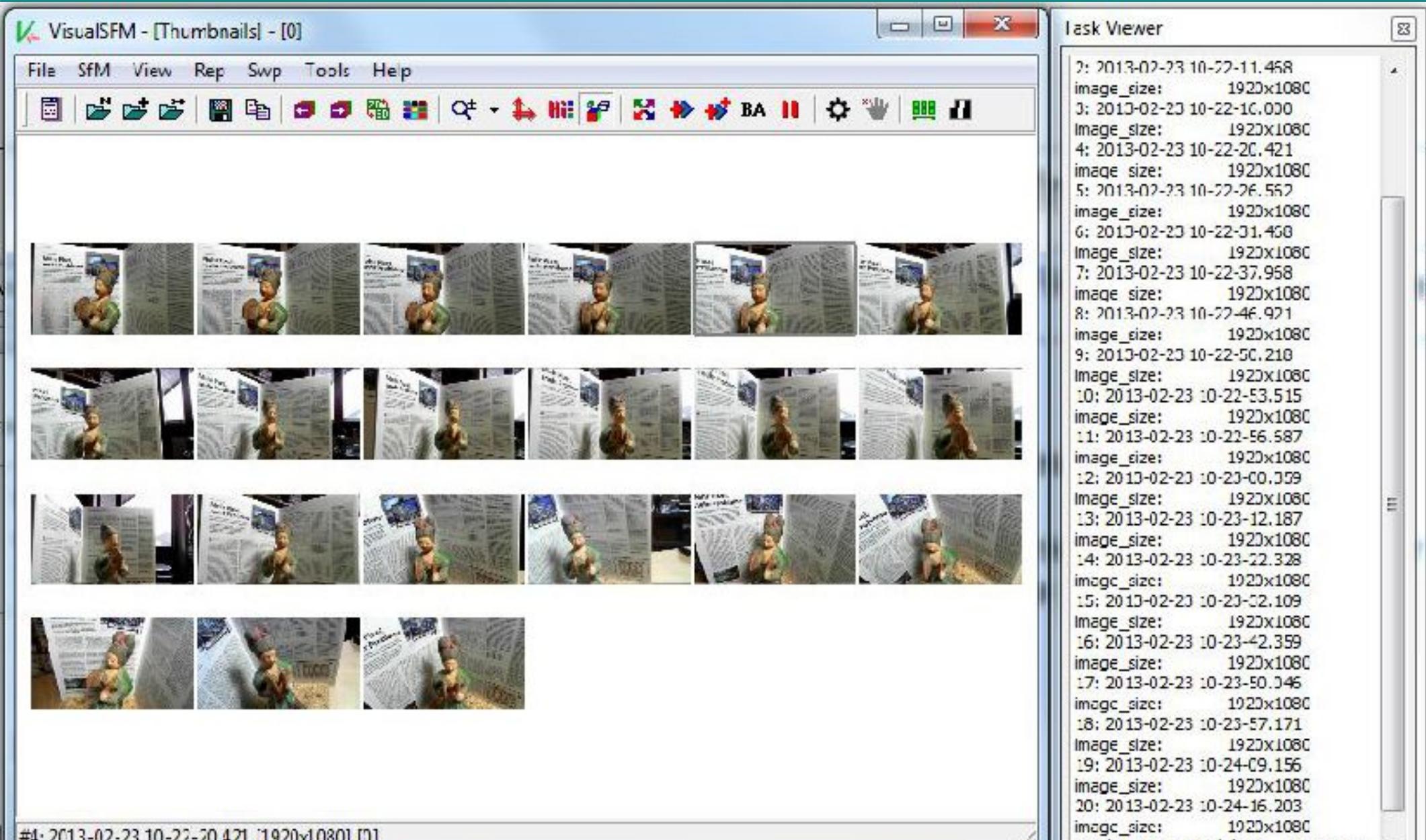
**Visual SfM Windows Version mit GPU Computing**

Chanchang Wu, Yatsuka Furukawa, Univ. Washington





# 3D-Rekonstruktion mit VSFM

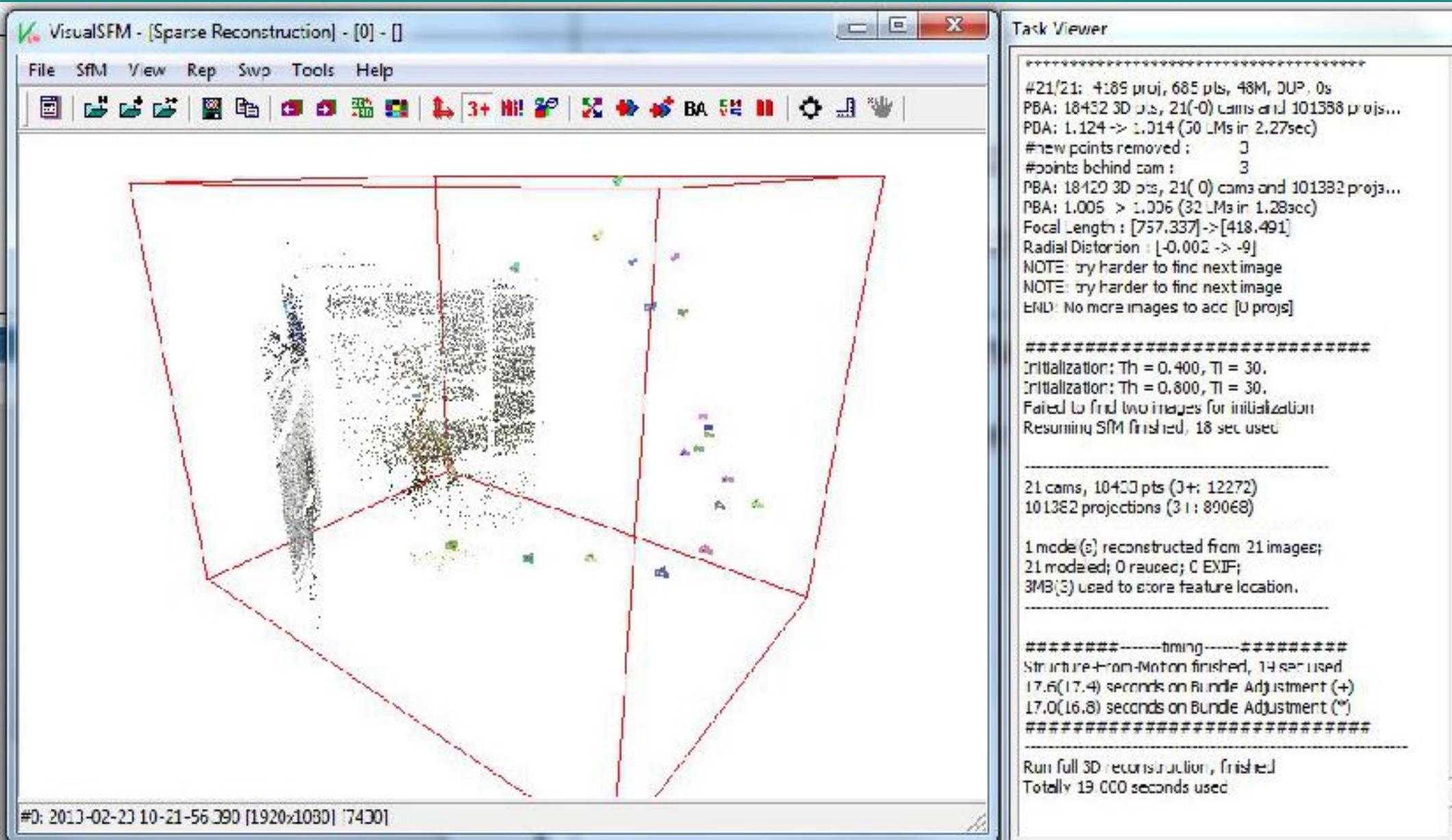


The screenshot displays the VisualSFM software interface. The main window, titled "VisualSFM - [Thumbnails] - [0]", features a menu bar with "File", "SfM", "View", "Rep", "Swp", "Tools", and "Help". Below the menu is a toolbar with various icons for file operations, navigation, and processing. The central area shows a grid of 24 image thumbnails, arranged in four rows and six columns, depicting a scene with a green and brown object on a table in front of a newspaper-covered wall. The bottom status bar shows the file path: "#1: 2013-02-23 10-22-20.421 1920x1080 [0]".

On the right side, a "Task Viewer" panel displays a list of tasks with their corresponding image sizes:

Task ID	Timestamp	Image Size
7	2013-02-23 10-22-11.468	1920x1080
3	2013-02-23 10-22-10.030	1920x1080
4	2013-02-23 10-22-20.421	1920x1080
5	2013-02-23 10-22-26.557	1920x1080
6	2013-02-23 10-22-31.460	1920x1080
7	2013-02-23 10-22-37.968	1920x1080
8	2013-02-23 10-22-46.971	1920x1080
9	2013-02-23 10-22-50.210	1920x1080
10	2013-02-23 10-22-53.515	1920x1080
11	2013-02-23 10-22-56.587	1920x1080
12	2013-02-23 10-23-00.359	1920x1080
13	2013-02-23 10-23-12.187	1920x1080
14	2013-02-23 10-23-22.328	1920x1080
15	2013-02-23 10-23-32.109	1920x1080
16	2013-02-23 10-23-42.359	1920x1080
17	2013-02-23 10-23-50.346	1920x1080
18	2013-02-23 10-23-57.171	1920x1080
19	2013-02-23 10-24-09.156	1920x1080
20	2013-02-23 10-24-16.203	1920x1080

# 3D-Rekonstruktion mit VSFM - Sparse Point Cloud



VisualSFM - [Sparse Reconstruction] - [0] - []

File SfM View Rep Swp Tools Help

Task Viewer

```
*****
#21/21: 4:85 proj, 685 pts, 48M, DUP, 0s
PBA: 18432 3D pts, 21(-0) cams and 101388 proj...
PDA: 1.124 -> 1.014 (30 LMs in 2.27sec)
#new points removed :      3
#points behind cam :      3
PBA: 18429 3D pts, 21( 0) cams and 101382 proj...
PBA: 1.005 -> 1.006 (32 LMs in 1.28sec)
Focal Length : [757.337] -> [418.491]
Radial Distortion : [-0.002 -> -9]
NOTE: try harder to find next image
NOTE: try harder to find next image
END: No more images to acc [0 proj]

*****
Initialization: Th = 0.400, TI = 30.
Initialization: Th = 0.800, TI = 30.
Failed to find two images for initialization
Resuming SfM finished, 18 sec used

-----
21 cams, 10450 pts (3+: 12272)
101382 projections (3+: 89068)

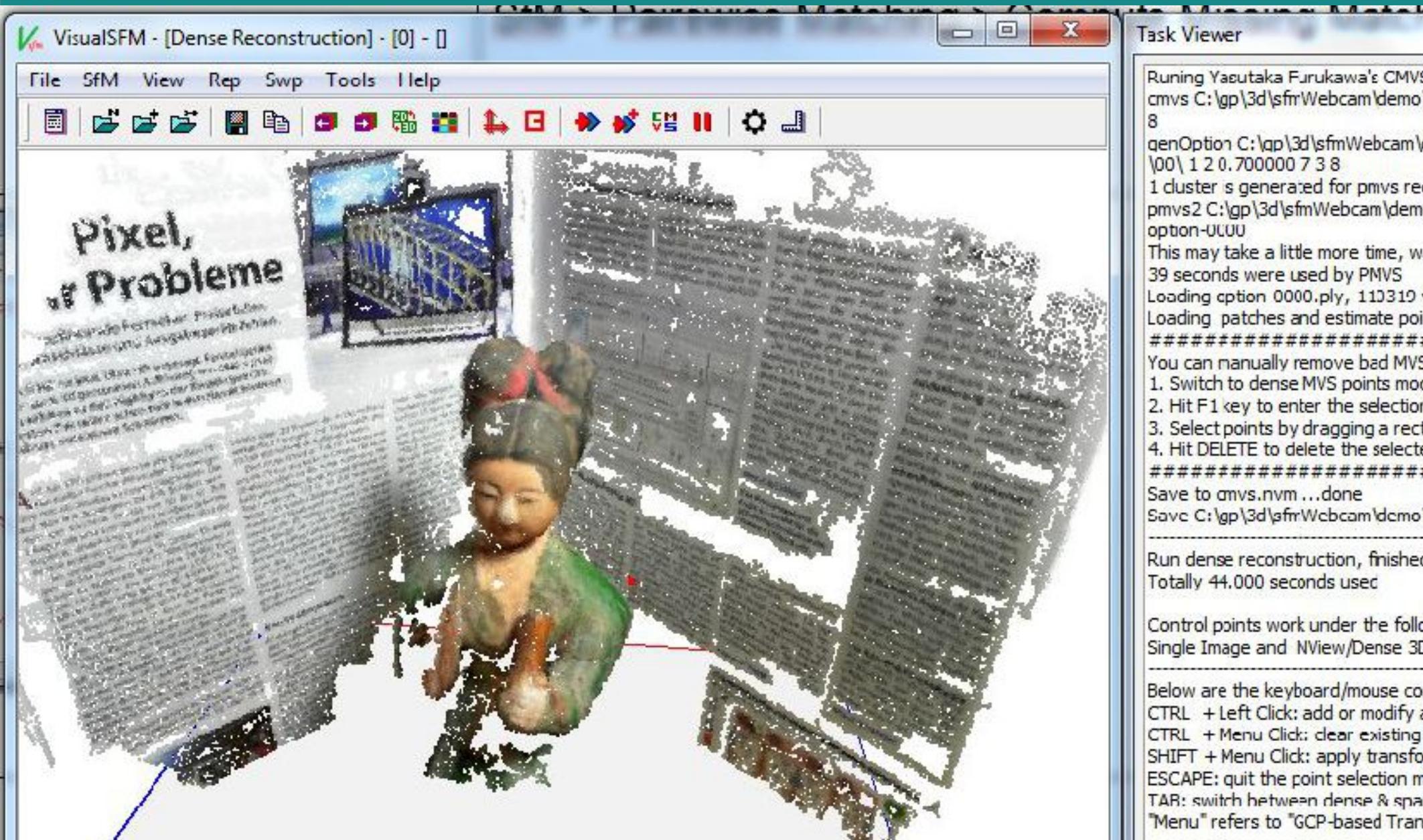
1 mode(s) reconstructed from 21 images;
21 mode(s); 0 reuse(s); C EXIF;
3MB(s) used to store feature location.

-----
*****-----timing-----*****
Structure-from-Motion finished, 14 sec used
17.6(17.4) seconds on Bundle Adjustment (+)
17.0(16.8) seconds on Bundle Adjustment (*)
*****

Run full 3D reconstruction, finished
Totally 13 000 seconds used
```

#0: 2013-02-23 10:21:56 390 [1920x1080] 74301

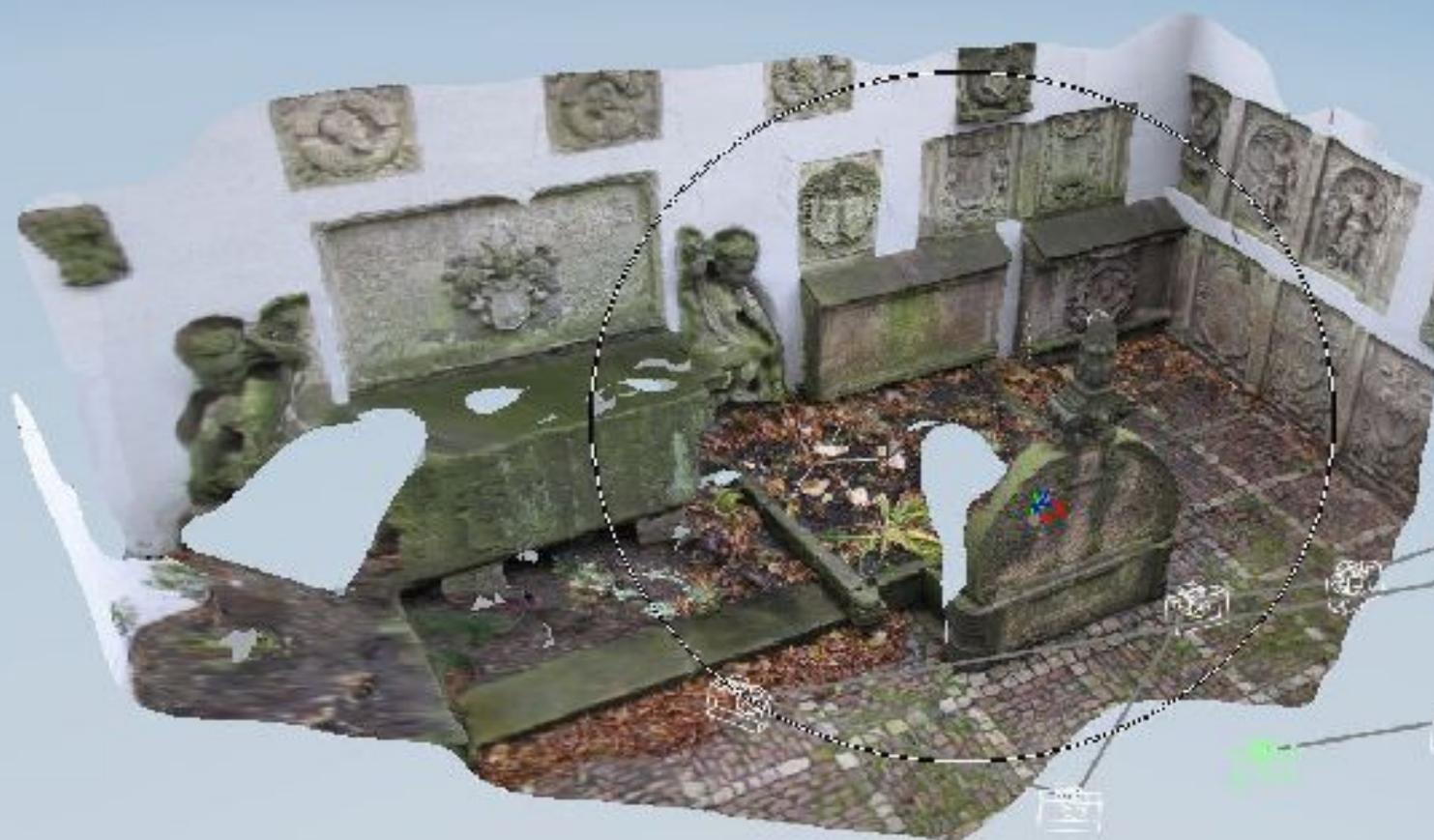
# 3D-Rekonstruktion mit VSFM - Dense Point Cloud



# Online Service 123DCatch

Autodesk 123D Catch - Capture\_2012\_11\_08\_12\_48\_34

File Edit View Manipulate Help

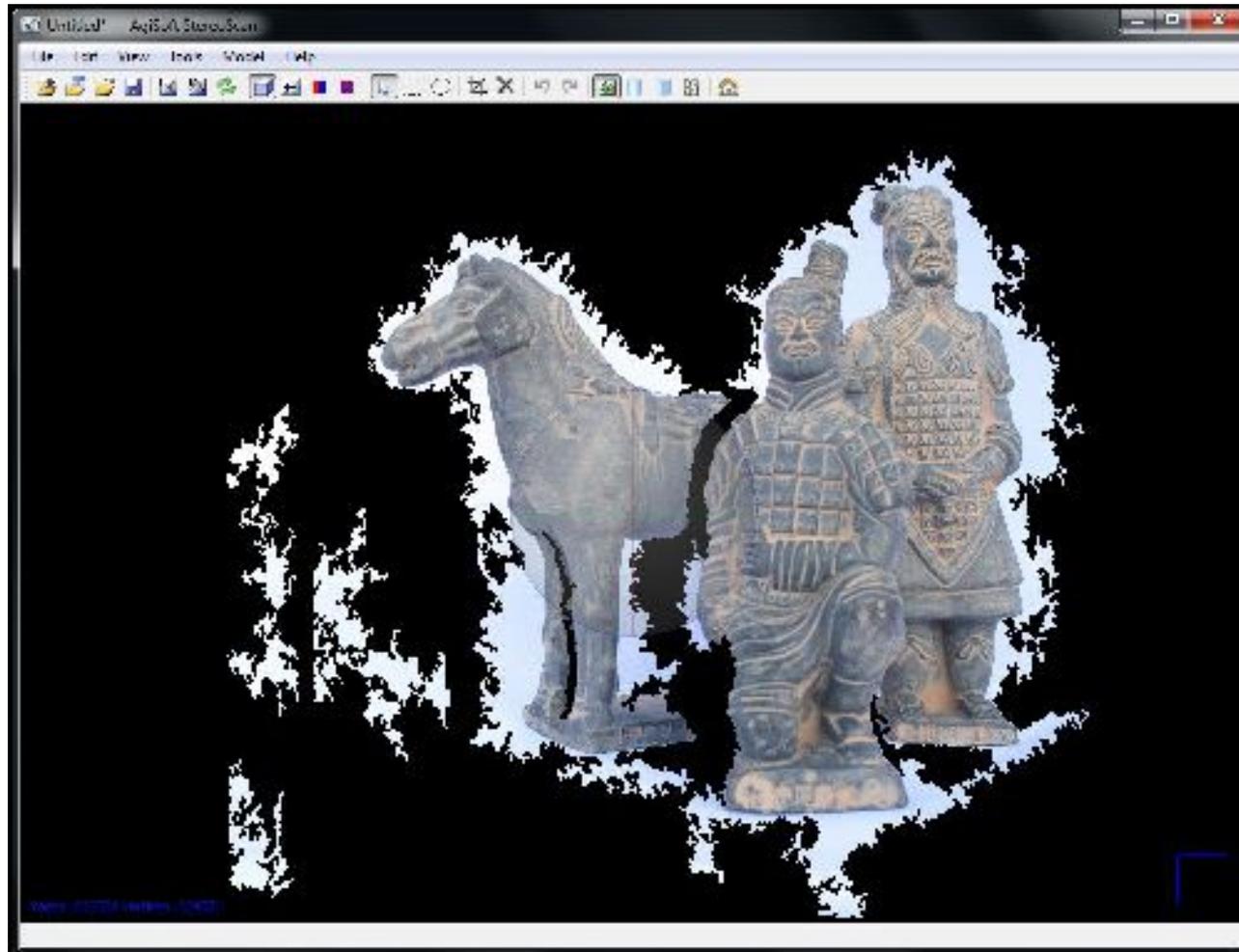


# Structure from Stereo



[ [www.agisoft.ru](http://www.agisoft.ru) | [www.photo-to-3d.com](http://www.photo-to-3d.com) ]

# AgiSoft StereoScan



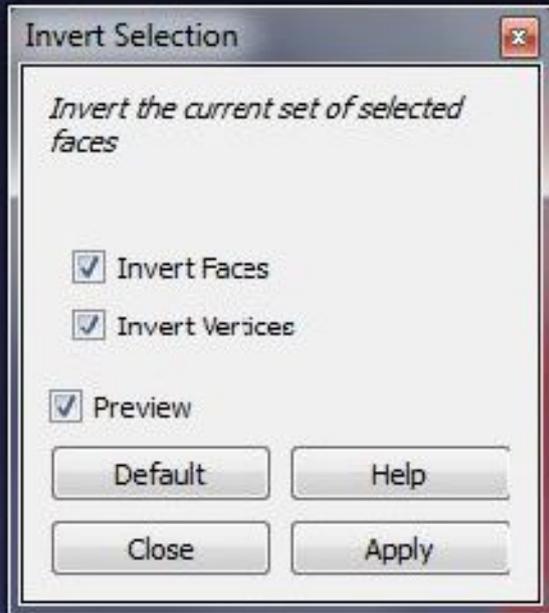
[ c:/programme/AgiSoft/samples]

# Mit Meshlab von der Punktwolke zur Oberfläche

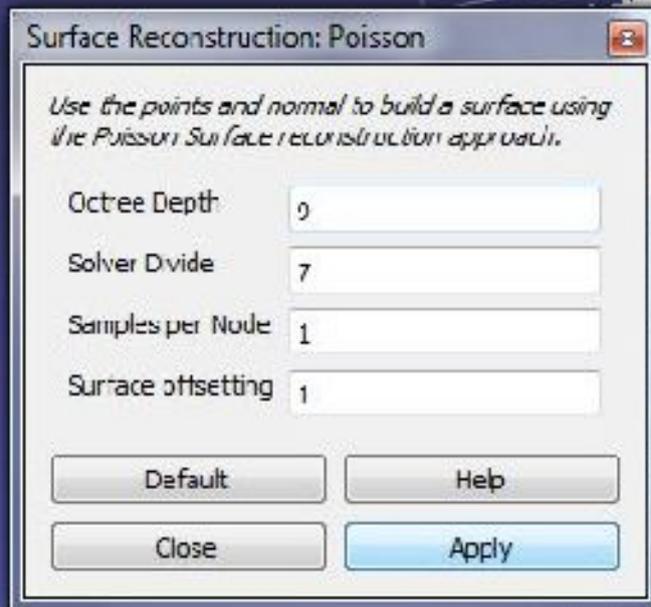


**Bereinigen der Punktwolke**  
**Poisson Surface Rekonstruktion**  
**Oberfläche reduzieren, glätten**  
**Alignment / Registrieren**  
**Textur übertragen**

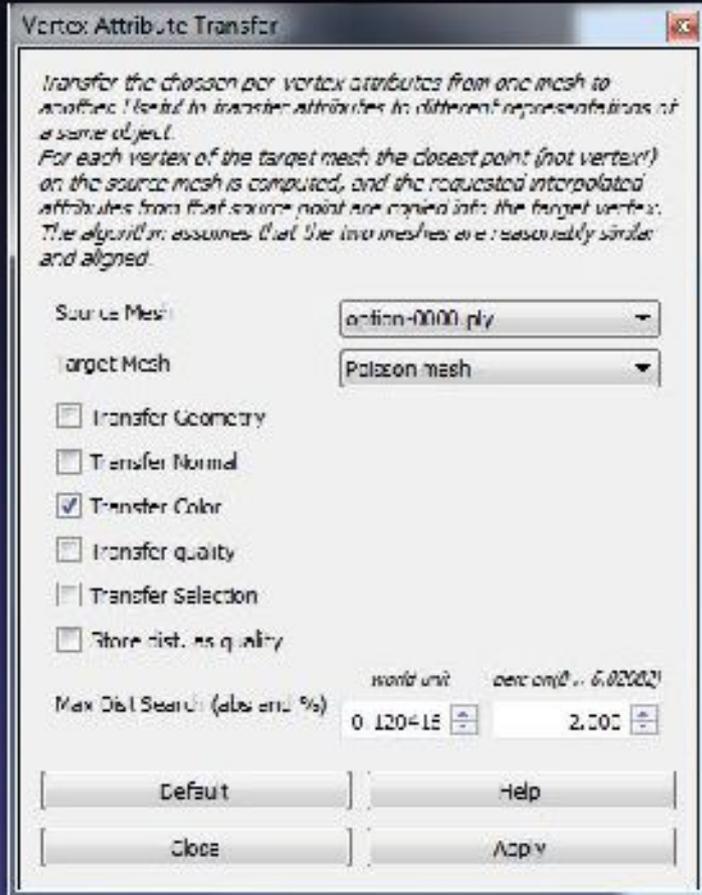
# Meshlab Delete / Merge Reduktion 0,5Mio Punkte



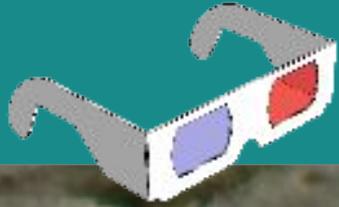
# Meshlab Oberflächenrekonstruktion

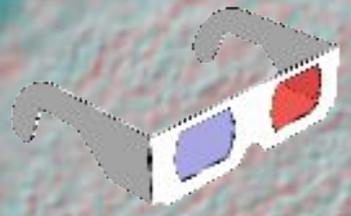


# Meshlab Attributtransfer



# Meshlab 3D-Oberfläche





# 3D Drucker Werkzeuge

**ReplicatorG - GCode Viewer**

**Meshmixer**

**123DPrint**

**Makerware**

**Netfabb Studio**

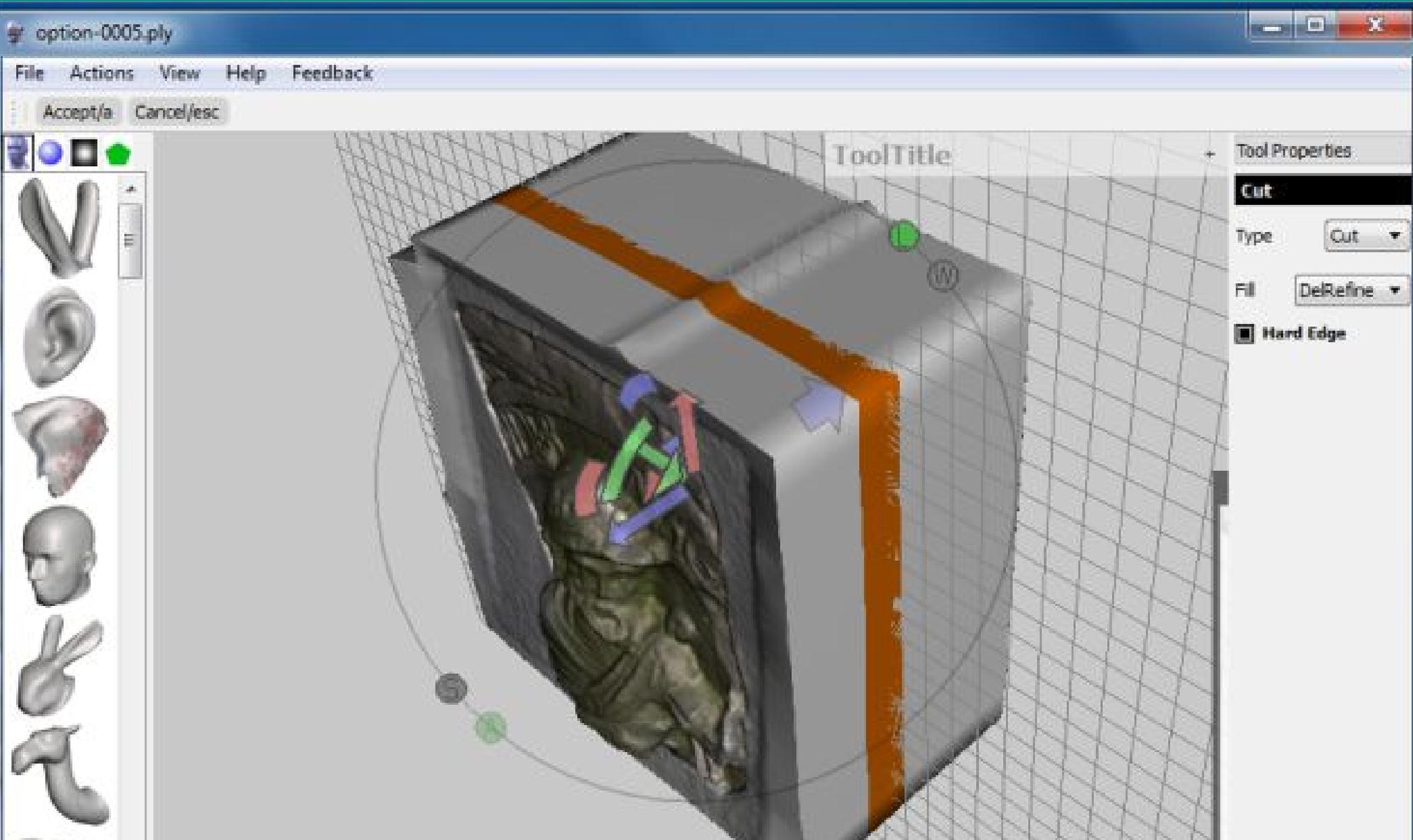
# 3D Drucker Werkzeuge

**Meshmixer: Korrektur, Solid  
(123DPrint: Latest)**

**Makerware: Positionierung, Skalierung**

**Netfabb Studio: STL Output**

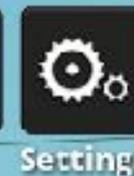
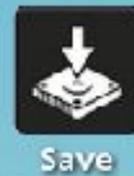
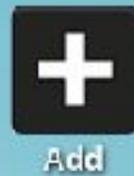
# Meshmixer von der Oberfläche zum Solid



# Makerware - Skalierung, Transformation

782 - Capture\_2013\_06\_22\_12\_42\_45.vrml - MakerWare

File Edit View MakerDots Services Help



Look (L)



Move (M)



Turn (T)



Scale (S)

## Change Dimensions:



X: 183,06mm



Y: 39,10mm



Z: 145,00mm

Scale To: 100,00%

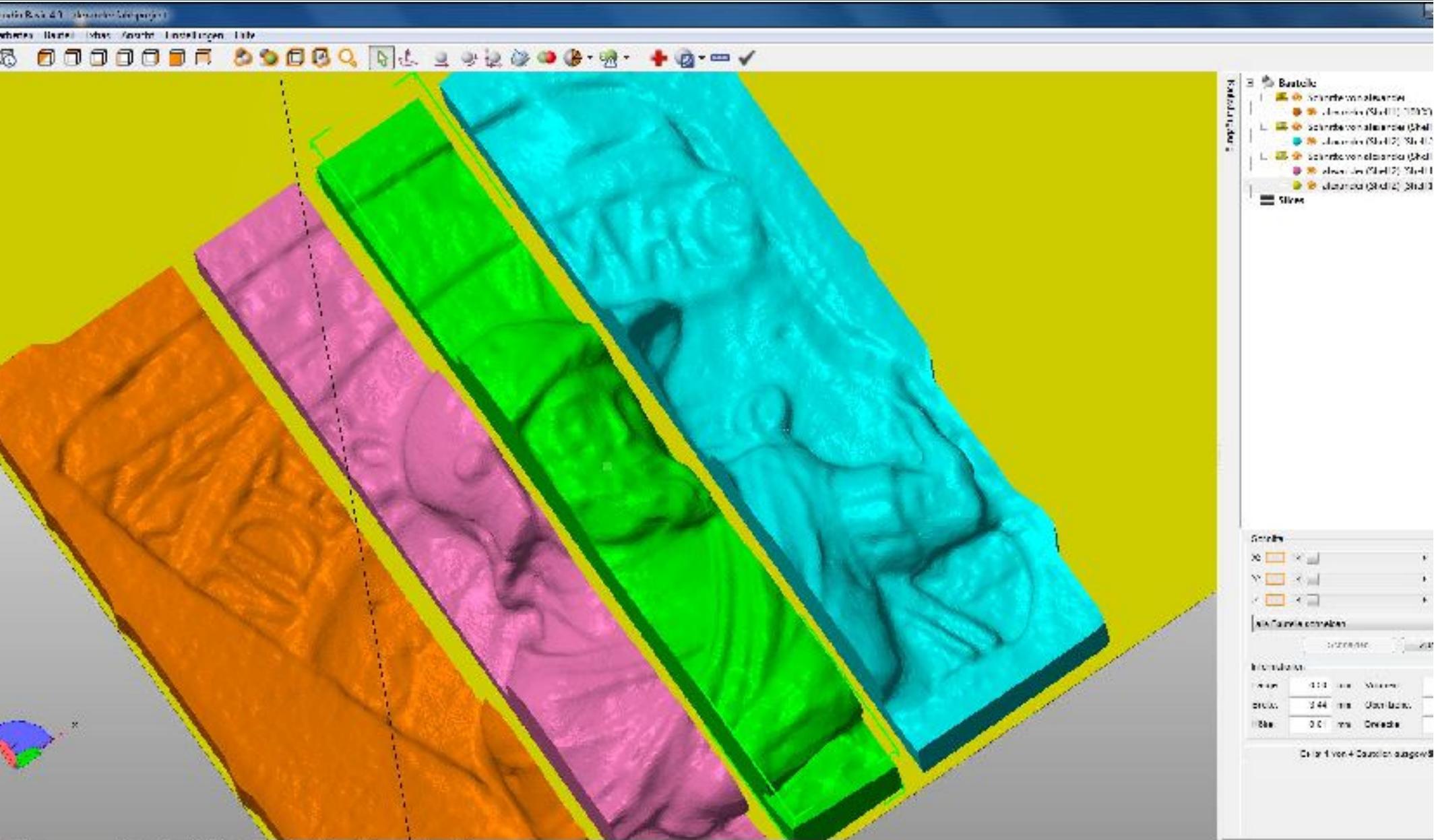
Uniform scaling

Inches -> mm

Maximum Size



# Netfabb Studio - Sclicing Tool & Repair



# Sketchfab.com das YouTube fer 3D-Modelle

The screenshot shows the Sketchfab.com dashboard. At the top, there is a navigation bar with the Sketchfab logo, user information (gp), and a search bar. Below the navigation bar, the main content area is titled "Your Dashboard" and features a prominent "UPLOAD A MODEL" button. The dashboard is organized into several sections:

- RECENT**: A grid of six 3D model thumbnails. The first row includes a stone relief, a white horse-like figure, and a dark, textured object. The second row includes a stone relief, a white rectangular object, and another white rectangular object.
- YOUR PROFILE**: A section for the user "gp", who has been a member since November 01, 2012. It includes a link to "Edit your profile" and a list of social media links for YouTube, Facebook, and Twitter.
- STATISTICS**: A summary of the user's activity, showing 6 Models, 93 Views, 985.4k Triangles, and 1 Rec.

# 3D-Druck Online-Service

A hand is holding a clear, rectangular 3D printed part. The part has a complex internal structure with several vertical pillars and a central circular feature. The background is a light-colored, textured surface.

[i.materialise.com](http://i.materialise.com)  
[www.shapeways.com](http://www.shapeways.com)

# Zusammenfassung

**Digital- und Tiefenkameras sind für die 3D-Objektaufnahme geeignet. Genauigkeit, Oberfläche, Umgebungslicht und Messvolumen bestimmen den Einsatz.**

**RGB-Sensoren wie Smartphone oder DCC mit SfM benötigen eine texturierte Oberfläche bei weniger eingeschränktem Meßvolumen. Primesense Carmine 1.09 bietet für den Nahbereich hinreichende Genauigkeit.**

**Vielen Dank für Ihre Aufmerksamkeit**

**[www.scanner.imagefact.de](http://www.scanner.imagefact.de)**