

1st 3D Metrology Conference – 3DMC
Aachen/Germany, November 22-24, 2016



Camera based process optimization in automotive design centers – 3D Arena in use

Andreas Rietdorf

Overview

- Theoretical backgrounds
 - Photogrammetry
 - Fringe Projection and White Light Scanner
- Automotive Design Centers
 - Issues and challenges
 - Multi camera arrays | 3D Arena
 - Aspects of accuracy
 - Applications and example

3D ARENA | AUTOMOTIVE DESIGN CENTRES

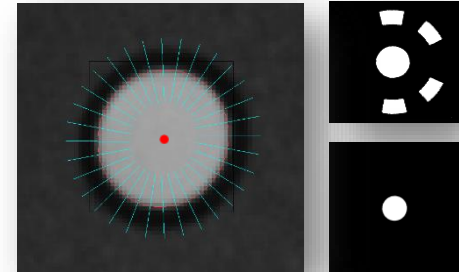
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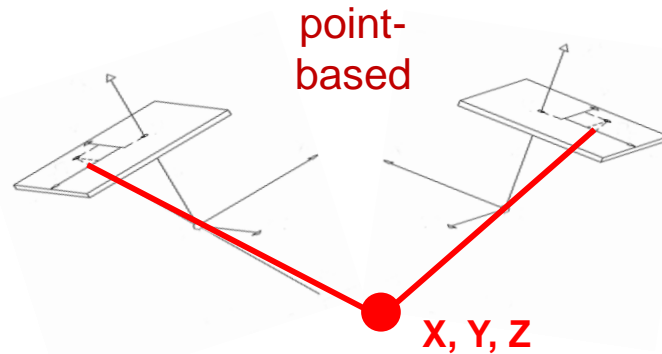
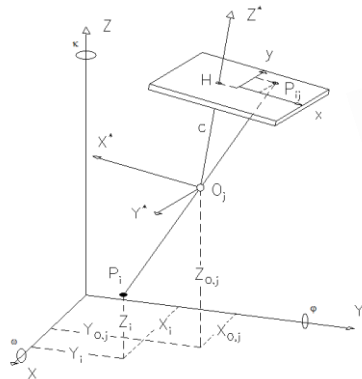
THEORETICAL BACKGROUND

Photogrammetry and Fringe Projection

- Methods of optical 3D measurement techniques
- Mathematical model of central projection of pinhole camera
- Bundle block adjustment



Precise subpixel measurement of **center of ellipse**



$$x' = x'_0 + z' \frac{r_{11}(X - X_0) + r_{21}(Y - Y_0) + r_{31}(Z - Z_0)}{r_{13}(X - X_0) + r_{23}(Y - Y_0) + r_{33}(Z - Z_0)} + \Delta x'$$

$$y' = y'_0 + z' \frac{r_{12}(X - X_0) + r_{22}(Y - Y_0) + r_{32}(Z - Z_0)}{r_{13}(X - X_0) + r_{23}(Y - Y_0) + r_{33}(Z - Z_0)} + \Delta y'$$

Collinearity equation

THEORETICAL BACKGROUND

Two approaches Photogrammetry



Single camera systems

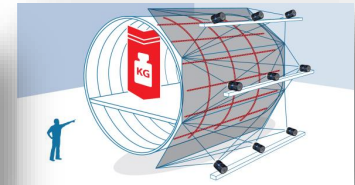
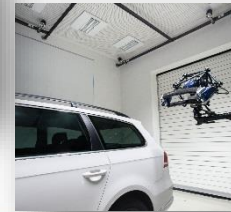
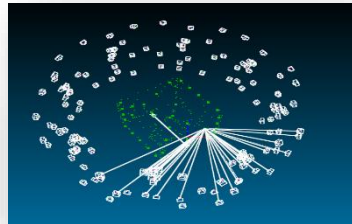
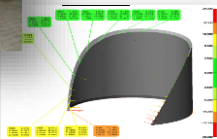
Stereo and/or multiple camera systems (camera array)

object equipped with user-defined number of targets
high **visibility to all targets necessary**

One camera, hand-held

„walking around“ the object, a lot of images must be taken

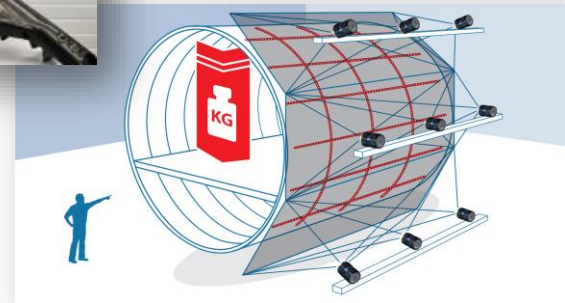
Static deformations, inspection



THEORETICAL BACKGROUND

Stereo camera systems / camera arrays

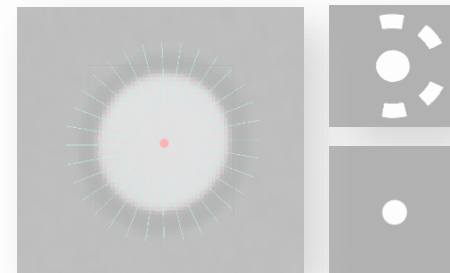
- Estimation of 3D coordinates by forward intersection with known
 - interior orientation
 - exterior orientation
- Accuracy better than 1:50.000
- Point Tracking
- Multi 6DoF
- Positioning
- Deformation Analysis
- Dynamic Applications
- Inspection of 3D geometrics with handheld CMM or adapters



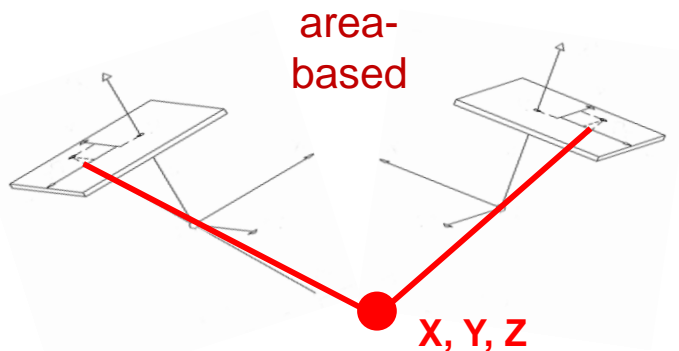
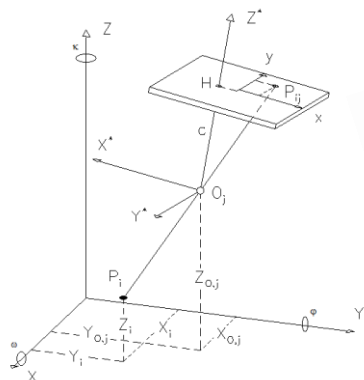
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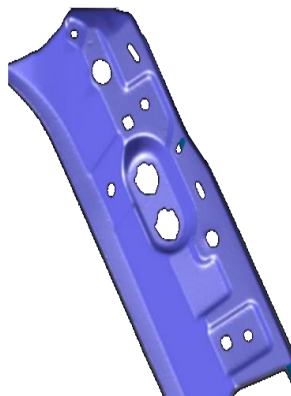
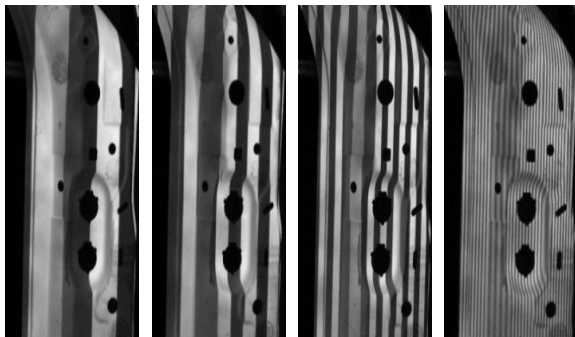


Analysis of **gray code** measurements for each pixel

THEORETICAL BACKGROUND

Fringe Projection | White Light Scanner

- Digital projection of grey code
- Short measurement time
- Different methods to combine patches
- Output - high density Point Cloud



StereoScan neo



PrimeScan



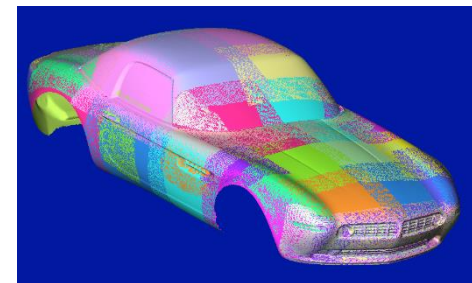
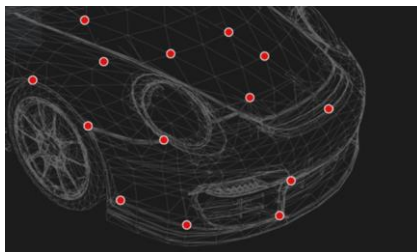
SmartScan

AUTOMOTIVE DESIGN CENTRES

Scanning full size cars

Scanning of large components and merging of point clouds:

- Photogrammetry with index marks
- Contour matching
- Tracking of scanning sensor with camera arrays → **3D Arena**



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AUTOMOTIVE DESIGN CENTRES

Around clay model



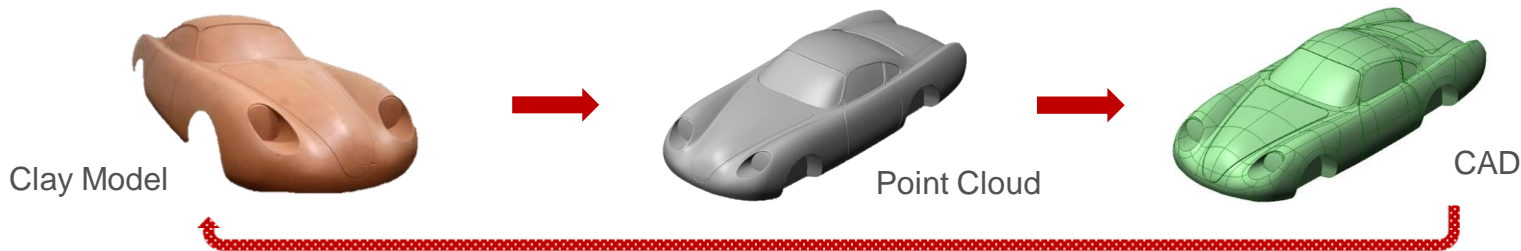
Source: diephotodesigner.de

AUTOMOTIVE DESIGN CENTRES

Around clay model

Challenges:

- CMMs are visual obstacles
- Milling machine positioning cumbersome
- Constant design changes
- Measurement takes time – designers do not have it
- Clay material not very suitable for blue light scanning
- Using reference markers is possible but cumbersome

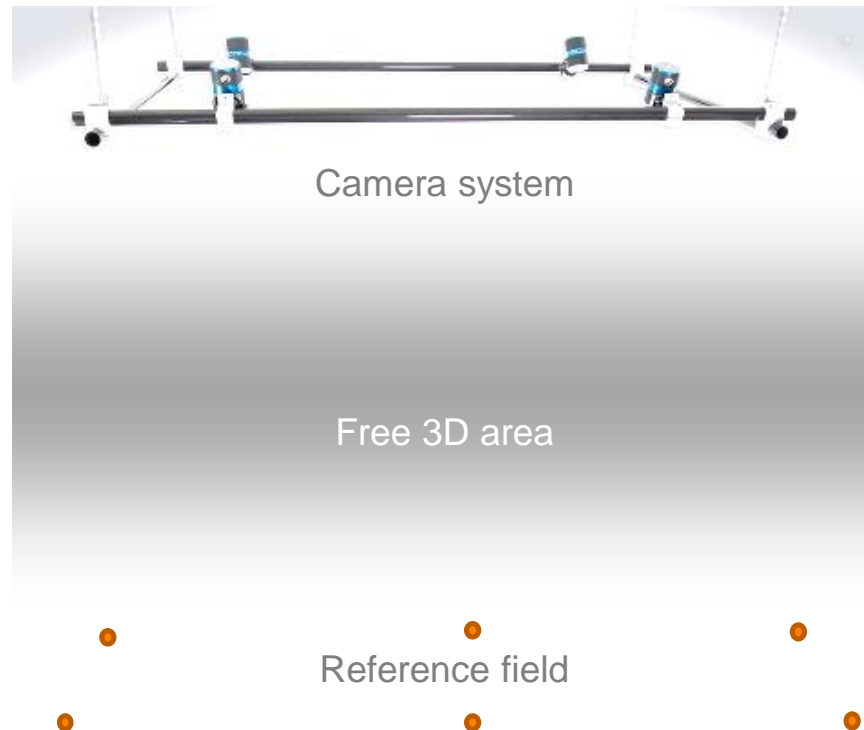


AUTOMOTIVE DESIGN CENTRES

Multi Camera Arrays | 3D Arena

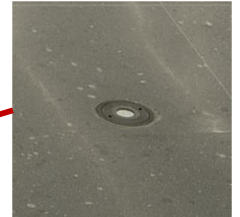
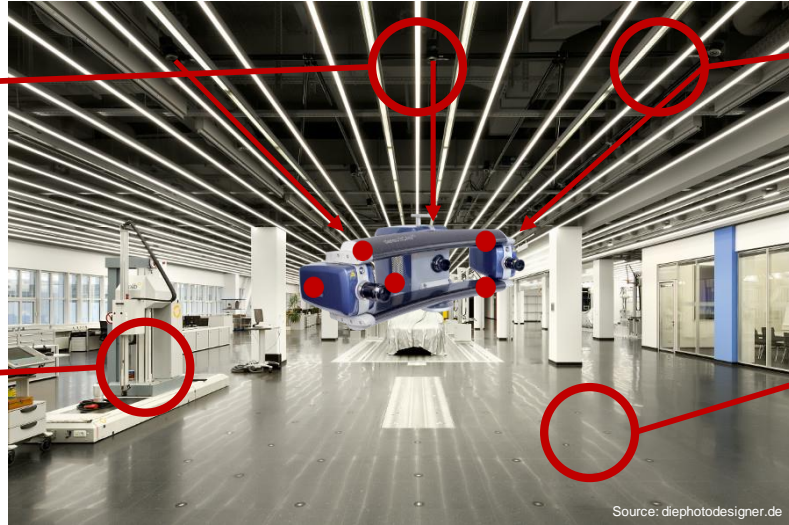
Concept:

- 3-Layer Model
 - Camera system
 - Free 3D area
 - Reference field
- Multi-camera-system for positioning and alignment of different objects/components in 3D
- Minimal setup of devices
- Easy handling
- Usable for various applications
- Extendable by further measuring and testing devices



AUTOMOTIVE DESIGN CENTRES

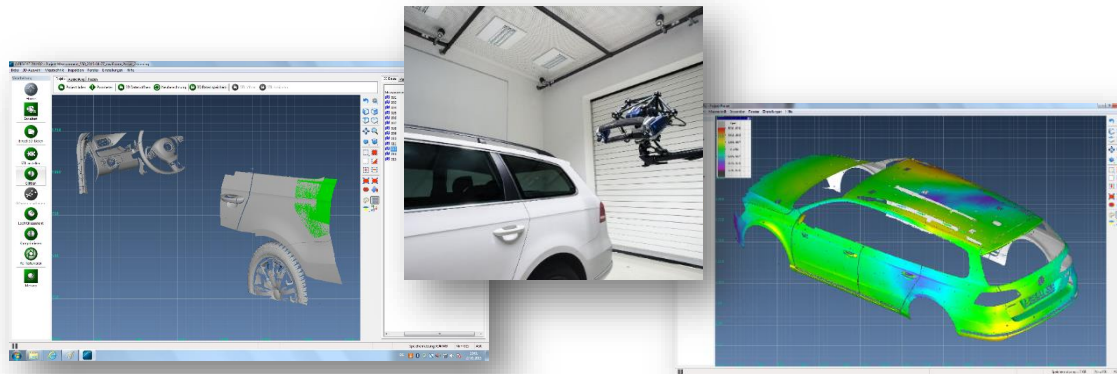
Multi Camera Arrays | 3D Arena



AUTOMOTIVE DESIGN CENTRES

Multi Camera Arrays | 3D Arena

- Tracking / Scanning / Probing in the whole measurement area
- Tracking of measurement systems (e.g. scanners) or tools
- Scalable for each application
- High demand for marker free scanning and multiple component adjustment



AUTOMOTIVE DESIGN CENTRES

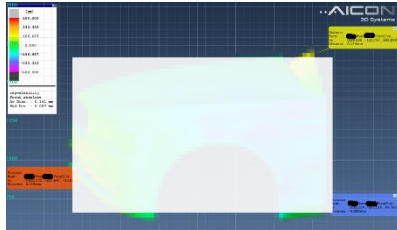
Aspects of Accuracy

- Measurement volume 8 m x 6 m x 2.5 m
- Sub-areas measured several times, L850
- Merging of datasets only 3D Arena based (left) and in combination with best-fit alignment (right)
→ deviations between two data sets:

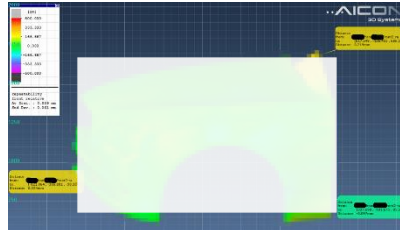


≈ 35 patches

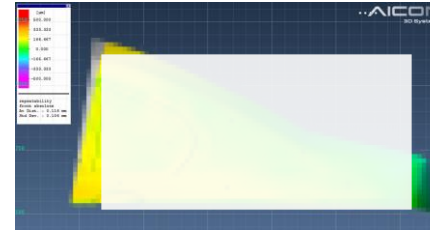
≈ 20 patches



Mean: **0.15 mm**
RMS: **0.26 mm**



Mean: **0.04 mm**
RMS: **0.07 mm**



Mean: **0.11 mm**
RMS: **0.1 mm**

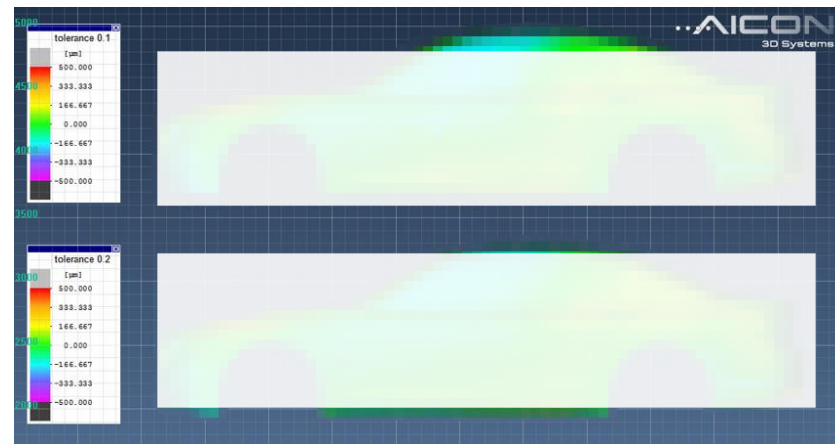


Mean: **0.03 mm**
RMS: **0.06 mm**

AUTOMOTIVE DESIGN CENTRES

Aspects of Accuracy

- Measurement volume 8 m x 6 m x 2.5 m
- Full size vehicle clay model
- Comparison between two alignment methods
→ reference points (1) and 3D Tracking (2)
- Approx. 300 reference points and 210 single scans
- Alignment of the meshes needs start values
- Max. deviations between (1) and (2)
0.2 mm



3D ARENA | AUTOMOTIVE DESIGN CENTRES

Summary

- Combination of different camera based optical measurements techniques
- High Accuracy with highly reliability
- Efficient and commercial option for CMMs, laser-based measurement systems, and tactile sensors
- Minimal setup of devices
- Easy handling
- Time and cost saving

3D ARENA | AUTOMOTIVE DESIGN CENTRES

FARADAY FUTURE'S AICON 3D ARENA



16
MoveInspect XR
tracking cameras

15M+
points on
vehicle scan

\$1M
custom build cost

2HR
scan time for
full-sized car

[Source: Faraday Future]

“This measurement solutions have increased our productivity significantly. Time savings on a whole vehicle clay model for scanning is about 70%!”

Steve Osorio, Faraday Future



[Source: Faraday Future]



[Source: Faraday Future]

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AICON PORTRAIT

AICON provides Systems for



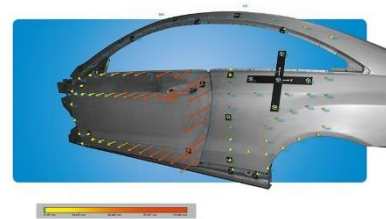
Geometric Dimensioning & Tolerancing

- Inline inspection
- Periodic check
- First part inspection



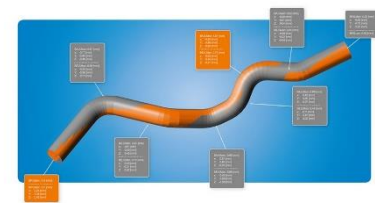
Inspection & Reverse Engineering

- CAD comparison
- Quality control
- GD&T



Deformation Analysis

- Load test
- Dynamic deformation
- Static deformation
- Tracking & positioning



Quality Control for Tube & Wire

- Inline inspection
- Reverse Engineering
- Machine set up

AICON PORTRAIT

Product Lines for Inspection, Testing, and Reverse Engineering



TubeInspect

Tube and wire measurement
with optical gauge



MoveInspect Technology

Modular portable coordinate
measurement technique



AICON Scanner

Surface scanning of complex
geometries