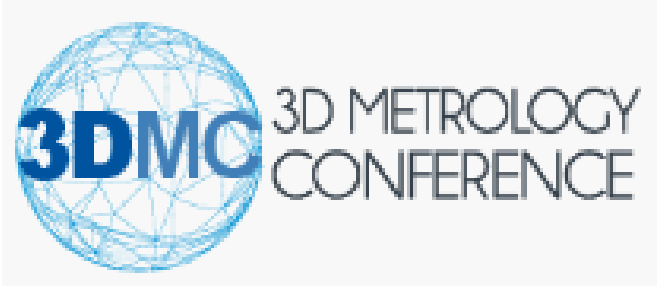
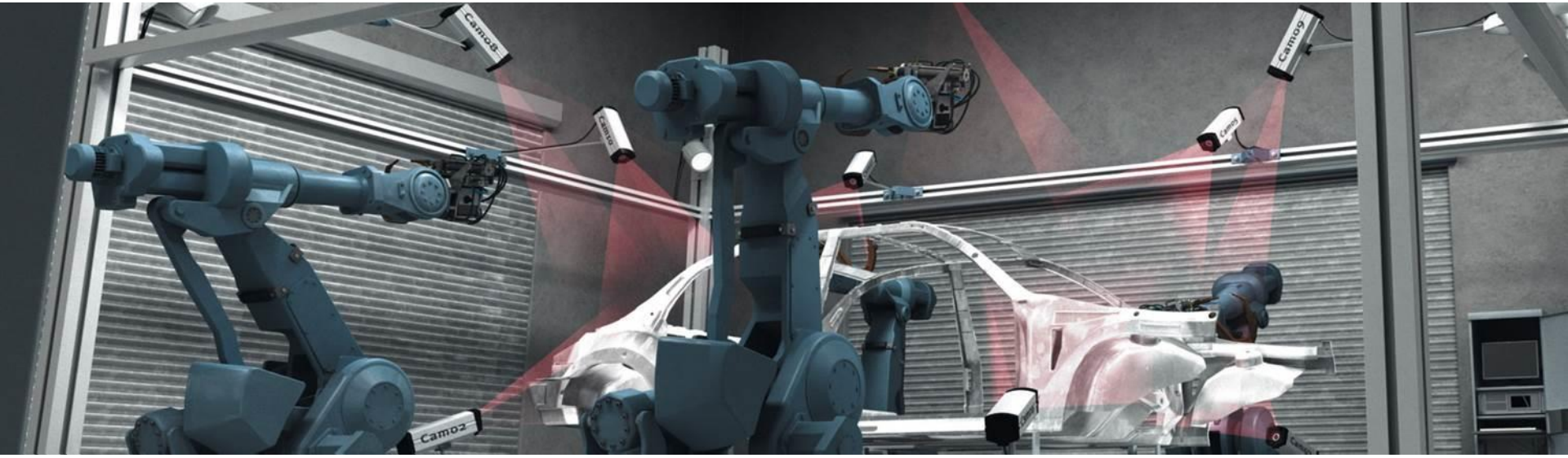


October 16-18,
Hamburg

Stereo Camera Head for 3D Laser Tracking

Michael Kleinkes • *VMT, Germany*
Christopher Völcker • *VMT, Germany*
Raimund Loser • *Hexagon MI, Switzerland*



Patch Camera

Flexible robot guided feature detection on large scale workpieces

Motivation

Ideas for hybrid measurement strategies

Measurement on large scale objects

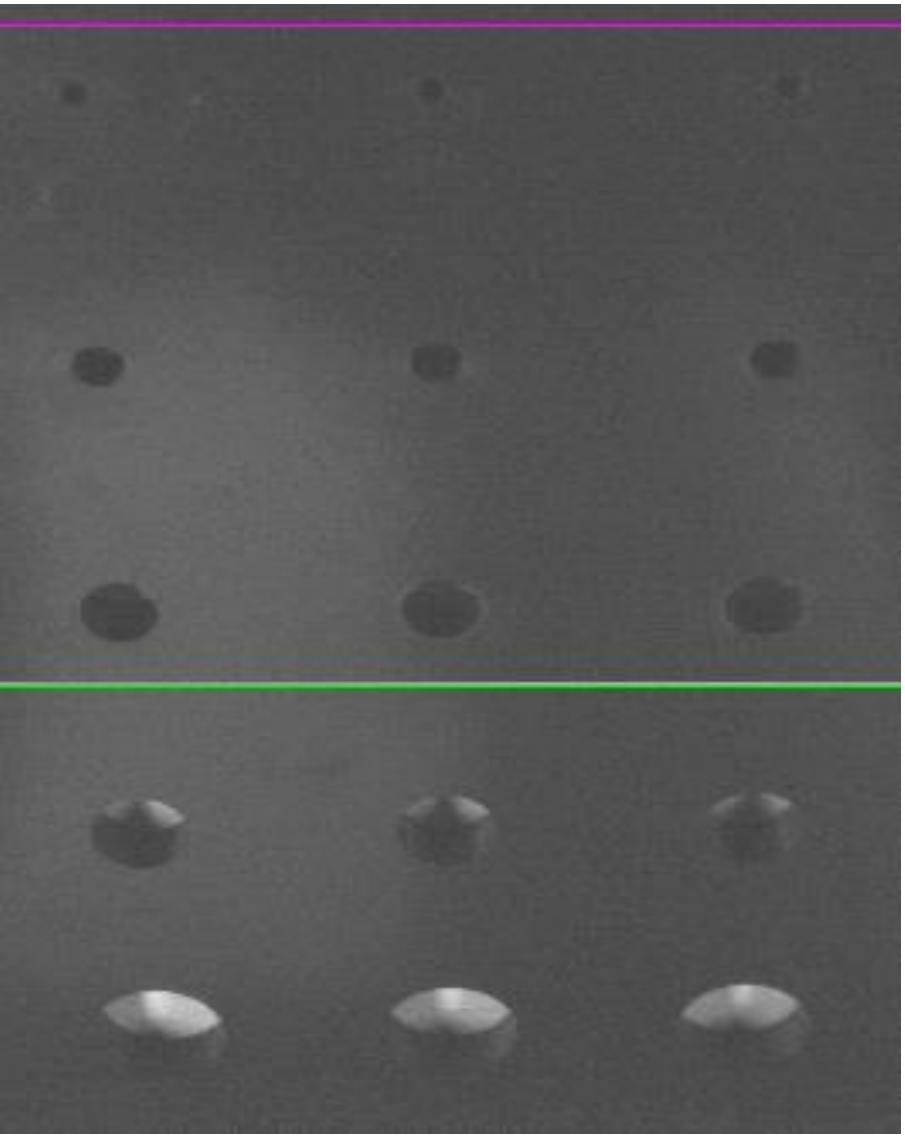
Is a topic which challenges the modern measurement technology.

The goal is to find an optimal solution between flexibility, costs, accuracy and speed. Often this brings a measurement system to its limits.

Flexibility
Autonomous capturing of measurement objects

Speed
Simultaneous processing of several features

Accuracy
Best possible absolute accuracy



Use case

Drilling holes in CFK

A CFK plate with drilling holes in different sizes stands as a representative for many applications in the field of large scale objects.

Measurement task is the detection of all drilling hole center points with relation to a global coordinate system.
The object should be captured completely, to correct a following robot process according to the detected center points. The transfer to a real object can be done e.g. with following facts:

20m object size

The complete object range has to be covered

20 min capture time

Time for capturing every single hole on the part

0,08 mm accuracy

Minimal accuracy of the combined measurement system

3000 holes

Spread on the part with sizes between 3 to 18 mm

The idea

Combination of two different technologies

Stereo-Vision
Image acquisition with two different cameras

Multi-Feature Evaluation
Extensive image processing tools and configurable software

Absolute Tracker
Flexible, laser-based 6dof-measurement on big distances

Multi-Side T-MAC
Individual creation of targets by multiple use of several probes

Dr. M. Kleinkes
Leitung Entwicklung
VMT GmbH

Dr. R. Loser
Produkt Manager
Special Products
Leica Geosystems AG

Laser-Tracker

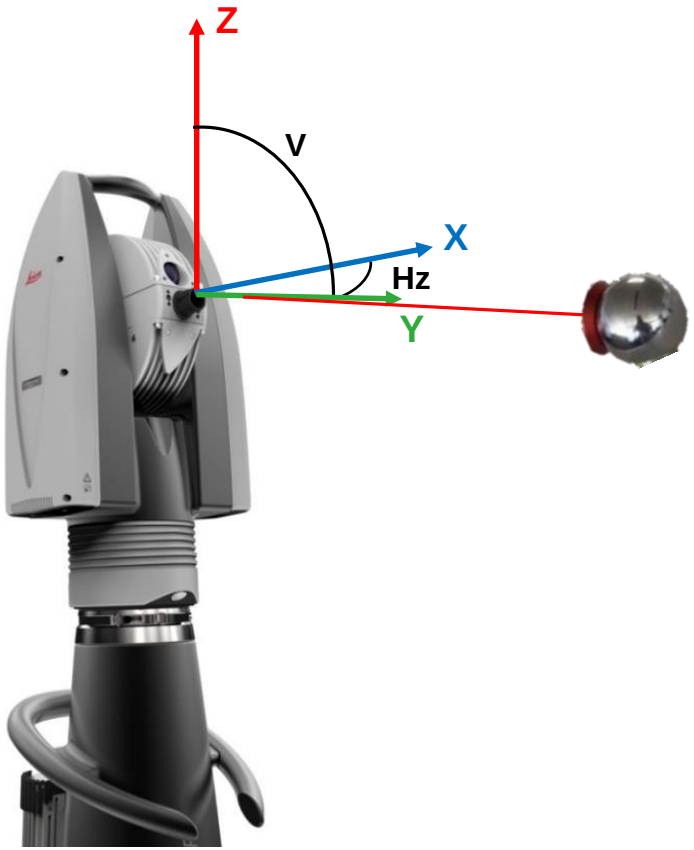
High accurate absolute single measurement

- Single measurements can be done with a large range
- High accuracy
- Flexible positioning in workspace
- Tactile feature detection or point cloud scan of single objects
- Multiple steps needed for evaluation of hole center points on object plane

Image processing

Capturing of complete image field relative

- Simultaneous capturing of multiple holes
- Fast calculation of hole center points
- Dynamic pose recognition of arbitrary holes
- Exposure time and angle of view must be adapted to the scene
- Camera position in space must be known



Leica Absolute Tracker

High accurate point measurements

Leica Absolute Tracker AT930

Basically identical with a total station, the absolute tracker AT930 is capable of taking single point measurements on a target

Measurement rate

Captures points with a rate up to 1kHz

Accuracy

Distance measurement in µm-range in the complete working area

PowerLock

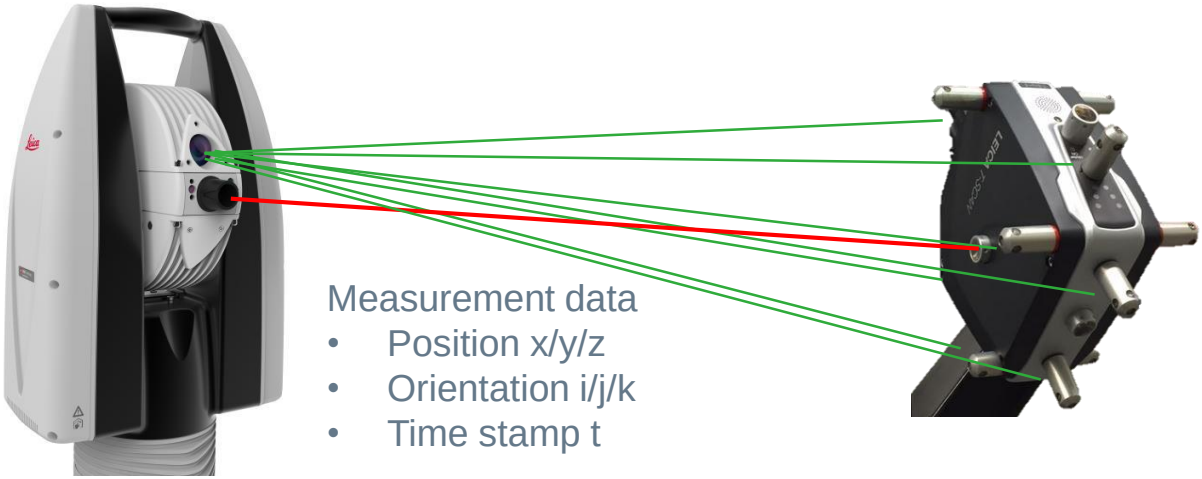
Dynamic laser beam lock-on without need to static laser stabilization

Absolute coordinates

Capturing of H- and V-angles together with a target distance. Device-internal conversion to x,y,z-coordinates

Leica Absolute Tracker

Extension to 6dof



Measurement data

- Position x/y/z
- Orientation i/j/k
- Time stamp t

Accurate
3D-measurement based on laser tracker technology

Flexibility
Combines photogrammetric measurement to 3D-point

6D
6 degrees of freedom in one single measurement

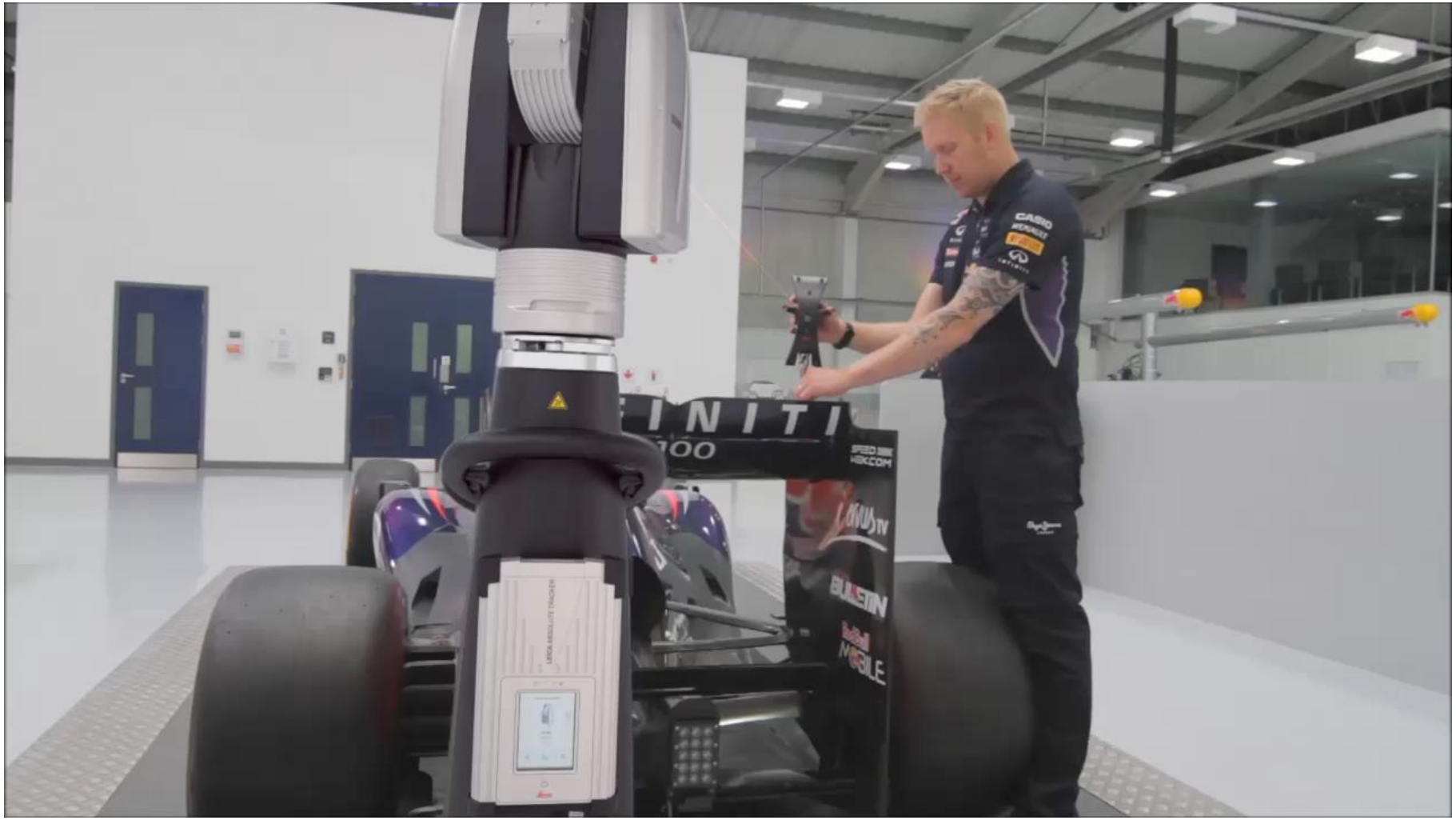
Timing
Creation of time stamp for every single measurement

VMT PEPPERL+FUCHS

Leica Geosystems

3DMC 3D METROLOGY CONFERENCE

Function of 6DoF Technology



Patch Camera

Integrated stereo-vision system

Complete system

Two cameras and an integrated, passive cooled mini-PC create a complete image processing system

Image processing plattform

Windows-based software with a wide range of different functionalities for the use of modern image-processing routines with a user-friendly HMI

Online-Protocol

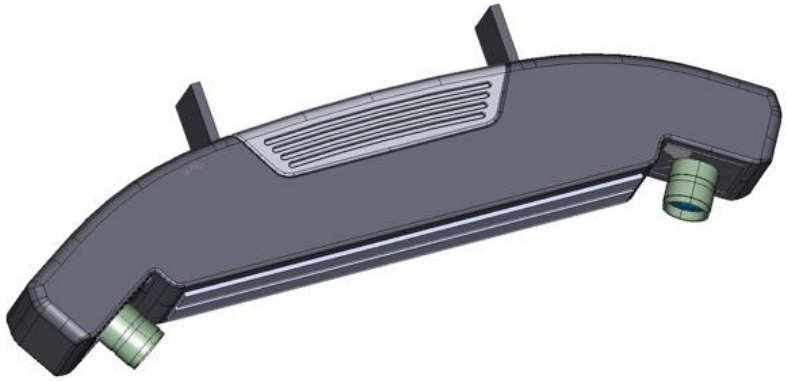
Each single measurement is trackable, analysable and repeatable

Statistics

Long-term evaluation via detailed statistic-functions, exportable for tracking of system or object changes

Communication

Interfaces like ProfiNet or digital I/Os offer an easy connect to moder industrial environments

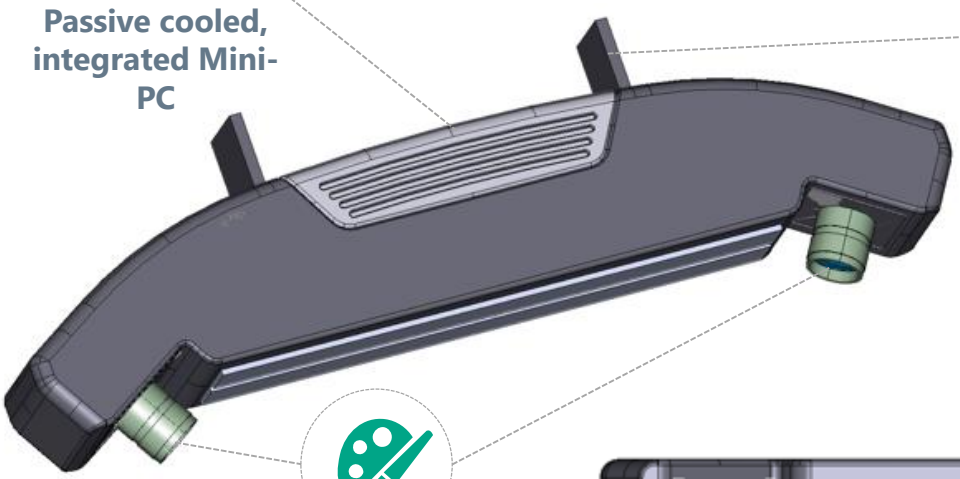


Patch Camera

Setup and components

Passive cooled, integrated Mini-PC

Bracket for adaption to robot



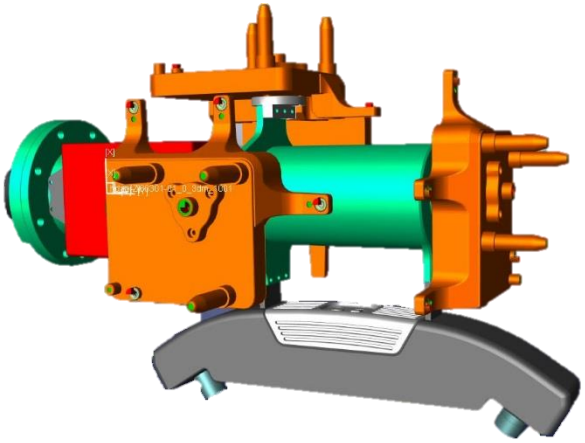
LED-illumination

Cameras

S/W, 1600 x 1200 Px

Symbiosis of tracker & camera

Advantages & Goals



Relative measurement via vision system

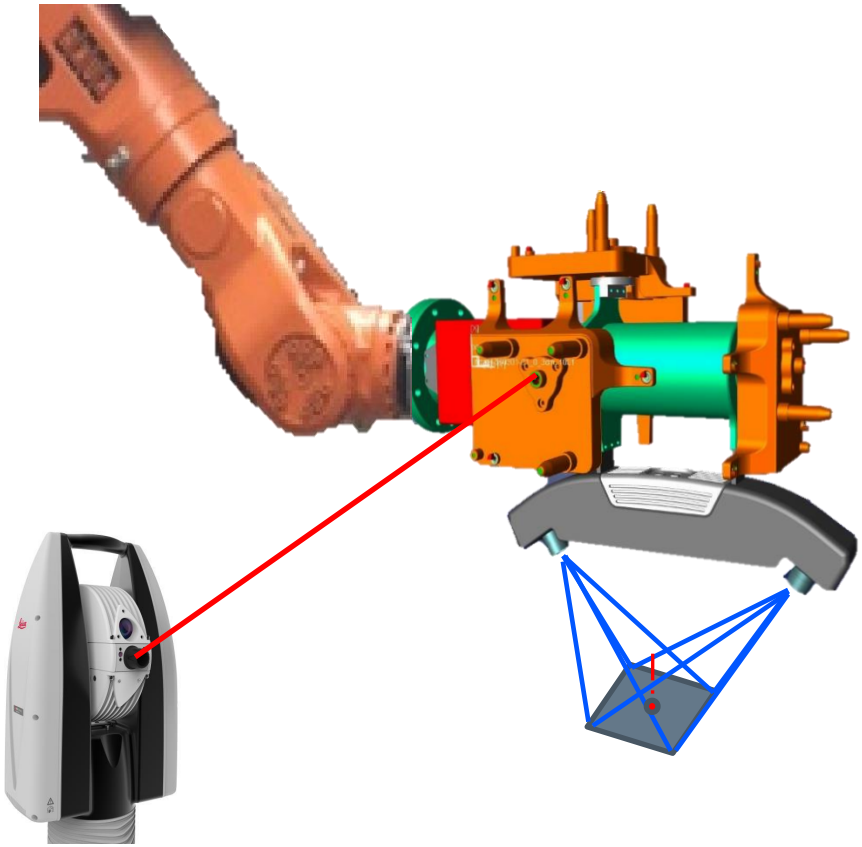
6D-Capture Multi-Side T-MAC

Ad-Hoc Calibration

3D-Coordinate in Space

Test setup

Robot guided measurement



Stereo-Vision
Capturing the scene with both cameras in stereo mode

Integrated evaluation
Image processing routines find the hole center point via cascaded actioins

Result calculation
Creation of 3D-coordinate in camera system

Ad-Hoc calibration
Measurement of currently visible Multi-Side TMAC frame

Conversion into global coordinate
The measured 6D-pose of TMAC-frame is converted with hole center point coordinate position in camera system

Detection

For finding arbitrary hole center points

Parameter setting

Every algorith of the tool set can flexible to adapted to the measurement task defined by the object

Pre-processing

Light shading or disturbances can be filterd out by several different filter algorithms

Blob detection

Threshold-based analysis of corresponding areas

Pre pose definition

Via center-of-gravity the rough drill hole center points can be pre-detected

Measurement

Starting from a pre-position, a precice detection of trivial geometries can be done for an exact feature meaurement

Multi feature detection

Intelligent analysis of images

Pre pose
Detected features as a start point for precise evaluation

Fine pose
Special algorithms for finding feature

Mapping
Solving the correspondance problem of stereo vision

Results
Output 3D-Coordinates in camera coordinate system

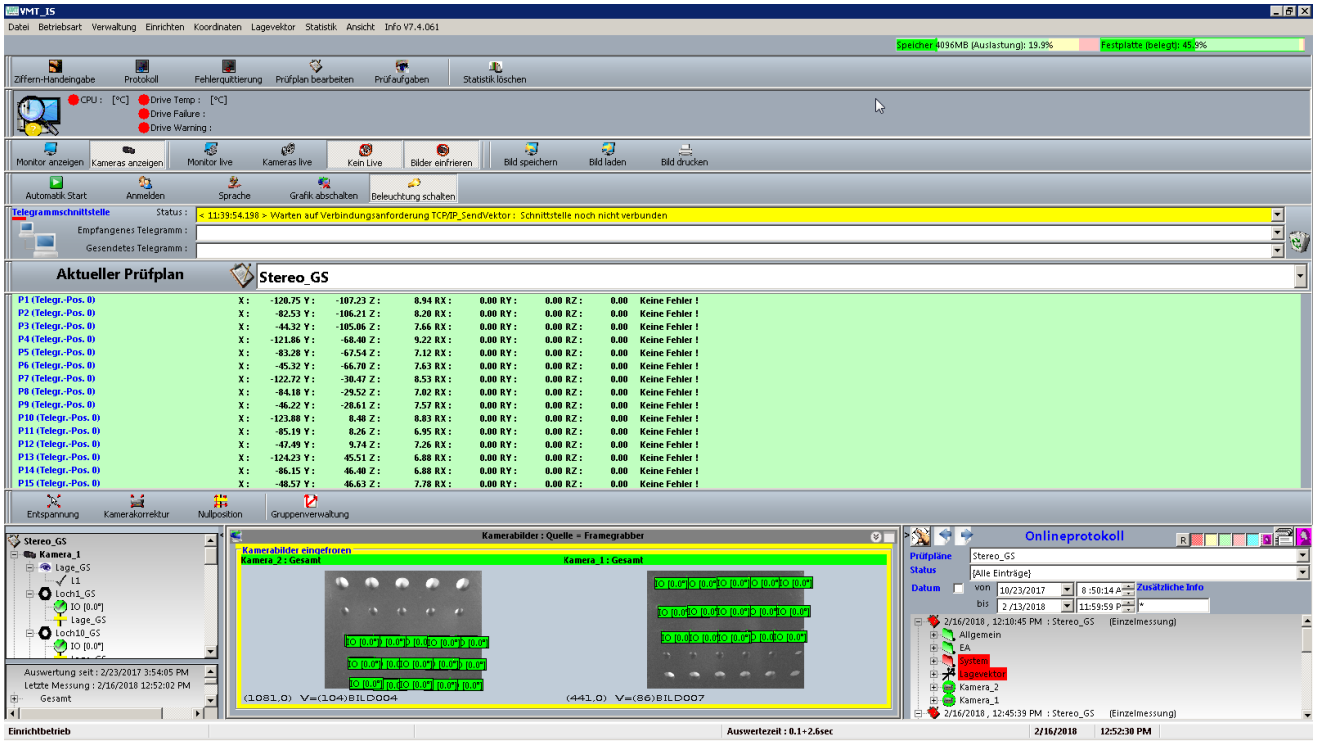
Aktueller Prüfplan	Stereo_GS							
P1 (Telegr.-Pos. 0)	X : -117.12	Y : -106.97	Z : 7.83	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P2 (Telegr.-Pos. 0)	X : -79.08	Y : -106.19	Z : 7.74	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P3 (Telegr.-Pos. 0)	X : -40.25	Y : -103.87	Z : 6.24	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P4 (Telegr.-Pos. 0)	X : -118.29	Y : -69.52	Z : 8.55	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P5 (Telegr.-Pos. 0)	X : -80.30	Y : -67.94	Z : 7.66	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P6 (Telegr.-Pos. 0)	X : -41.17	Y : -65.84	Z : 5.37	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P7 (Telegr.-Pos. 0)	X : -120.04	Y : -31.21	Z : 9.25	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P8 (Telegr.-Pos. 0)	X : -81.23	Y : -29.68	Z : 7.26	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P9 (Telegr.-Pos. 0)	X : -43.52	Y : -28.83	Z : 7.68	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P10 (Telegr.-Pos. 0)	X : -120.86	Y : 7.18	Z : 8.32	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P11 (Telegr.-Pos. 0)	X : -82.31	Y : 8.01	Z : 7.05	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P12 (Telegr.-Pos. 0)	X : -44.63	Y : 9.49	Z : 7.41	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P13 (Telegr.-Pos. 0)	X : -121.90	Y : 45.18	Z : 8.02	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P14 (Telegr.-Pos. 0)	X : -83.06	Y : 46.14	Z : 6.85	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	
P15 (Telegr.-Pos. 0)	X : -44.22	Y : 45.42	Z : 4.92	RX : 0.00	RY : 0.00	RZ : 0.00	Keine Fehler !	

Integrated image processing platform VMT_IS

Configuration
Quicklinks

System performance
Memory, CPU load

Control plan
Active configuration



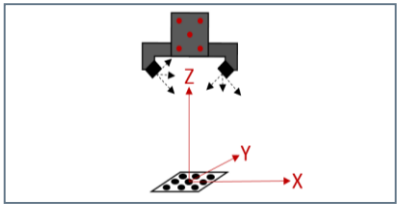
Results
Single values of actual measurement

Statistics
Long-term values of all measurements

Result pictures
Raw images and overlays for detected elements

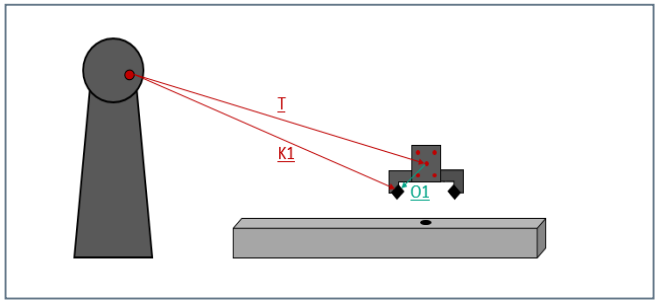
Online protocol
Saved measurements, sortable and repeatable

Calibration and Data Collection Sequence



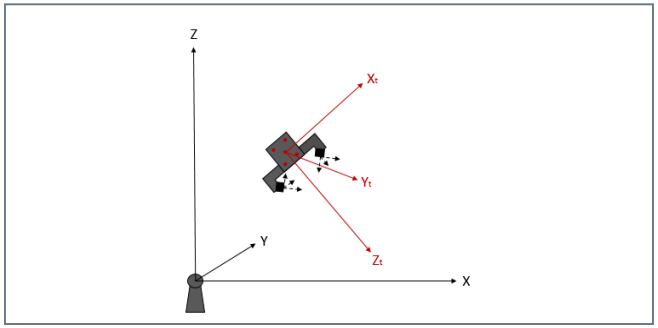
Camera Calibration

Image Coordinate System



Coordinate Transformation Vector

Image Coordinate System to Local T-Mac Coordinate System



6DoF Measurement

Local T-Mac Coordinate System to
Absolute Laser Tracker System or Object System

Results

Single values in Absolute Coordinates of the Object

“Factors Influencing Accuracy”

Calibration procedures of the measurement devices

- Camera System,
- T-Mac device,
- Transformation Vector Image to Local Coordinate System

General System Geometry

- Vector length Origin Local System to Image Coordinate System
- Stereo Base between Camera Chips
- Focal length of Camera Objective
- Resolution of Camera Chips

Measurement and Environmental Conditions

- Target illumination
- Object reflectivity
- Temperature Influence
- Measurement time
- Measurement algorithm
- Mechanical stability

Test Measurements

Calibration procedures are implemented and used

- Open for improvements if necessary

General System Geometry Parameters

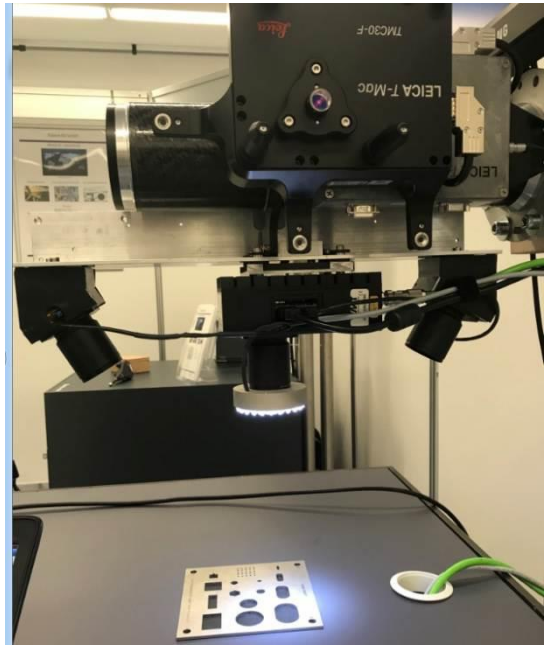
- Vector length: 400 mm
- Stereo base: 400 mm
- Focal length: 12 mm
- Chip Resolution: 1600 x 1200
- Pixel Size: 4.5 µm

Target Illumination Test

Development of an illumination concept and measurement algorithm

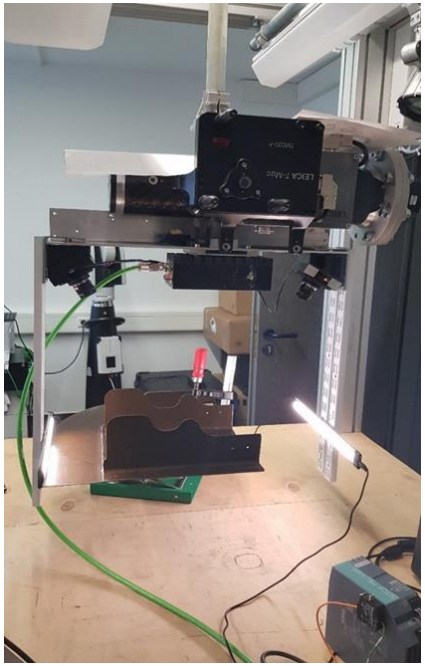
- ring light central illumination
- area light (LED strip lights)
- using indirect illumination dome
- dark field illumination

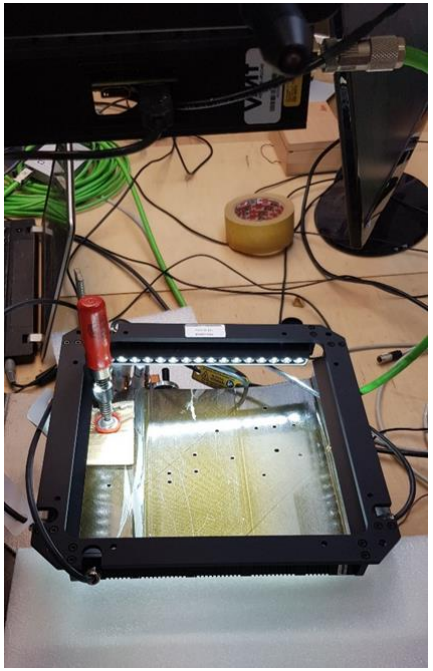
IlluminationTests



Ring light Illumination

LED-Strip light Illumination





Dark field Illumination

First Measurement Results

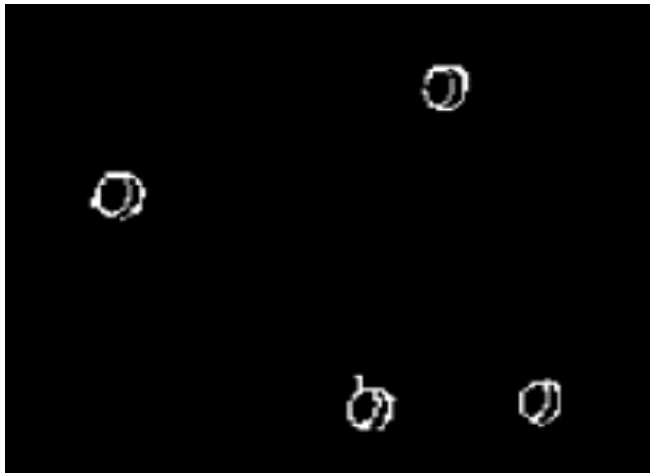


Image example with LED-Strips

Improved feature detection
using dark field illumination

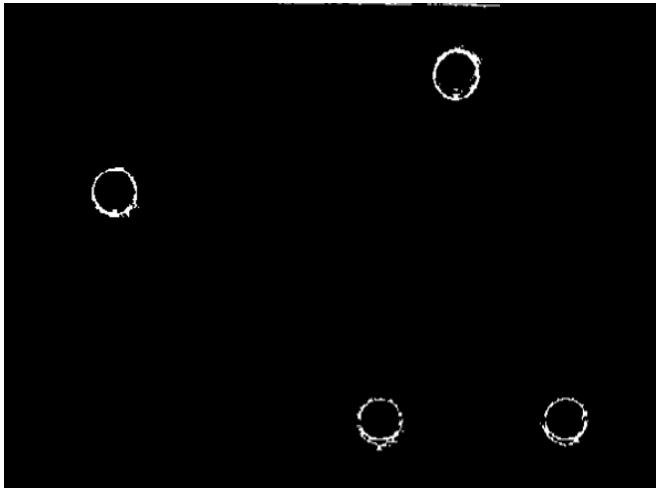
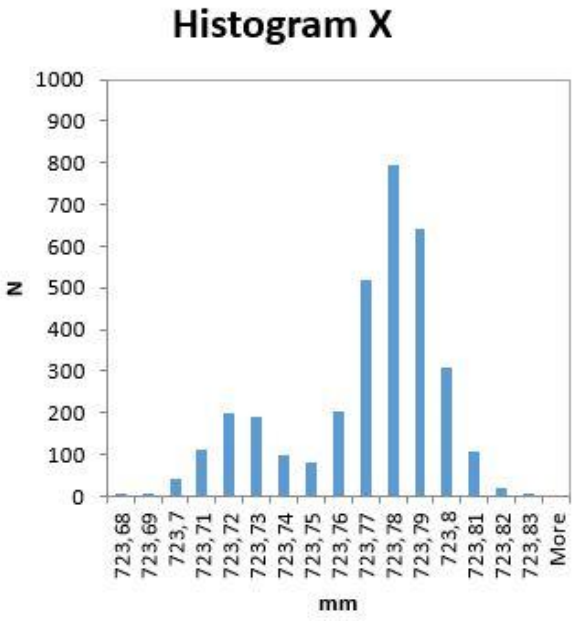
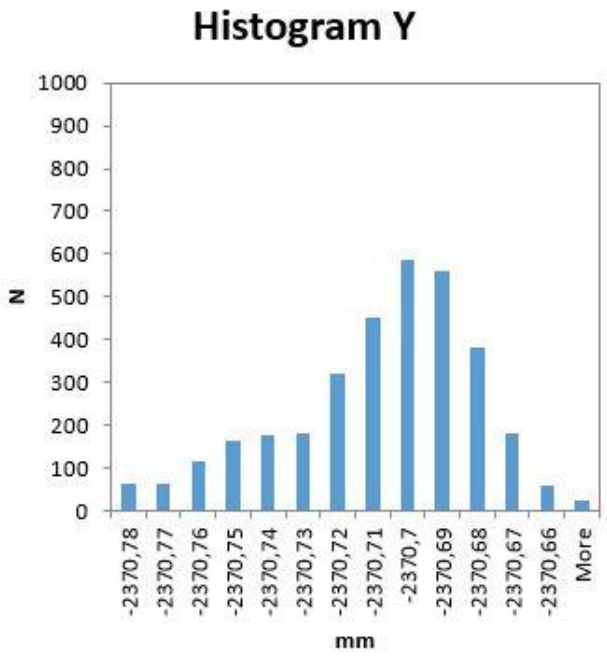


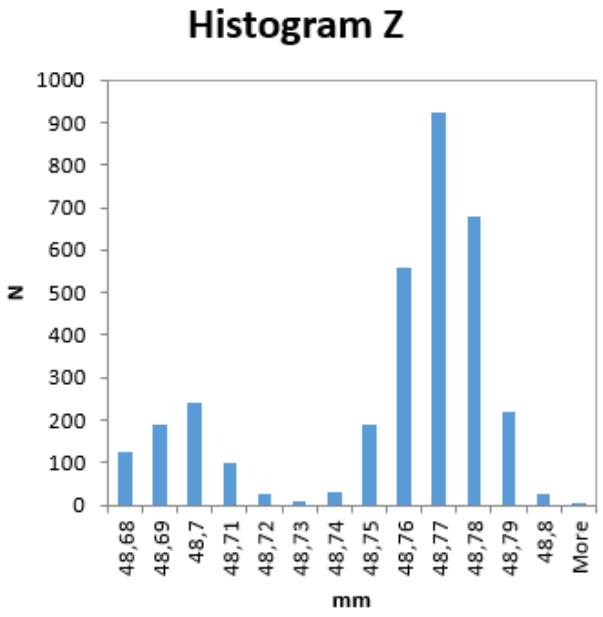
Image example dark field illumination

First Measurement Results

Measurement Repeatability







- Number of measurements: 3328
- Measurement time: 700 ms
- Measurement range in all directions: ± 0.06 mm

Next Steps

- Complete test measurements
- Establish a decision matrix
- Select an automation application
- Define Camera and Geometry parameters
- Assemble a Patch Camera accordingly
- Provide Test Equipment to a Pilot Customer
- Review Results together with Pilot Customer
- First System installations

Thank you

Dr. R. Loser
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