

Technical specification – Portable 3D measuring machine *kolibri move*

Brief description of measuring system

kolibri move is a robust 3D digitizer that works on the basis of digital self-calibrating fringe projection. Two cameras capture different structured light patterns. With the help of triangulation, similar to the human stereo vision, the exact 3D coordinates can be calculated for each single camera point. The patented use of an additional stationary camera enables a complete highly accurate surface digitizing without reference markers (that have to be fixed on object's surface), matching procedures, or a special object positioning.

A special *MULTIview-technology* enables a self-calibrating measurement process where the absolute position and setting of cameras and projector is not relevant. The system is therefore inured to changes of environmental conditions (thermal fluctuations). Precise engineering mechanics is not necessary.

Special features of the measuring system *kolibri move*:

- No reference markers
- High accuracy
- Self-calibration
- No image matching
- High reproducibility
- Fast measuring process

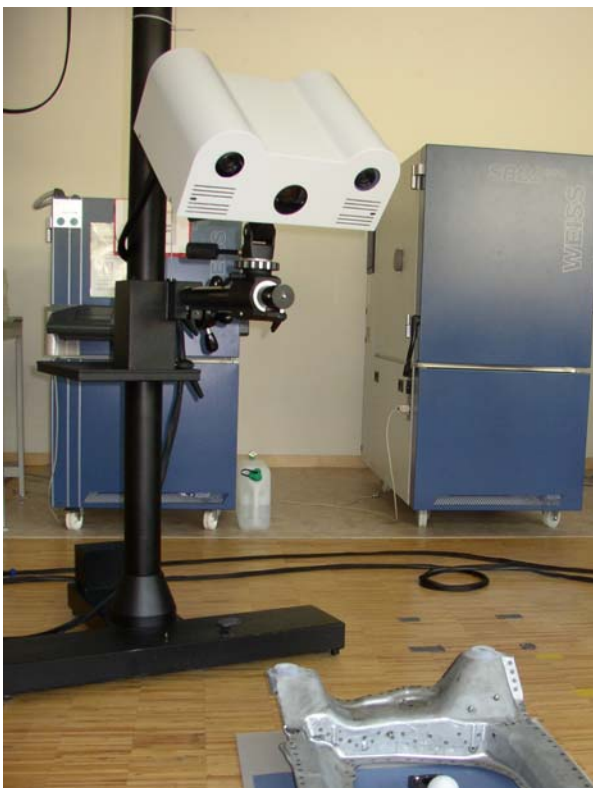
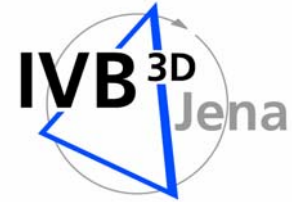


Figure 1: *kolibri SENSOR* on tripod (l.), Stationary camera (r. t.), structured light on design model (r. b.)



The *kolibri move* is a non-automated 3D measuring system for nearly volume independent shape digitizing. The standard measuring volume of the system covers objects up to approx. 2.5m in length. The single measuring volume of the *kolibri SENSOR* (volume that can be covered by 1 scan) is about \varnothing 440mm.

The *kolibri SENSOR* is moved and positioned around the measuring object manually to capture images from different directions. The stationary cameras as well as the measuring object remain unmoved during the complete measuring process. The stationary cameras generate virtual reference markers that enable to register all taken images into one coordinate system automatically. An extension of the measuring volume can be realized by adding further stationary cameras to the measuring setup.

During measurement the operator has to ensure an overlapping of the particular scans. The handling is supported intelligently by the operating software. The software supports e.g. an automated camera shake test that detects shocks, vibrations or strong changes of ambient light and starts in case a new measurement automatically.

The scaling of measured data is made by the additionally delivered scaling dumbbell. After finishing the measurement process the system calculates all taken views into a uniform coordinate system. To higher the completeness of the recorded data it is possible to take and integrate single scans, even after finishing the actual measuring process. Generally one scan captures 1.45 Mio points in approx. 7 sec.

The highly accurate 3D data of the measuring objects can be used for the following applications:

- Global 3D deviation to CAD data
- Section based analysis and 2D/3D dimensioning
- Geometrical dimensioning and tolerancing (GD&T)
- Wall thickness inspection
- Reverse engineering

The 3D digitizers are used for first-article inspection, for low-batch and serial inspection as well for reverse engineering in rapid prototyping and digital mock-up.

In addition to the non-automated system *kolibri move* the *kolibri SENSOR* can also be used in the fully-automated measuring set up of the system *kolibri Flex 400*. The *kolibri Flex 400* contains an electronically controlled object stage as well as an electronically controlled lifting and tilting column. Pre-customized measuring schedules enable a fully-automated and complete measurement by different height positions and attack angles of the *kolibri SENSOR*. The maximum measuring volume is \varnothing 440 x 250 mm³.

Both systems *kolibri move* and *kolibri Flex 400* can be delivered in a bundle because they use the same *kolibri SENSOR*. The *kolibri SENSOR* can easily be switched from the manual to the automated setup.



Figure 2: Automated setup *kolibri Flex 400*

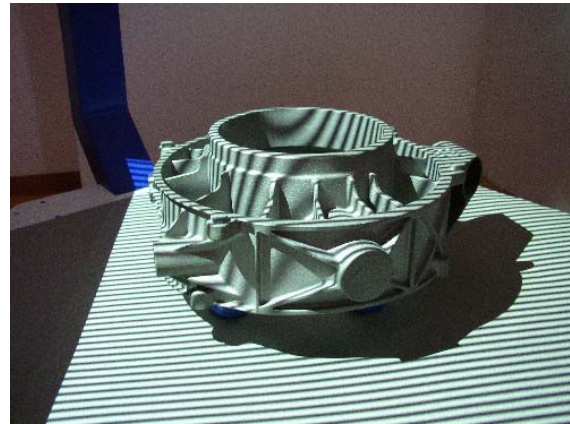


Figure 3: Fringe pattern on a cast component

The final measuring result is highly-defined 3D-point cloud of the object's surface. The point cloud can be triangulated and post-processed with standard 3D-evaluation software for quality inspection, reverse engineering, geometrical dimensioning and tolerancing etc. *kolibri* systems work well with software solutions from the company GEOMAGIC Inc.

The application fields of the 3D- measuring system are mainly in quality inspection, reverse engineering and rapid prototyping:

Quality inspection*	Reverse engineering**
<ul style="list-style-type: none"> • Generation of geometric models (STL data) by triangulation 	
<ul style="list-style-type: none"> • Colour indicated comparison between CAD model and as-built part • Align models using the method of choice – datums, 3-2-1, reference point systems best fit • Geometrical dimensioning and tolerancing • Gap & flush, edge comparison • Wall thickness inspection • Industry specific solutions, e.g. turbines, automotive industry • Automated creation of inspection reports • Easy data transfer per ASCII, Excel, CSV etc. 	<ul style="list-style-type: none"> • Creating of water tight models for rapid prototyping and digital manufacturing • Automated conversion of complex polygon models to precise NURBS-Models for CAD-, CAM- and CAE-systems • Model editing capabilities include creation of tunnels and holes • Smoothing of surfaces and boundary edges, offsets and shell surfaces in preparation for digital manufacturing • Industry specific solutions, e.g. aerospace, automotive industry, dental industry, medicine, art and archaeology

* requires e.g. 3D-evaluation software Geomagic Quality

** requires e.g. 3D-evaluation software Geomagic Studio

The measuring principles and system are patented by the Fraunhofer Gesellschaft. IVB as development partner of the Fraunhofer Institute for Applied Optics and Precision Engineering in Jena develops, manufactures and distributes the measuring machines.

System components

kolibri SENSOR	The sensor unit consists of the following components: <ul style="list-style-type: none"> • Digital DMD projector • 2 cameras and adequate objectives • Robust base plate with fastening elements for tripod head
Tripods	<ul style="list-style-type: none"> • 1 x big tripod for flexible positioning of <i>kolibri SENSOR</i> • 2 x small tripods for stationary cameras • Relative ball heads
Stationary cameras	2 stationary cameras + objectives
Artefacts	<ul style="list-style-type: none"> • Certified dumbbell with sphere distance of L = 200mm • Certified dumbbell with sphere distance of L = 900mm • Certified plane 400mm x 400mm
Soft- and Hardware	Soft- and hardware consists of the following components: <ul style="list-style-type: none"> • PC for system control (control of the projector and 3+x cameras) • Operating system under Windows XP • 19 " monitor, keyboard, mouse
Rack	19 "-Rack for the PC, monitor and equipment
Accessories	<ul style="list-style-type: none"> • Cable from sensor unit to desktop (10m) • Cable from stationary cameras to desktop (10m)

The measuring system will be delivered according to the following technical data and performance parameters:

Installing conditions

Dimensions	Depending from the size of the measurement object, minimum \varnothing 5m x 3m
Electricity	115-230V, 16A, 50Hz
Positioning place	Oscillations/ vibrations of the building or the air as well as strong changes of ambient light can affect the functionality of the system. The customer is responsible to quantify these affects and in case to install e.g. an oscillation isolation.
Temperature	15.... 25°C

Measuring field size

Standard measuring volume (2 stationary cameras)	Max 2,500 x 1,000 x 750 mm ³ Larger fields can be realized by additional stationary cameras
Single measuring volume of <i>kolibri SENSOR</i>	Max \varnothing 440 mm x 250 mm

Measuring time

Measuring time	7 sec/scan
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Requirements for the measuring object

Surface structure of measuring object	Non-transparent or non-diffusely reflecting surface
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Measuring accuracy

Regarding to measuring systems using fringe projection there have to be distinguished between the terms resolution and measuring accuracy. The fringe projection of *kolibri move* projects a continuous metrics in the space. A single camera pixel is thereby up to 40 times more precise than its size on the measuring object. The resolution – means the distance of two camera pixels on the measuring object – is defined by the number of camera pixels and the observed measuring field. Is the resolution to low small details cannot be fixed (see also appendix 2 for classification „smallest feature“).

The measuring accuracy is nearly the same in all 3 spatial directions.

Point spacing	0.3 - 0.4 mm
Accuracy (sphere-spacing-error)	$\Delta L \pm 50 \mu\text{m}$
Noise	$\sigma = 20 \mu\text{m}$

System computer

Processor	\geq Pentium 4 dual core 3,0 GHz
RAM	4 GB
Hard disc	\geq 100 GB
Operating system	Windows XP
Graphics card	Dual-head
Screen	19“ flatscreen

The PC is a component of the measuring system. It may not look like an "office computer", foreign software and changes of basic windows settings can lead to functional failures. We recommend using a separate PC for data evaluation, office applications and the integration in a company network.

Cameras

Resolution (cameras of the sensor unit)	SXGA – 1,392 x 1,040
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