

# Optical measurement with structured light scanner based on automated search for the best measurement positions from CAD data of the measured part

Tomáš Koutecký

*Small minds are concerned with the extraordinary, great minds  
with the ordinary.*

Blaise Pascal

*This presentation is co-financed by  
European Social Fund and The Czech  
Republic State Fund.*



INVESTMENTS IN EDUCATION DEVELOPMENT

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*This presentation was created as a part of the project: " Complex System for Attracting, Education and Continuing Involment of Talented Individuals to Research Centers of AS CR and FME BUT ", reg. no. CZ.1.07/2.3.00/09.0228*



## INTRODUCTION - THEME

**Supervisor:** doc. Ing. Jan Brandejs, CSc.

**Supervisor specialist:** Ing. David Paloušek, Ph.D.

Automation of 3D optical photogrammetry measurement.



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## INTRODUCTION

- Inspection – verification of prescribed specifications
- Traditional methods – contact instruments ← automation not possible
- Recent methods – CMM, Laser scanner, Structured light scanner
- Automation of particular phases of inspection – measurement, registration, evaluation
- Drawing-less documentation – CAD-based inspection



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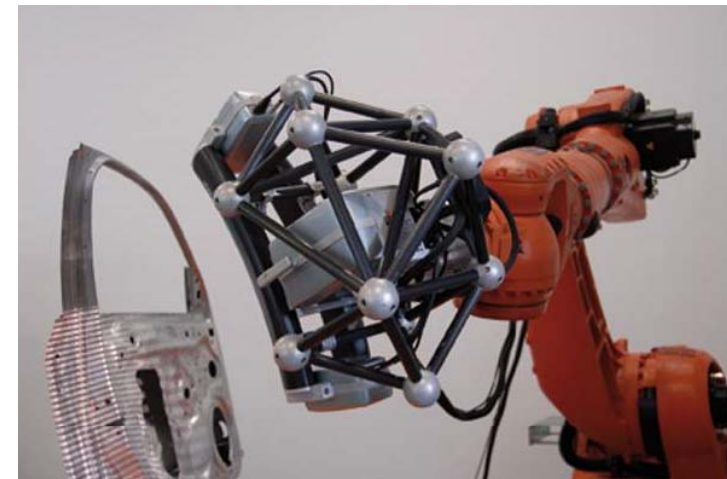
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## MOTIVATION

- CMM measurement is slow with few acquired points
- Increasing adoption of optical systems in industrial applications
- Time savings employing automation



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## LITERATURE REVIEW

- Automation in CMM inspection
- Automation in Laser scanner inspection
- Automation in Structured light scanner inspection



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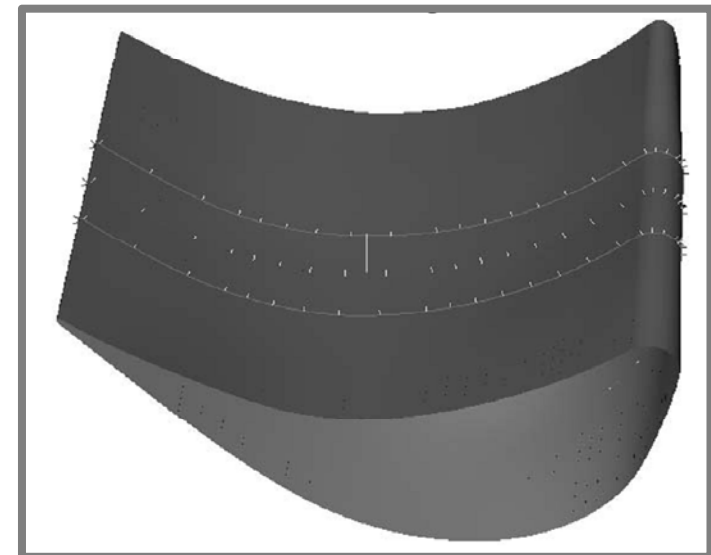


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## LITERATURE REVIEW - CMM

### AINSWORTH, I.; RISTIC, M.; BRUJIC, D. 1999, 2000

- Registration of CAD and CMM coordinate system
- Offset NURBS surfaces
- More accurate registration than with conventional method
- Surface sampling – measurement points
- Uniform, curvature based, minimum sample density, parameterisation-based

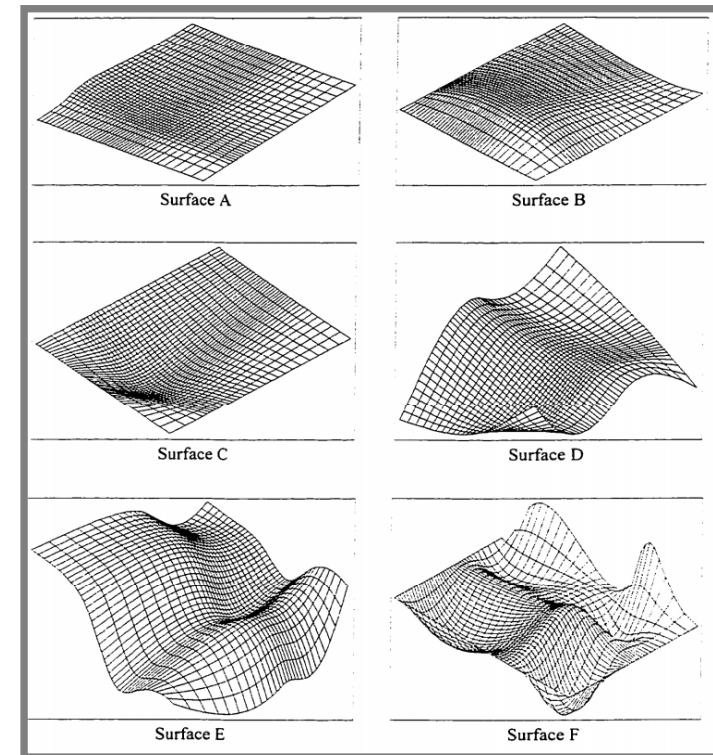


**Conclusion:** Better description of free-form surfaces in inspection

## LITERATURE REVIEW - CMM

ELKOTT, D. F., ELMARAGHY, H. A., ELMARAGHY W. H.  
2002

- Sampling of the surface for the measuring points
- 4 sampling algorithms + genetic algorithm
- Equi-parametric, patch size based, curvature based, hybrid
- Best results with genetic algorithm but with long computing time



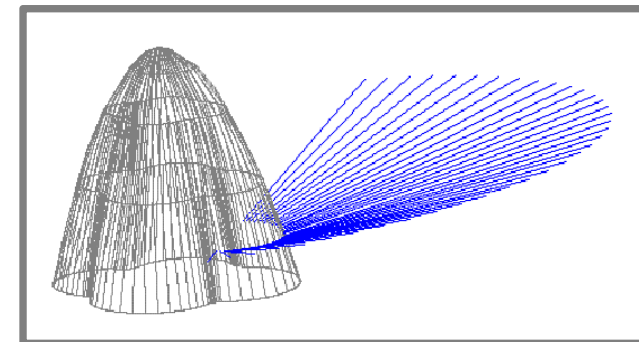
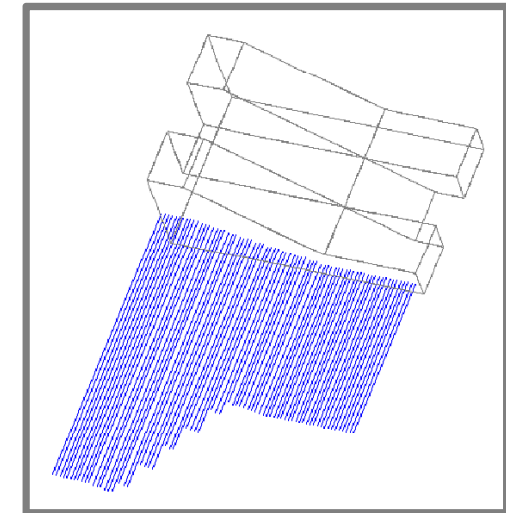
**Conclusion:** Robust solution for free-form surfaces measurements with CMM

## LITERATURE REVIEW – Laser scanner

### PRIETO, F., et al. 1999, 2000, 2002

- Laser scanner best positions (based on CAD data)
- Best results with: 170 to 240 mm distance
  - 35 to 35 ° angle ( $\alpha$ )
  - 15 to 35 ° angle ( $\beta$ )
- Collisions avoidance (voxel model)
- Strategy improved accuracy of measurement

**Conclusion:** Optimal positioning increases the accuracy  
Viewpoints projection strategy

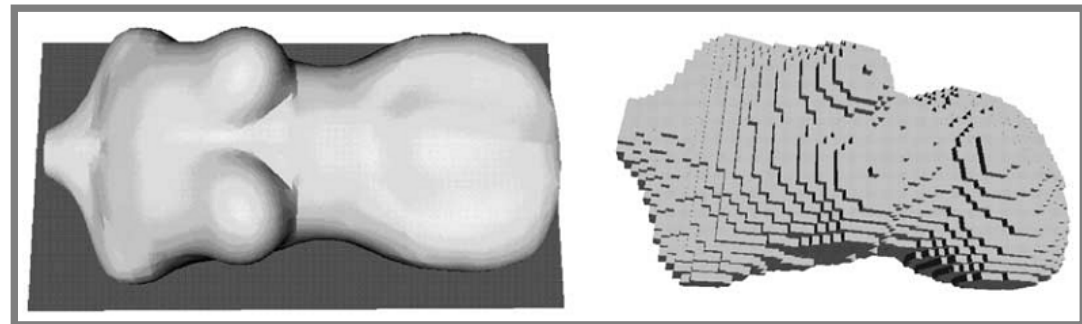


## LITERATURE REVIEW – Laser scanner

**MARTINS, F. A. R., GARCÍA-BERMEJO, J. G., CASANOVA, E. Z., PERÁN GONZÁLEZ, J. R. 2006**

- Manual measurement with poor positions → lower accuracy
- Voxel model – viewpoint set & scanning path generation

**Conclusion:** Voxel model vs. NURBS surfaces in other publications

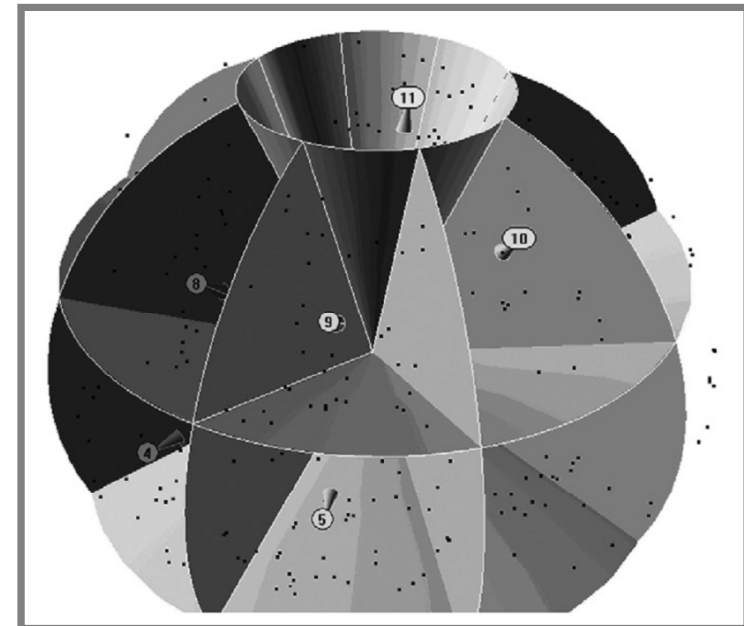


## LITERATURE REVIEW – Structured light scanner

### GERMANI, M., et al. 2009, 2010

- Complet inspection system with 6 DOF robot
- CAD-based possition computation
- Surface Nomal and Visibility Map methods
- Sphere strategy, Patch sliding strategy
- Time savings 25 – 45 %

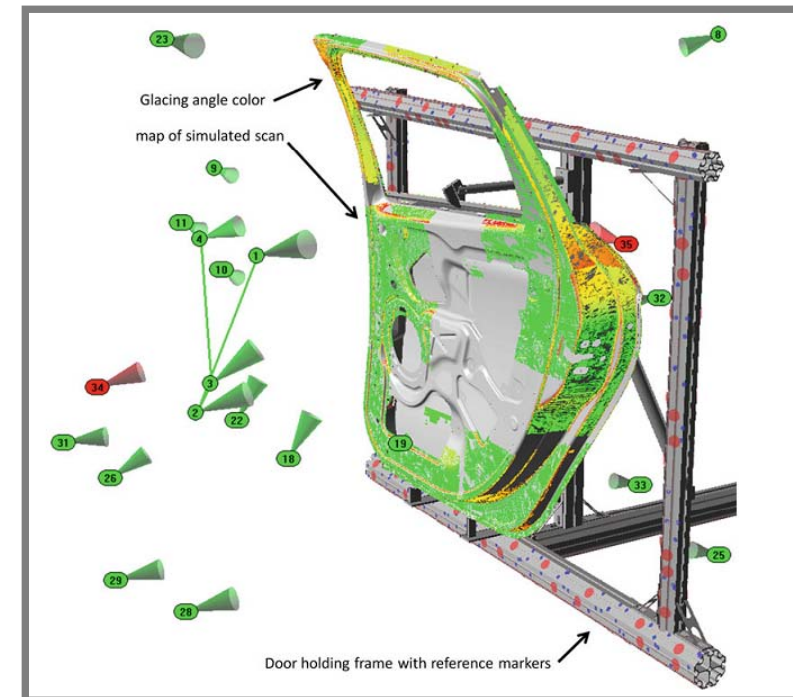
**Conclusion:** Presented strategies and methods  
useful for own utilization



## LITERATURE REVIEW – Structured light scanner

### GERMANI, M., et al. 2012

- Extension to previous work
- 5 strategies – GD&T, Trims and cutouts, Large multifaces surfaces, Global coverage, Specific target points
- Iterative view planning
- Registration – RPM or ICP method
- Suitable for complex parts (e.g. car door)



**Conclusion:** Methodology of view planning process; strategies for inspection tasks

## CRITICAL ANALYSIS

- **CMM** – registration and sampling problems using different algorithms
  - continuous improvements in free-form surfaces measurements
- **Laser scanner** – registration problems (ICP or assisted)
  - optimal viewpoints problems
  - viewpoints projection strategy & voxel model
- **Structured light scanner** – optimal viewpoints algorithms based on different inspection tasks
  - virtual simulation of measurement
  - methodology of view planning process

## GOALS OF RESEARCH AND METHODOLOGY

- Algorithms for optimal viewpoint placement for two cameras structured light scanners considering models for illumination and reflection

### Methodology

1. *Viewpoints placement calculation* – recursive, genetic or neural algorithms
2. *Illumination and reflection model* – ray tracing, ray casting, Z-buffer methods
3. *Robot positions accessibility* – reverse kinematics
4. *Verification on various objects*

## CURRENT STAGE OF PROJECT

### Theoretical part:

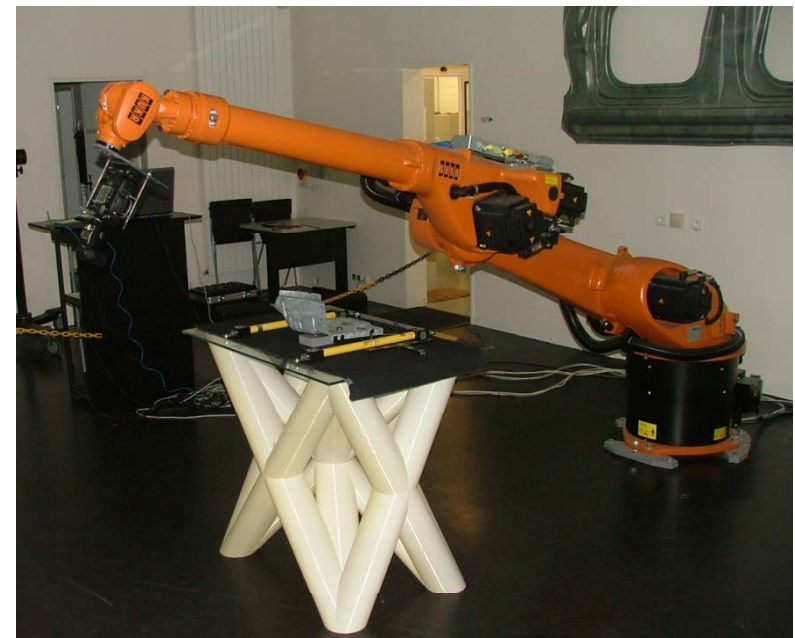
- Literature review
- Formulation of objectives
- Known algorithms selection

### Practical part:

- Robot positioning skills
- Parameters and algorithms for optimal positions
- Employment of reflection model
- Robot position accessibility
- Verification measurements

### Final part:

- Formulation of conclusion
- Publishing the dissertation



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# Thank you for your attention

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