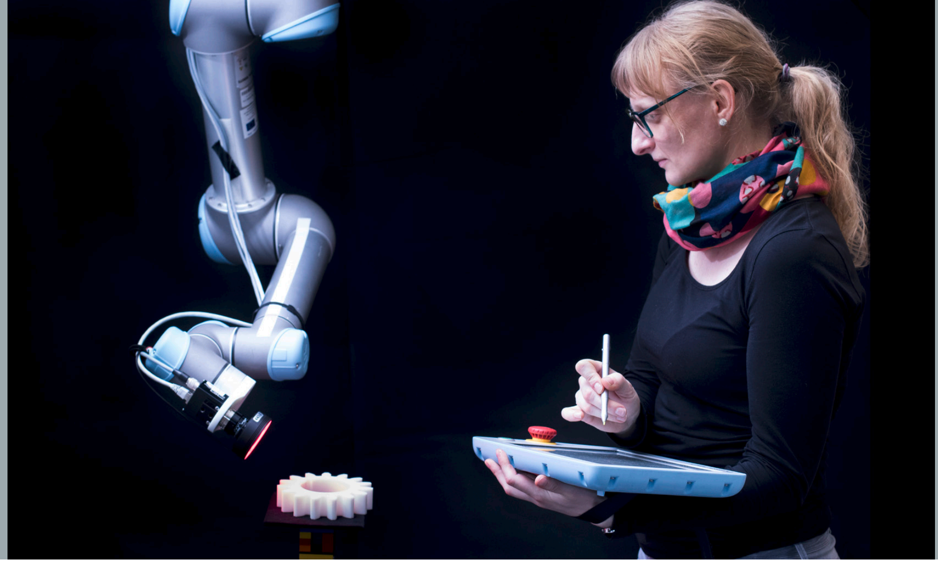

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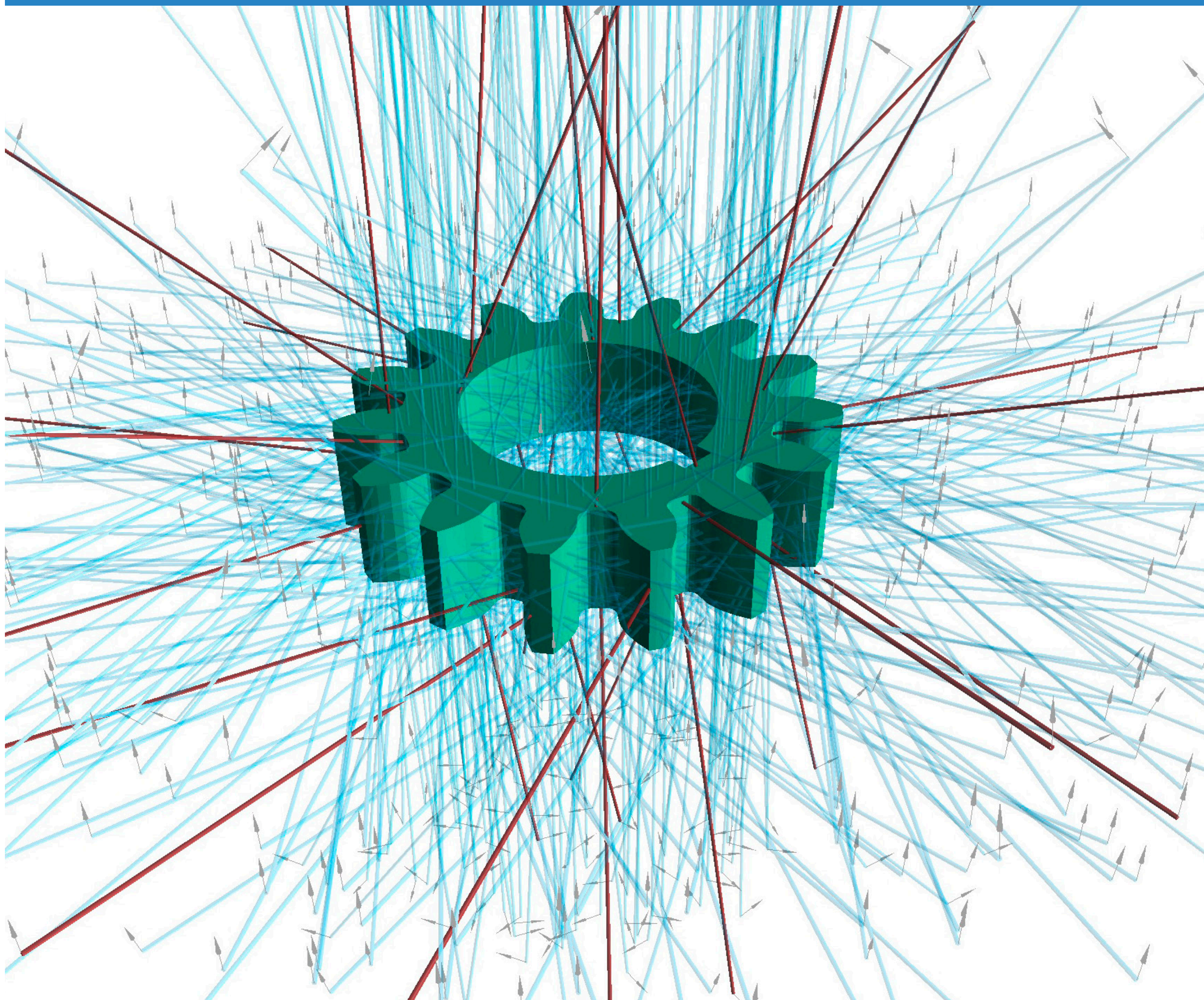
VIRTUAL IMAGE PROCESSING



4 *The otherwise tedious manual training of the robot can be automated with the ITWM software.*

Why Virtual Image Processing?

For most of the applications, the inspection systems are custom developed and require a prestudy, where the requirements for such a system are determined.

The prestudy consists of building a physical inspection system (data acquisition) prototype and algorithm development. The hardware configuration and arrangement is a laborious process, relying greatly on the experience of the engineer building it. The system will then be used to acquire images of the defected samples, which serve as basis for computer vision algorithm development.

Problems with the state of art are following:

- Inspection system design relies completely on the engineers experience
- Hardware components are often heavy and have to be remounted for every new configuration, posing a big restriction on the number of configurations which can be tested
- Number of defected samples is limited, making it difficult to develop robust systems
- Objects of high geometrical complexity are hard to inspect due to problems with self-occlusion
- Depending on the material of the object it may be very hard to acquire an image of the object in which the illumination is homogeneous (e. g. metal material will always contain many reflections and areas which are too dark or over exposed)

The ITWM is working on solving all of the above stated problems by orienting our research to Virtual Image Procesing and making a “digital clone” of the complete prestudy process.

Demonstrator

Currently, the Revolving/Evolving Product Inspection (EPI) developed at Fraunhofer ITWM is a step on the way to virtual inspection. During the circumferential inspection, not only the general conditions such as component geometry and surface condition are taken into account as precisely as possible, but the system has also learned where possible problem areas can lie during the analysis.

It is first “fed” with the CAD data of a workpiece. This means that the inspection system knows what a good part should look like. The software is designed to calculate individual scan paths for the objects

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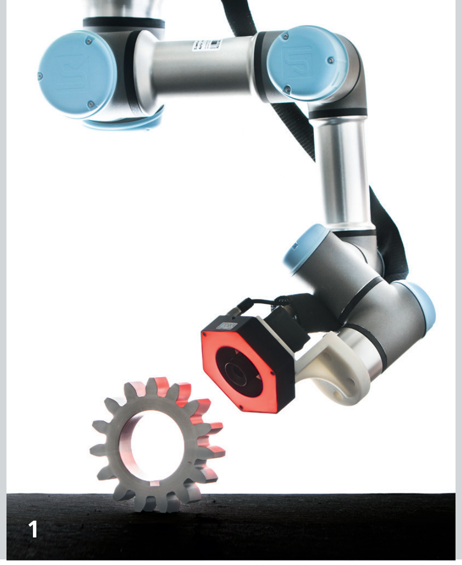
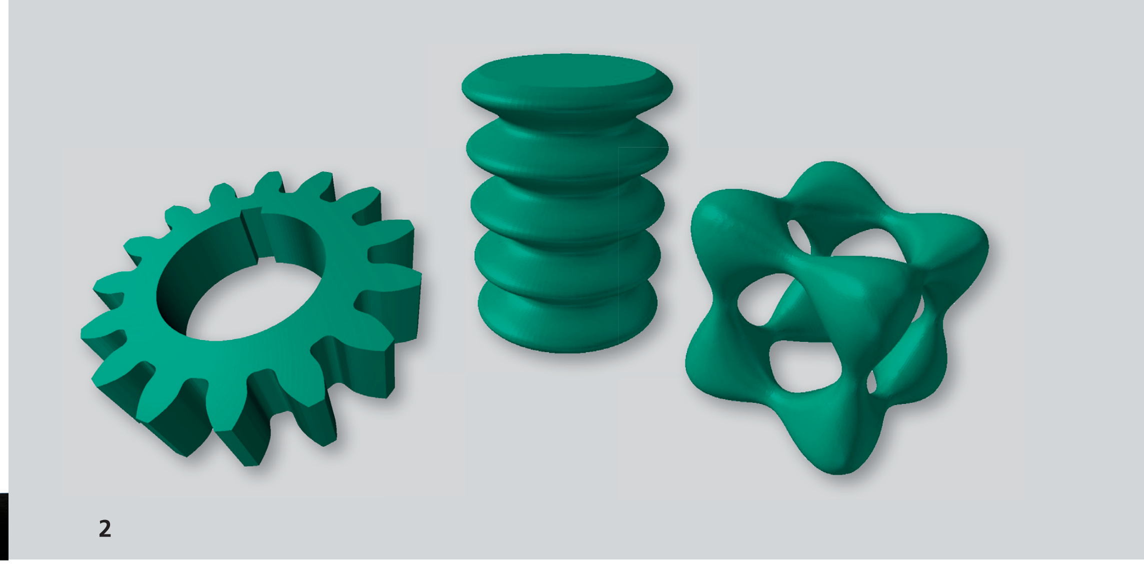
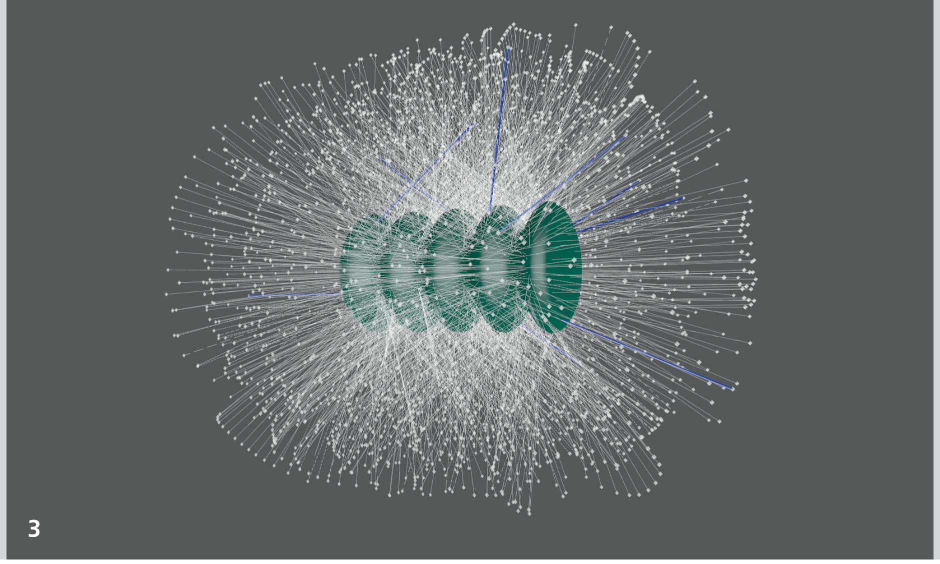


1 *Demo System: Optical control of complex products; Goal: Simulate complete inspection environment*



2 *Some examples of geometrical complex products*



3 *The picture shows a CAD model with the visualization of all possible viewpoints (2,778 white markers) and a limited selection of viewpoints (nine blue markers).*

What is Virtual Image Processing?

Production facilities are becoming more flexible, so that no new plants have to be built when switching to new products. Every step of the production is controlled and digitalized to be as flexible as possible. And yet, when it comes to inspection, months of pre study are required, and no off-the shelf solution is available.

An inspection system consists of many hardware components, typically selected and parameterized by experienced engineers on the basis of physical tests.These tests of different hardware solutions cost a lot of time and effort – several hours per test run. Therefore, a configuration is often chosen that works but is not optimal.

To make this process more flexible and efficient, we are developing an adaptive, simulation-based framework for a process we call Virtual Image Processing: in the future, industrial inspection systems will be completely virtual designed and tested for reliability using this framework.

Optical inspection of complex products

The ITWM combines the fields of image processing, computer graphics, machine learning and robotics to make optical inspection of complex products possible. The basic idea is to simulate the complete process of an optical inspection in the computer.

Paradigm shift in surface inspection

The Virtual Image Processing research group is set on changing the paradigm by developing a modular framework fully capable of planning the acquisition requirements to completely inspect any given product. Using computer vision, computer graphics, machine learning and robotics it is possible to develop a framework offering tools for design optimization, allowing the assumption of a flexible image acquisition setup. Currently, very little or no research is focused on inspection system design and optimization.

Framework Development

A virtual image processing framework can overcome this gap, by thoroughly testing the acquisition hardware of choice and simulating the result. Most importantly, it makes optimization of component positioning possible, without requiring the engineer to remount the equipment repeatedly. Furthermore, computer vision algorithms can be developed and tested on simulated images, along with the acquired ones, overcoming a frequent problem of defect sample acquisition. Such problems are often found in industries where defects occur rarely but are critical when they do – airplane blisks (Blade Integrated Disk) and car brakes are two examples.

Virtualization Core in Focus

The virtualization core of the system consists of the components “Planning” and “Simulation”. We simulate what the camera sees and use this information to design the inspection system. The planning component calculates multiple system configurations, consisting of cameras, optics, lighting. The virtualization core calculates possible hardware solutions from the CAD model – the geometry – of the product and various inspection parameters such as defect types, product material and inspection speed. In addition, the user receives a series of simulated images that can be used to test the inspection system during development.

The planning component calculates an inspection process with optimal surface coverage of the product according to the previously defined requirements. With the help of the simulation component, it is possible to carry out this planning even for geometrically complex products where the automation of today’s systems has so far failed.

The necessary illumination and a list of camera viewpoints are calculated from the CAD model of the product. For this process, the entire inspection environment is modelled and the behavior of the sensors is simulated using a physical based rendering. The traversal path of the camera is then planned based on a list of viewpoints.

The framework is currently being researched and developed on several fronts in parallel:

- Parametric surface estimation
- Active model-based position planing and optimization
- Camera lens modelling
- Position-based defect augmentation
- Surface light response modelling