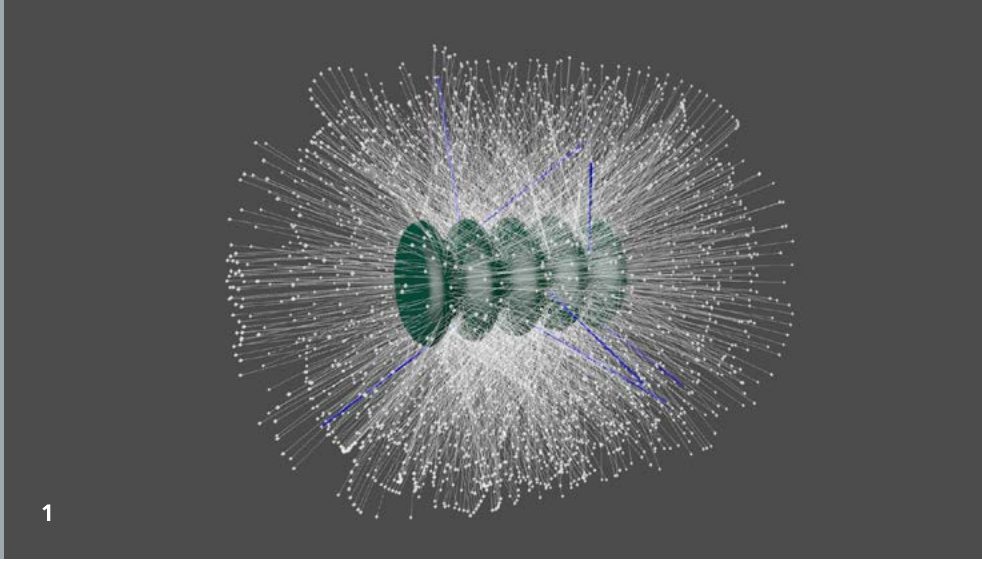

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VIRTUAL IMAGE PROCESSING

1 *CAD model of a test object with camera viewpoint candidates (white) and the final viewpoints selected in the optimization step (blue).*

Factories are getting more and more automated. Production plants are becoming more flexible, so that no new facilities have to be built when switching to new products. However, the integration of automated quality control systems is often neglected. Inspection systems, on the other hand, are inflexible and designed to inspect specific products at great expense. Virtual image processing is one way to solve this problems.

An inspection system consists of many hardware components, typically selected and parameterized by experienced engineers on the basis of physical tests. New systems are developed iteratively. Experts design an initial system, which is then modified until it can inspect the product with sufficient accuracy. 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. The resulting sub-optimal image quality must be algorithmically compensated later.

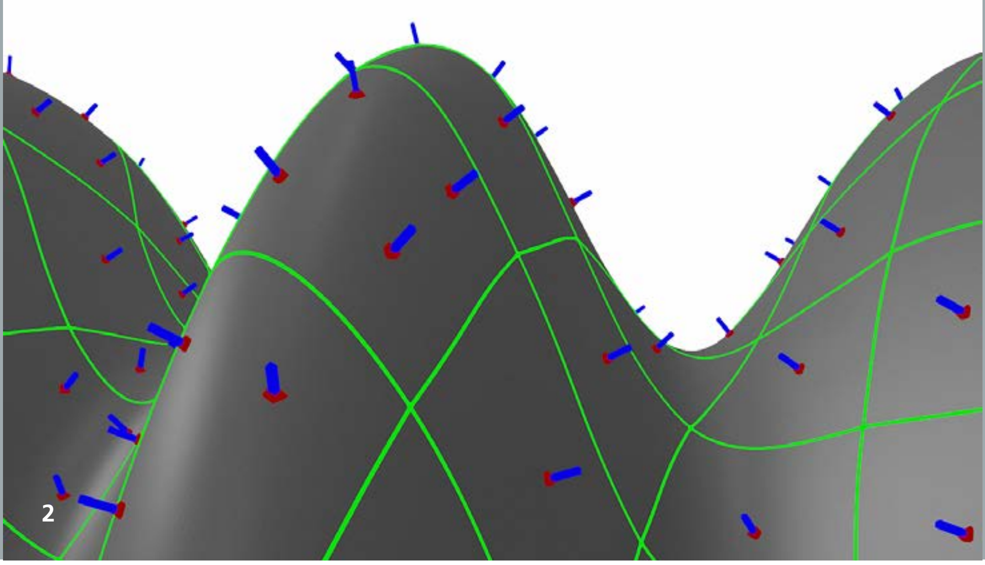
Digital twins simplify quality control

To make this process more flexible and efficient, we are developing an adaptive, simulation-based framework that will revolutionize the development process for inspection systems. In the future, industrial inspection systems will be completely virtual designed and tested for reliability using this framework.

For most of the produced components, there will be a CAD model, the so-called digital twin. Every step of the production process will be computer controlled. It will be possible to manufacture different products in small quantities with the same equipment. At the same time, the demands on quality are also growing. So what does an inspection system in such a factory have to look like? Above all, it must be possible to adapt it quickly and easily to changed production conditions. This will involve the use of several robots that can take analyzable images from free-form surfaces and even complicated geometries. The inspection system of the future will also predict how reliable it can detect certain defects at different areas of the product.

Virtualization core for planning and simulation

On the way to a complete framework for virtual inspection planning and image processing, we first optimize the positioning of product and camera; in addition, we develop simulation algorithms to generate a sufficient number of images of all defects to be found. These are often lacking in areas where defects can have devastating effects, such as turbine disks or brakes.



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, etc., which the robot can later use for optimal inspection. 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.

2 Close-up of the pivot points for the camera viewpoint candidates. A few points cover flat areas, while more points are generated in strongly curved regions

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.

Current research results: Position planning

Currently we research and develop our framework on many topics in parallel: parametric surface reconstruction, active model-based position planning, camera lens modeling, position-based error augmentation and surface illumination modeling. The focus is primarily on position planning - the backbone of the overall system. We will modularly extend and supplement it with new functionality in order to be adapt the framework to product-specific requirements.