The Cornea

Recent technological developments in vision and imaging will increase the potential for application of optical principles in precision measurement and decision support. This 'vision' had led Dutch engineering company MECAL to extend its portfolio with engineering services and product development support in vision and optronics technology. It now includes automated visual inspections in combination with automated recognition and decision processes, inspections on micron and nanometer level, and development and small-scale production of diagnostic systems. The Cornea Topographer case may serve as an example.

Technological development leads to an ever-increasing availability of low-cost computing power and CCD-enabled cameras. This broadens the industrial application scope of vision technology in the area of precision inspection and positioning. For example, fully- or semi-automatic 3D shape measurements of precision-engineered parts by full image reconstruction may replace point-to-point measurements by 'conventional' coordinate measurement machines. It helps to speed up inspection considerably.

Figure 1. The Cornea Topographer.

Inspection

This trend can be applied fruitfully in the area of (defect) inspection. For instance, MECAL has delivered a system for continuous automated inspection of cast parts that are used in car engines. The cast parts have varying shapes with dimensions of up to 50 x 50 mm^2. Camera and illumination were developed to meet workshop conditions, an image and learning database was defined, and good/fault recognition algorithms were developed and tested. As a result, deviations (in dimensions) of down to 5 µm can be detected. In general, MECAL expects the accuracy for routine inspection of precision parts to decrease from 10-20 µm to the submicron level within five to ten years. Another factual example is an optical precision scanner, capable of measuring the surface of a 2 x 2 m^2 flat object at 10 µm accuracy levels. It will be incorporated in a measurement system, to be used for verifying tolerances of CNC-milling procedures.

Core competences in developing and manufacturing such opto-mechatronic inspection systems are accurate alignment of optical components, optimal control of their positioning, vibration isolation of the mechanical

Topographer case

construction, and image processing (software). Next to 'still' images, multiple or streaming images may also be inspected, for example in fluid process monitoring (concerning bubbles having dimensions less than 1 mm).

Medical optics

Interesting medical applications for optical inspection can be found in the field of eye diagnostics. Recently, MECAL has developed two scanning systems for use by (para) medical practitioners. One case involved a collaboration with India, where reaching out to the poor with easy-to-use, high-quality, low-cost medical scanners is a driver for medical technology development. As diabetes has a high prevalence in India, diabetic retinopathy is a logical 'target' for eye inspection aimed at early and easy detection. To that end, an eye scanner and pre-diagnosis system, for analysis of patients' retina and cornea images, was developed in close cooperation with Indian technology partners.

The Cornea Topographer case

The second medical case involves the Cornea Topographer, which can map the topography of the cornea with higher accuracy and wider range than currently available systems. Mapping the cornea topography is relevant for eye disease detection (such as keratoconus, a degenerative disorder involving changes in the shape of the eye), eye surgery, eye

Company profile: MECAL

MECAL is an independent engineering company, offering services and products in various markets. Headquartered in Enschede, the Netherlands, MECAL employs over 100 professionals, working from offices in the Netherlands, USA, and Japan. MECAL analyses, consults, designs, develops and integrates advanced solutions. Having its origin in MEchanical CALculations, MECAL has grown into an engineering company for the semiconductor industry, the wind energy market and mechatronic product development. It can deliver anything from a concept sketch to a complex product in numbers up to 100.

In wind energy, MECAL aims to help customers – major wind turbine manufacturers, developers, utilities, and wind farm owners – to increase performance and enhance the lifespan of the wind turbine(s). In the semiconductor industry, MECAL helps OEMs and fab owners to detect and decrease vibrations in order to enhance the performance of their equipment. Recently, MECAL has extended its scope towards the vision & optronics market.

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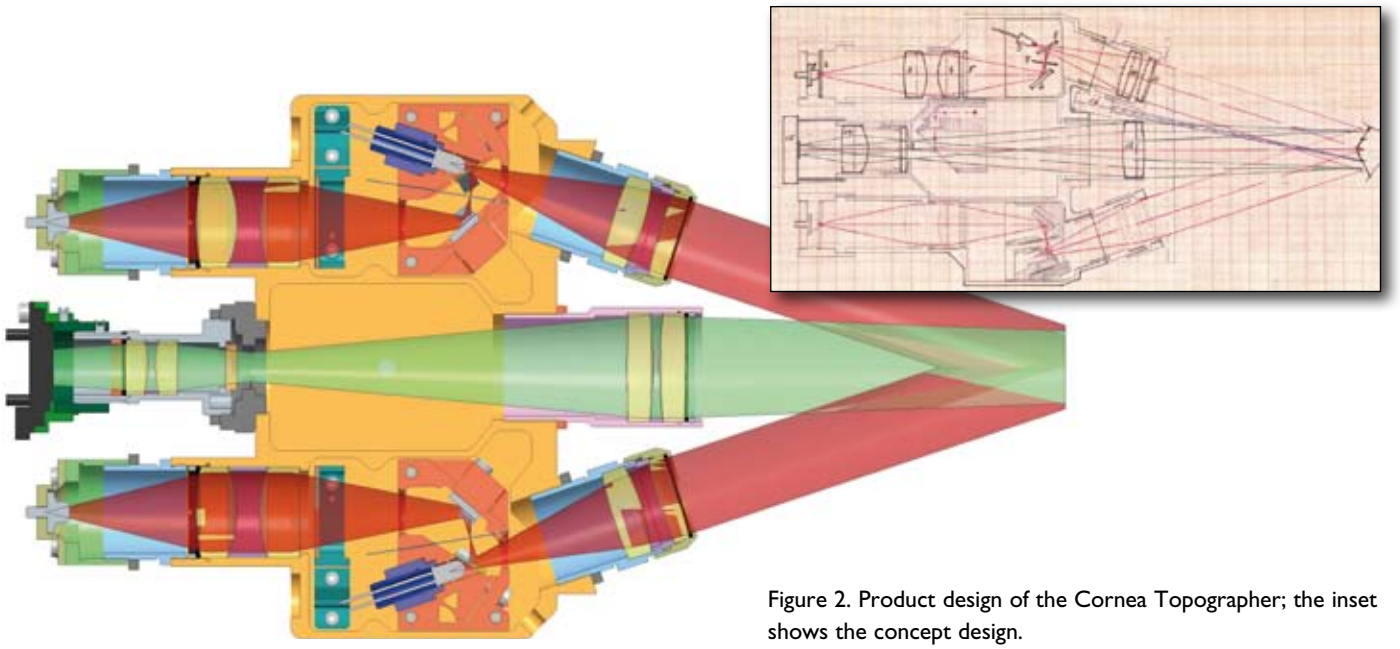

Figure 2. Product design of the Cornea Topographer; the inset shows the concept design.

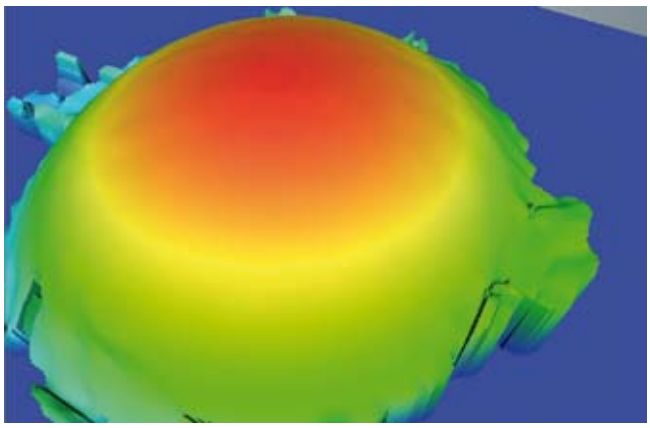

Figure 3. Contour map of the cornea, reconstructed from measurements with the Cornea Topographer.

Figure 4. Detail of the prototype, showing the adjustment of the lenses using elastic hinges.

treatment such as lasering, and contact lense manufacturing (for obtaining a better and more comfortable fit).

Design

Figure 2 shows the concept design. Two projection units, on both sides of the central imaging unit, are used to project patterns on a circular surface of 20 mm diameter. Interference of the two patterns gives rise to so-called Moiré patterns. These patterns are recorded by a 0.45 million-pixel CCD camera and a software algorim converts the data into contour maps of the cornea; see Figure 3. The uncertainty associated with the data in this map is 25 µm in all three directions.

Marketing

After MECAL completed the product design, prototypes of the system were built by Nedinsco, based in Venlo, the Netherlands. Figure 4 presents a detailed view of the prototype as show in Figure 1. At the moment, these instruments are being used for clinical studies conducted by Polish medical researchers. Marketing of the commercial instrument, see Figure 5, will be done by Dutch start-up Meyeoptics.

Figure 5. The final version of the instrument for use by clinicians and opticians.