TWO-VIEWING-PLANES-PROJECTION: THE NEW WAY OF MEASURING SPECTACLE FRAMES

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Abstract: Only the two-viewing-planes-projection measuring principle is able to measure each closed spectacle frame. It is the first functional optical principle for this measuring task. All the other frame tracers on the market depend on a tactile measuring principle. They are especially not able to measure the needed ground of the groove in the frame of so called high curved sport frames. Therefore, till now, a two-dimensional measurement of a pattern plane was used instead of measuring the three-dimensional groove.

The two-viewing-planes-projection setup can calculate out of two 90° shifted perspectives of the spectacle frame by a camera system the form and the circumference for the needed eyeglasses – even for sport frames.

Keywords: spectacle frame, frame measuring, image processing, three-dimensional measuring.

1. THE NEED FOR MEASURING A SPECTACLE FRAME

In the year 2011 more than 60 % of all adults in Germany carry spectacle frames. Therefore the eyeglasses have to be adjusted for the spectacle frame by the optician. After the costumer has chosen his spectacle frame and his defective vision is checked out, it is necessary for the optician to measure the groove of the spectacle frame with a so called frame tracer. The measurement of the spectacle frame is needed, because of the huge range of the different designs and their manufacturing inaccuracies. Each frame tracer on the market depends on a tactile measurement principle with a contact force on the groove of the spectacle frame. Nowadays the most common frame tracer in Germany is the Nidek LT 900 [1]. The contact force is able e.g. to warp the spectacle frame or to shift the spectacle frame in its holder [2].

For these reasons an optical measurement principle was investigated for determining the groove of a spectacle frame within the scope of this work. Extensive analysis of the state of the art and theoretical physicals led to the usage of the machine vision principle. Thereupon a measurement principle is derived and its ability is verified for measuring the groove of the spectacle frame. The measurement principle is called two-viewing-planes-projection. It is bases on two 90° shifted perspectives by a camera system.

2. THE SETUP OF THE TWO-VIEWING-PLANES-PROJECTION

The two-viewing-planes-projection was developed to a prototype, because of its easy engineering assembly as well as its clear and quick measuring process. Due to the very high cost of telecentric objectives each half of the spectacle frame is measured by its own in the chosen setup. In the present work the viewing direction is varied by translation and rotation between the image processing system and the measuring object, see Fig. [1].
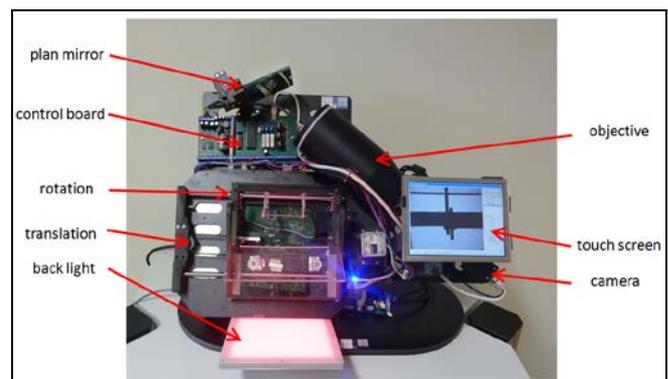

Figure 1: Demonstrator for the two-viewing-planes-projection

The spectacle frame is recorded by a machine vision system in front and side view. Out of the front view the measuring values of the xy-plane are detected and the xz-plane is determined out of the side view. A visual assignment of the two projections with marks, such as in the photogrammetry, is not necessary because this correlation is realized mechanically.
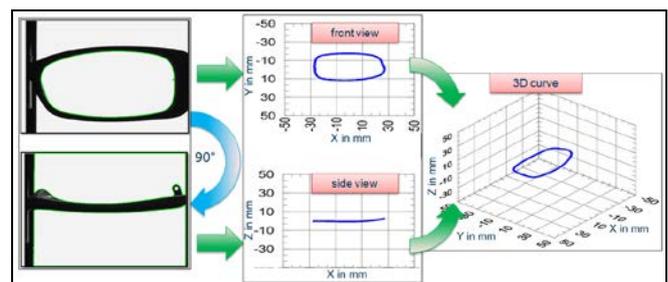

Figure 2: Getting the 3D curve out of the font and side view

It must be ensured by the mechanical structure that the spectacle frame is fixed securely in the holder. During the movement no relative movement is allowed between the holder and the spectacle frame. At the beginning of the measurement, the spectacle frame is aligned. This alignment is achieved when the upper and lower edge of the spectacle frame overlap in the side view. Within the different views the measuring points are detected by contour tracing algorithms, see Fig. [2].

Out of the measuring points from the two viewings the three dimensional run can not be calculated correct. The depth of the groove is missing. In [3] is shown that the groove of the spectacle frame is an undercut. So an additional groove-depth-measuring-method is needed. This method can be integrated in the measurement process or has to be supplied externally. It is sufficient to detect the depth of the groove at one measuring position, as shown in [2].

When looking at the material and shape properties of the frame groove, an innovative and novel method is used for this measurement task. It is a combination of tactile and optical measurement. The measuring method is shown in Figure 3 in a sectional view through the frame groove.
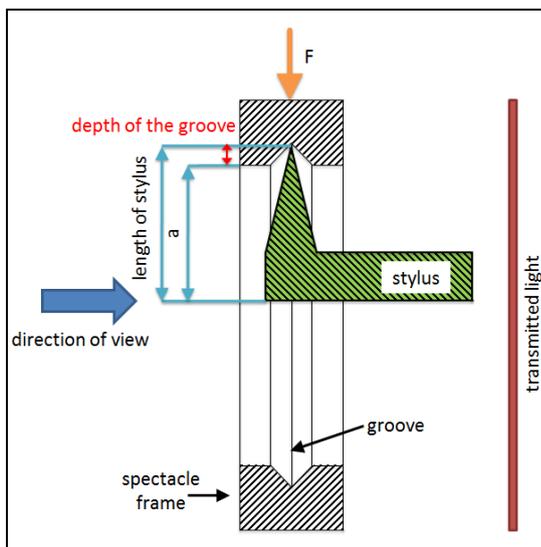

Figure 3: The groove-depth-measuring-method.

The aim of this method is to get the depth with reference to the information in the front view. For this purpose, a stylus is inserted in the measuring range of the image processing system in the frame groove. The length of the stylus is known and it is greater than the maximum depth of the groove. Furthermore, the angle of the stylus top is smaller than the groove angle in order to touch always the ground of the groove. A contact force F, acting on the spectacle edge opposite to the stylus, prevents the lifting of the spectacle frame. The free movement of the spectacle frame during insertion ensures that the stylus is centered in the v-shaped groove. The location should be chosen so that the entire frame groove is depicted with stylus on the camera sensor. Subsequently, a contour trace along the rear edge of the frame groove is performed. From the obtained measurement the values of the spectacle frame can be extracted from those of the stylus. The range of spectacle frame that is covered by the stylus is interpolated by the

neighboring areas. Using the measured values of the stylus its position is determined in the image. In connection with the measurement data evaluating the illustrated distance (a) is determined between the rear edge of the frame groove and the lower edge of the probe. The depth of the groove is the difference between probe length and the distance (a). With this measuring method the depth of the groove is detected fast, material and form independently. For the measurement procedure also indicates the ease of use and low cost.

All these measuring steps are needed for the following fabrication of the eyeglasses [2].

3. EVALUATION OF RESULTS

The areas of interests (AOIs) of the side view (left) and front view (right) are shown in Fig. 4. There are AOI search lines (green) for the determination of the adjustment angle drawn, which detect the upper and lower edge of the rim of the spectacle frame. The beginning of the lower AOIs is selected as a function of angular position. The design and the properties of extremely low-frames are considered by it.
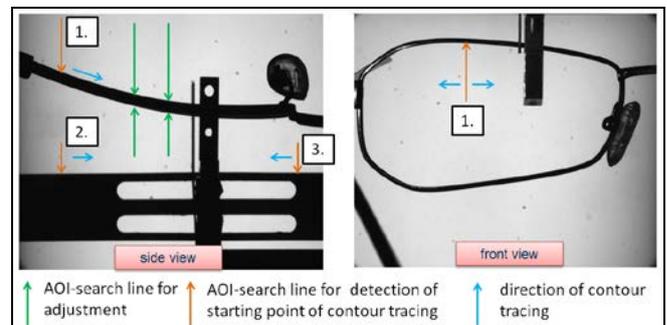

Figure. 4: Measuring process with two contour followings.

To determine the measuring values of the side view three contour tracings are necessary in total. The first takes place at the top image region to measure the back rim frame. The first valid edge is selected as the starting point of the contour tracing (orange). The direction of the first contour tracing is directed to the bridge to get to points along the back side.

The other two contour tracings (2 & 3) are for determination of measurement points along the front edge of frame, which is interrupted by the spectacle holder. The position of the spectacle holder is known within a calibration curve, whereby the orientation of the AOI starting point for finding optical valid points is given. Toward the center of the image each case a further contour point is determined, which indicates the direction of the contour tracing. The contour tracing of these traces with input parameters only work for a mechanical connection of the frame with the eyeglass holder and if the position of the spectacle holder is known by the calibration curve. This results in a complete independence of the spectacle frame and its variety of forms for the measurement assessment in the side view [2].

In the front view (Fig. 4) the position of the spectacle holder is known. It is also known that the spectacle holder is mechanically connected to the eyeglass frame. The determination of the AOI search line is thus chosen on the

basis of the spectacle holder. The AOI search line (1 right) is always from the image center to its edge directed.

It is detected the spectacle rim which serves as the starting point of the contour tracing. To take account of all spectacle frame shapes, the contour tracing is from the starting point in two directions. The direction is determined depending on an adjacent contour point [2].

The results of contour tracings of the side and front view are not directly usable for manufacturing of ophthalmic lenses. The measured values contains problematic areas (orange) by the construction of the spectacle holder and attached parts of the eyeglass frame, see Fig. 5.
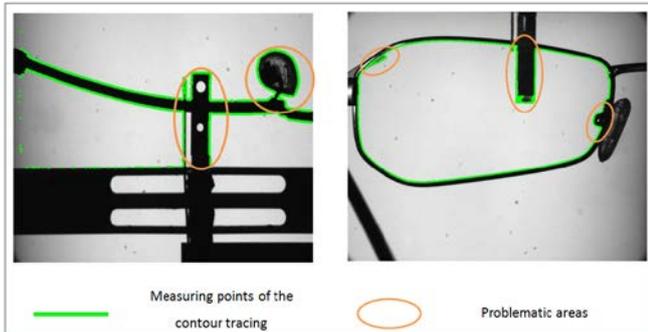

Figure 5: Problematic areas in side and front view

In the side view the problematic areas are eliminated with a circular approximation. For the elimination in the front view a-priori knowledge is needed. The production of the spectacle lens is effected by a rotating grinding wheel against the likewise rotated lens blank. In its result from the production process only can be a convex shape of the spectacle lens. The application of the algorithm to obtain a convex hull to eliminate projecting into obstacles takes place after [4]

3. CONCLUSION

Final physicals at the prototype for the measurement method with two-viewing-planes-projection showed the disadvantages of tactile frame tracers are removed and the measurement of the groove of a spectacle frame is carried out with high accuracy [2]. This can be seen in the well grinding results in Fig. 6 and also in Table 1.

Figure 6: First grinding results with the
two-viewing-planes-projection

Table 1: Comparison between Nidek LT 900 and demonstrator

parameter	NIDEK LT900 [2]	demonstrator
number of measuring points	1000 per frame side	2000 to 3000 per frame side
measuring depth (Meniskenwölbung)	Z = 30 mm	Z = 50 mm
box size	X = 20..70 mm	X = 1..70 mm
	Y = 24..55 mm	Y = 1..50 mm
uncertainty of measurement	0,1 mm per circumference measurement	0,08 mm per circumference measurement
stylus changes after...	ca. 15.000 measurements	no wear parts
measuring time per spectacle frame	30 s	25 s
Measuring principle	tactil (Inductiv position encoder)	optical (Zwei-Tafel-Messverfahren)
measuring force	8 N	none
measuring equipment ability C_g	2,86	3,56

The development leads to a design which can be seen in Fig. 7.

Fig. 7: Design of the demonstrator [5].

ACKNOWLEDGEMENT

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