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DETERMINATION OF SHARPNESS AND HOMOGENEITY FOR (HIGH-RESOLUTION) HEADLIGHTS AND LAMPS

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Technical task:
With the introduction of the DML (Digital Matrix Light) headlamp in the etron sportback and the alternative technology DGL (Digital Grid Light) headlamp based on µAFS or EVIOS, a projection of characters, special light distribution or driver assistance images (e.g. track width) is possible. This requires the sharpest possible image on the road via the lens system, which today is mostly done by manual/subjective evaluation.

In addition, light-dark boundaries are evaluated manually/subjectively, using gradient-based methods or edge detection algorithms.

The homogeneity of headlamps and other lights is also evaluated manually/subjectively, in some cases (exclusively for some headlamps, for no other lights) with gradient based methods.

Initial situation:
The evaluation of sharpness and homogeneity is in most cases done by subjective/manual evaluation and is therefore hardly comparable or objectified. An evaluation of previous methods for homogeneity assessment showed that there is a big difference between the calculated value and human perception. Today's pixel arrays for daytime running lights are exclusively evaluated manually/subjectively with regard to the sharpness/over-sharpness of the segments.

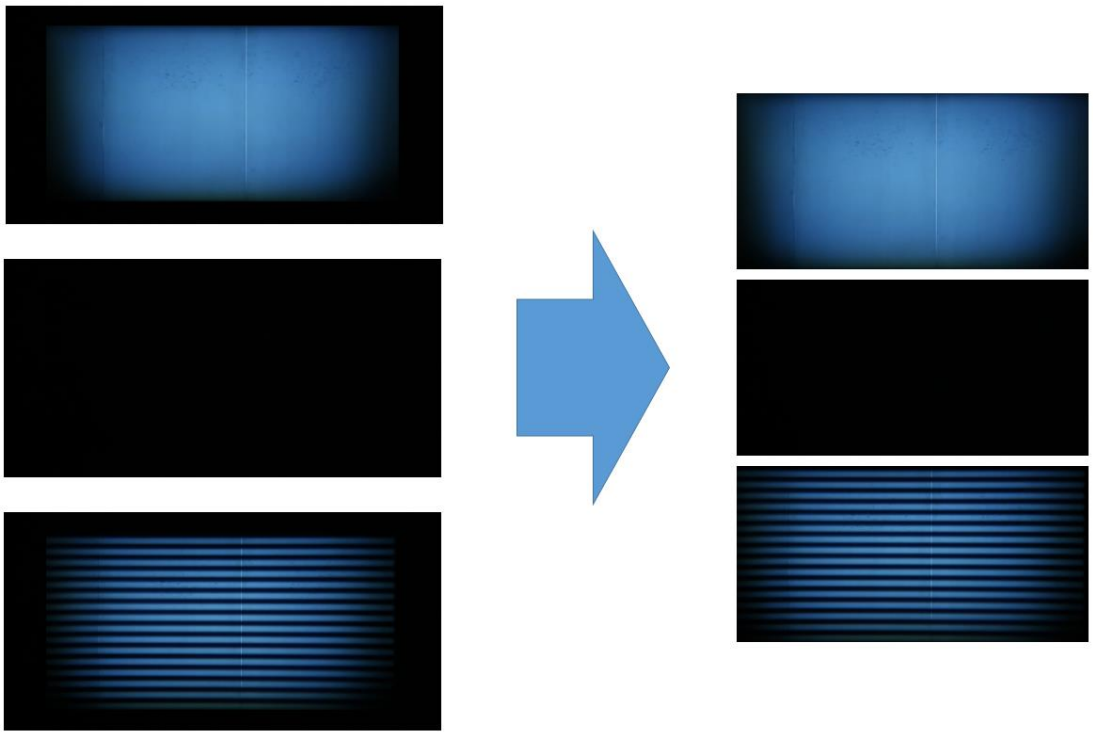
Solution:
The evaluation of the sharpness or homogeneity of headlights or luminaires is performed by means of a defined procedure based on the frequency analysis (FFT) of test images. The result is normalized by using an artificially generated reference image. This eliminates certain systematic test errors (e.g. uneven grain of the test wall). The result of this procedure is a number (possibly several, if the image is divided into different areas) that provides information about sharpness or homogeneity.

The sharpness/homogeneity evaluation can be used while the vehicle is in motion (using the built-in vehicle camera) to detect aging effects of the headlamp, to predict/recommend workshop stops or to activate headlamp cleaning systems (even dirty or defective headlamps can appear blurred or inhomogeneous).

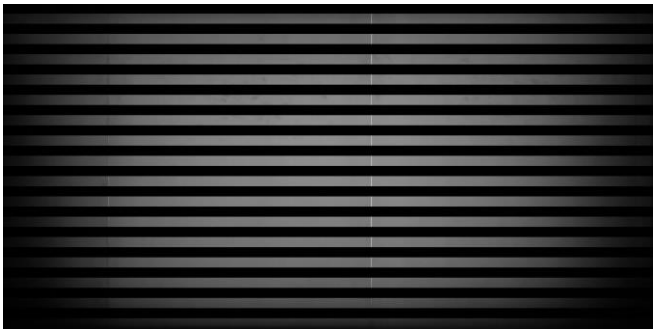
Advantages:
An objective evaluation of sharpness and homogeneity is possible with great comparability. The described procedure can be applied flexibly to different headlights and lights (e.g. also taillights or direction indicators). An evaluation of homogeneity and sharpness is done by means of a procedure. This results in an optimal night vision and reproduction of the projection or, as a result, the desired design.

Possible application:

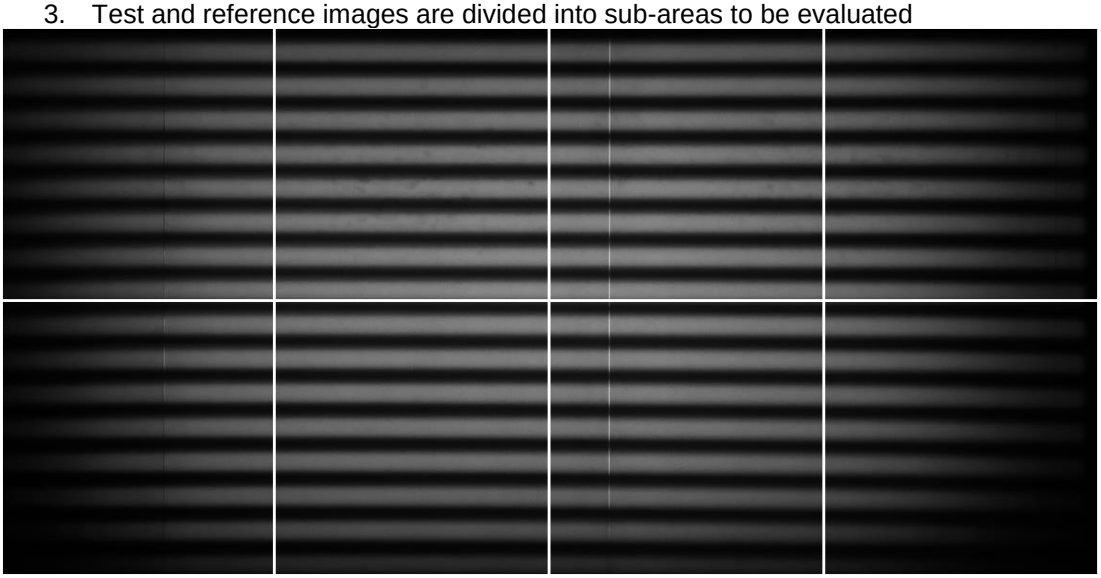
0. the captured images are optionally manually or automatically cropped to the area to be evaluated (usually the area of the white image).



1. Captured images are converted to grayscale images
2. min. a reference image (same number and representation as test image(s)) is artificially generated: lines or columns of the white and black image are masked and added

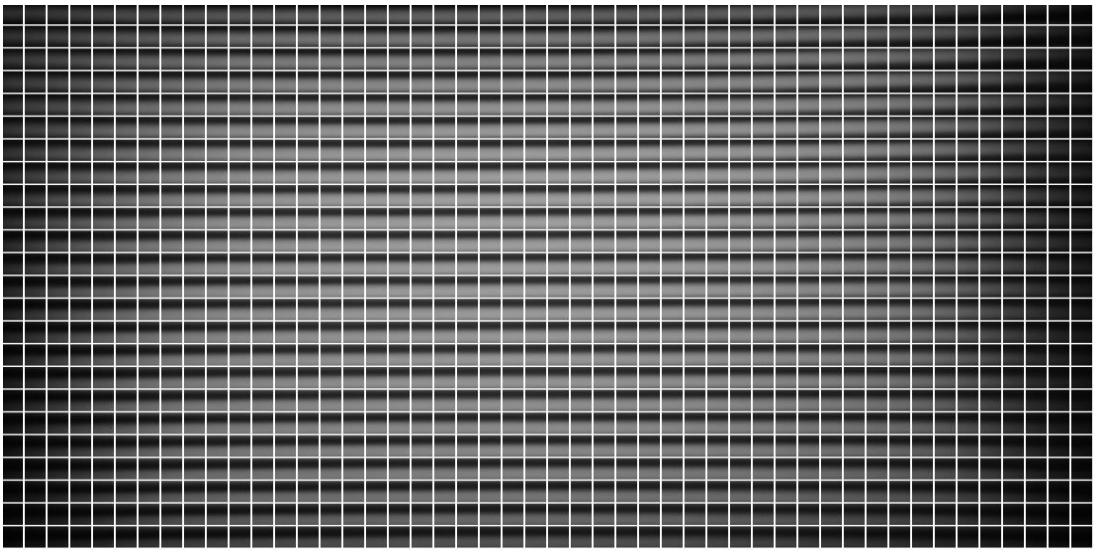


3. Test and reference images are divided into sub-areas to be evaluated

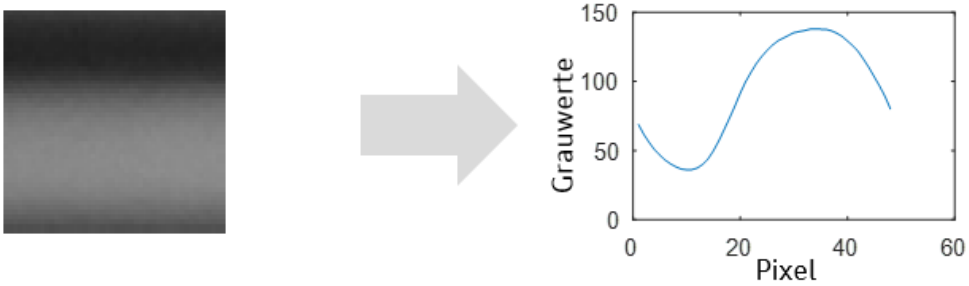


The following steps 4-7 are performed for the test and reference image analog/parallel

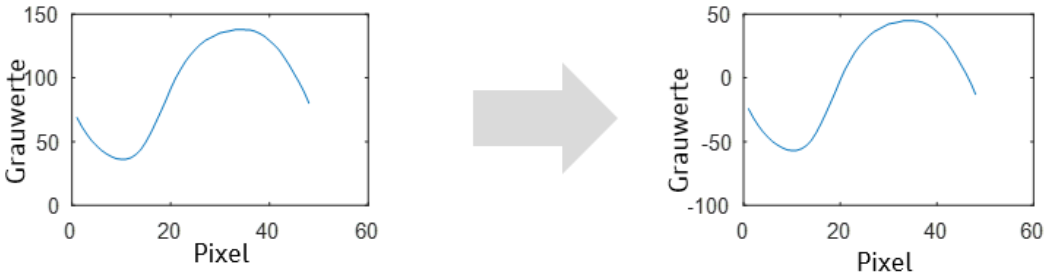
4. The image or the sub-areas to be evaluated are further divided into smaller, square sub-areas, which have a side length of one period length of the line pairs



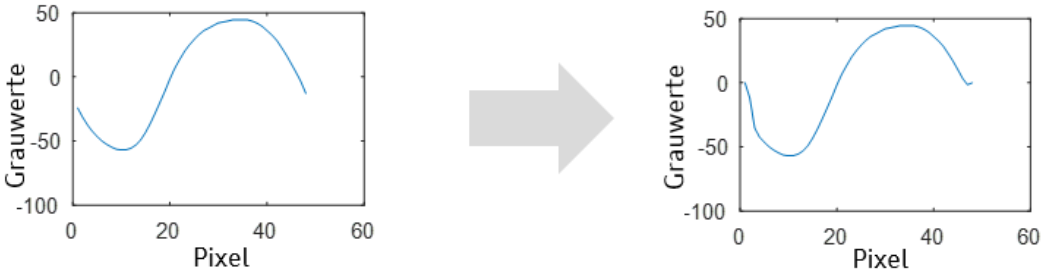
5. Converting image to pre-processed signal
   a. The subareas are reduced to line or column vectors (depending on the orientation of the test pattern) (e.g. averaging, max-pooling, ...)



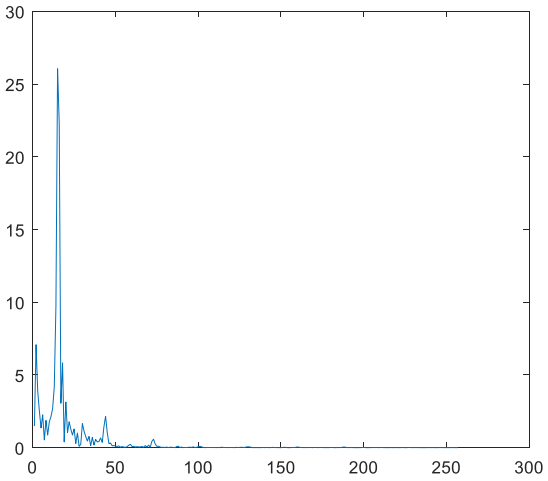
   b. Average value adjustment (subtract offset)



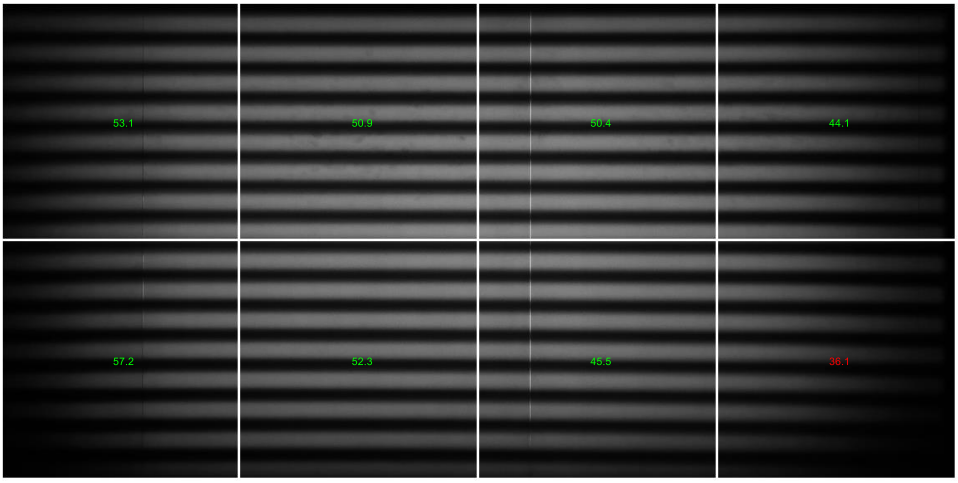
   c. Filtering with window function for later FFT (e.g. Tukey, Hanning, ...)



6. determine FFT of the signal



7. calculate area under FFT (without equal parts, f=0)
    a. SQF (Subjective Quality Function)
8. 8. form percentage ratio between SQF_Test and SQF_Reference
    a. Rating number Y
9. 9. average all Y of the smaller, square subareas in the area of the larger subareas to obtain the valuation number X
10. 10. Weight X with sensibly determined threshold value.
    a. O.K. or N.O.



The procedure is shown here using a DML headlight, but can be applied to any lights and headlights (halogen, xenon, LED, laser) without modification.

For a homogeneity evaluation a white test image is used, the reference image can be created in the same way.

The difference between homogeneity and sharpness is that high values X are required for sharp images and low values X for homogeneous images.