

Test-Time Dependence of the Accuracy of a 3D-Stereophotogrammetry Measuring-Instrument Using Structured Light

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Abstract

For a broad set of 3D measurement applications fast data-acquisition is essential. Depending on the task it may be feasible to trade accuracy for a more rapid measurement process. Based on a stereophotogrammetrical system, which uses structured-light and a correlation-technique to allocate homologous points in a series of stereo-images, a reference object was captured and reconstructed with a variety of measurement-periods.

1 Introduction

Stereophotogrammetry is an optical measurement method which is well adapted for various technical and medical applications [1-3].

The background of our activities was to develop a method for function orientated diagnostics and therapy in dentistry to provide prognoses for jaw-growth or surgical procedures.

The aim was to get a dense 3D point cloud of a human face by a single, rapid measurement.

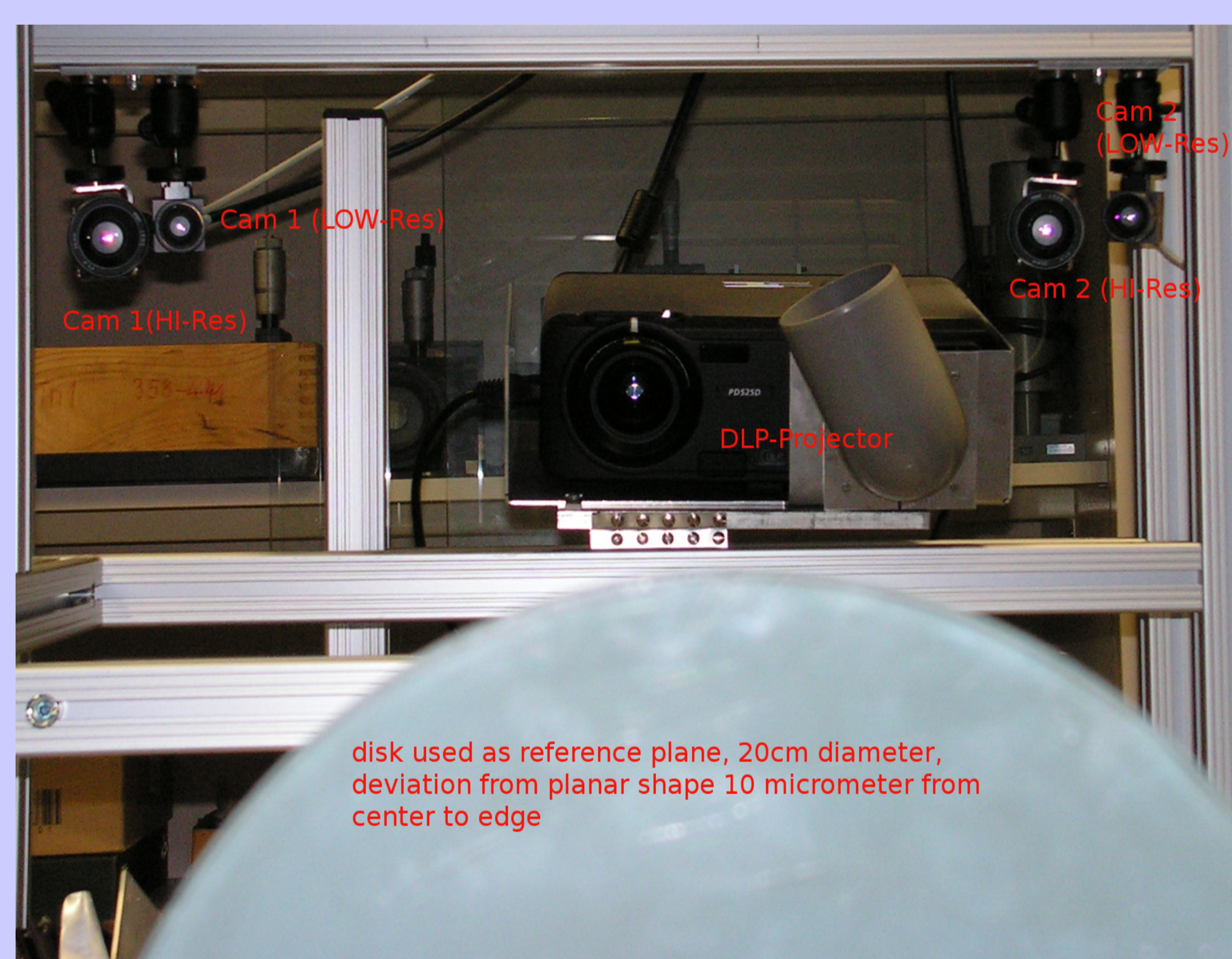
As a much broader class of tasks require a fast measurement-process, it was interesting to test the accuracy of our system with different measurement-periods.

Most techniques that use structured-light to encode the object's surface, rely on a series of images to find homologous points. Though the test-time-limit is given by the minimum amount of images necessary to yield a dense and accurate point cloud of the object.

3 Experimental Setup

The figure below shows the experimental setup, which consists of a digital light projector and four cameras (two for high-resolution (1280x960) stereo-setup and two for low-resolution stereo-setup (640x480)).

The lateral resolution is about 0.2mm for the high-resolution setup, and 0.5mm for the low-resolution setup.



5 Conclusion

Depending on the setup and task a decrease of the measuring time is possible with only moderate loss of accuracy.

The presented system is able to capture all data within 2s (HI-Res) or 0.7s (LOW-Res) with good quality. Tripling the test-time improves rms-results up to 30%.

Furthermore, the underlying working-principle of the system supports the use of high-speed cameras. Using state of the art cameras and a electronical modified digital light projector test-time could be reduced below 10ms.

References

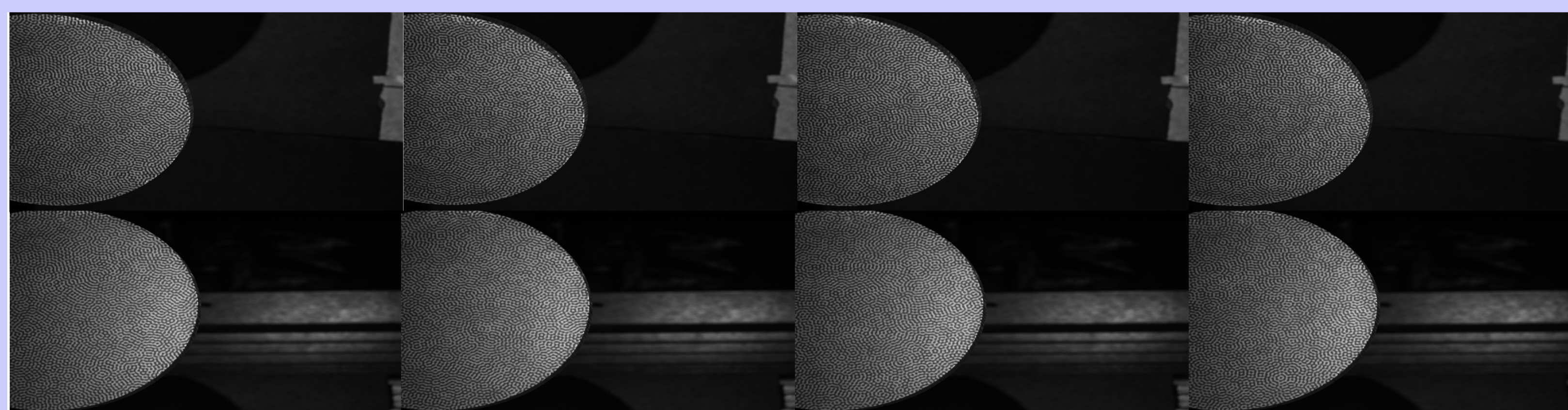
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2 Photogrammetrical Method

For spatial encoding of low-intensity structured objects, a sequence of statistical, band-limited patterns is used. As soon as a new pattern is projected onto the object's surface, the two convergent cameras synchronously capture images of the scene.

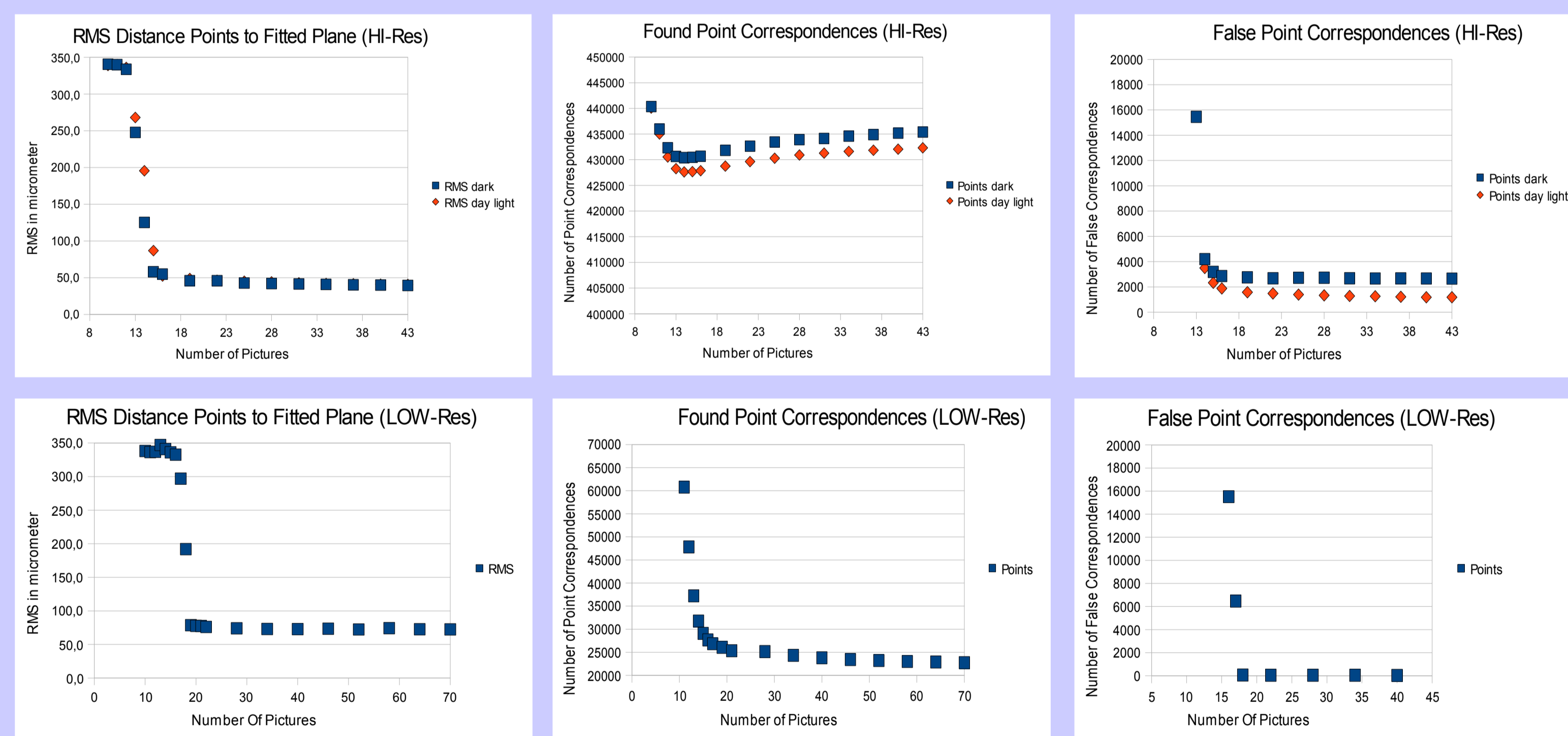
As a result, every point of the object's surface is characterized by a unique sequence of intensity values. For allocating homologous points a correlation algorithm is implemented. Given a sequence of intensity values of a pixel in the image-batch of one camera, it tries to find the most similar sequence of a pixel in the image-batch of the second camera. Here similarity is expressed through a well-known correlation-technique used in image-processing [4], which yields good results at low intensity levels and compensates anisotropic reflection properties of the scene to a certain degree.

If the maximum of the computed correlation coefficients exceeds a predefined threshold („degree of similarity“), two pixels are accepted as homologues.



4 Results of 3D Measurements

To evaluate our experiments in terms of accuracy a matt-finished glass-disk of 20cm diameter was produced. The surface of the disk is used as a reference plane. After capturing the images and calculating the point cloud, we fit a plane to the reconstructed points. Then the distance of every point to the fitted plane can be calculated.



An example of a result of the reconstructed disk is shown below. The point cloud consists of about 430000 points. By comparing the image-series shown in section (2) with the pictures below, it is possible to see that even at the brim of the disk, where the human eye can hardly see structured areas, several hundred points are found by the correlation-technique.

