THE PHOTO-CD - A SOURCE AND DIGITAL MEMORY FOR PHOTOGRAMMETRIC IMAGES

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ABSTRACT

The Photo-Compact Disk, introduced by KODAK in 1992, will become a very important tool for every photogrammetrist using digital images. The maximum resolution of 2048 x 3072 pixel referring to a 24 x 36 mm negative image, that is equivalent to an absolute value of about 12 micrometer, leads to the expectation of a high quality standard.
The presented paper deals with the analysis of accuracy and geometrical stability of the Photo-CD as one possible tool for low-cost and easy analog-digital conversion of images. The further use of the digital image itself for measuring, digital correlation or rectification and even the long time storage of the images are interesting aspects of this new approach.

KURZFASSUNG

Die Photo - Compact Disk, die bereits 1992 von KODAK am Markt eingeführt wurde, kann sich zu einem bedeutsames Werkzeug für jeden mit digitalen Bildern arbeitenden Photogrammeter entwickeln. Die Auflösung von 2048 x 3072 Bildpunkten bezogen auf ein 24 x 36 mm Negativ, das bedeutet eine absolute Auflösung von etwa 12 Mikrometer, läßt eine hohe Qualität dieser Bilddaten erwarten.
Die vorliegende Arbeit behandelt die Untersuchungen bezüglich Genauigkeit und geometrischer Stabilität der Photo - CD, die als möglicher Weg für einfache und kostengünstige Analog-Digital-Wandlung von Bilddaten erscheint. Die weiterführende Verwendung der digitalen Bilder für Bildmessung, digitale Korrelation und Entzerrung sowie die Verwendung als Medium für die Langzeitspeicherung sind weitere nennenswerte Aspekte dieser neuen Technologie.

1. INTRODUCTION

Digital Photogrammetry is a still growing, very important sector in monitoring monuments and sites. Comfortable enhancement, measuring, digital correlation and rectification have lead to a great interest of users all over the world. Getting digital images out of digital or still video cameras is often not satisfying referring to the solution of the images. Scanners for analog-digital conversion are either expensive or insufficient referring to their geometrical stability and accuracy. The introduction of the Photo-Compact-Disk by KODAK in 1992 establishes a tool to get photos digitized in a low-cost way with no need to own a high precision scanner yourself.

2. TECHNICAL SPECIFICATION OF THE PHOTO-CD

KODAK introduced this new medium for digital images in 1992. It looks like any Compact Disk that is used for audio or software purposes. Up to 100 images of small format films can be stored on one CD in true colour (24 bit) format. The way to get digital images is easy: you bring your exposed or developed films, or even diapositives, to any photoshop and get your Photo-CD a few days later.

The images have then been scanned with a high resolution of 2048 x 3072 pixel using a special equipment of a PCD Film Scanner 2000 and a Sun SPARCstation 2. The images are converted from RGB (red-green-blue) to YCC-format, which is able to describe the same image through its luminance and two parameters of chrominance. Using the deficiency of the human eye the chroma components are stored in a less resolution and in combination with the Huffman-coding this results in a high data-compression from about 18 Mbyte down to 3 - 4 Mbyte for each 24 x 36 mm image.The exact file size is depending on its particular details.

Five different resolutions are stored in one data-file. The base of all images is a resolution of 512 x 768 pixel. All the others are derivatives of factors 4 and 16 of this base-resolution.

The two highest resolutions are stored only by their differences to the base image.

Base - Factor	Base / 16	Base / 8	Base	Base * 4	Base * 16
Resolution (pixels)	128 x 192	256 x 384	512 x 768	1024 x 1536	2048 x 3072

Table 1: The integrated resolutions of a Photo - CD - image

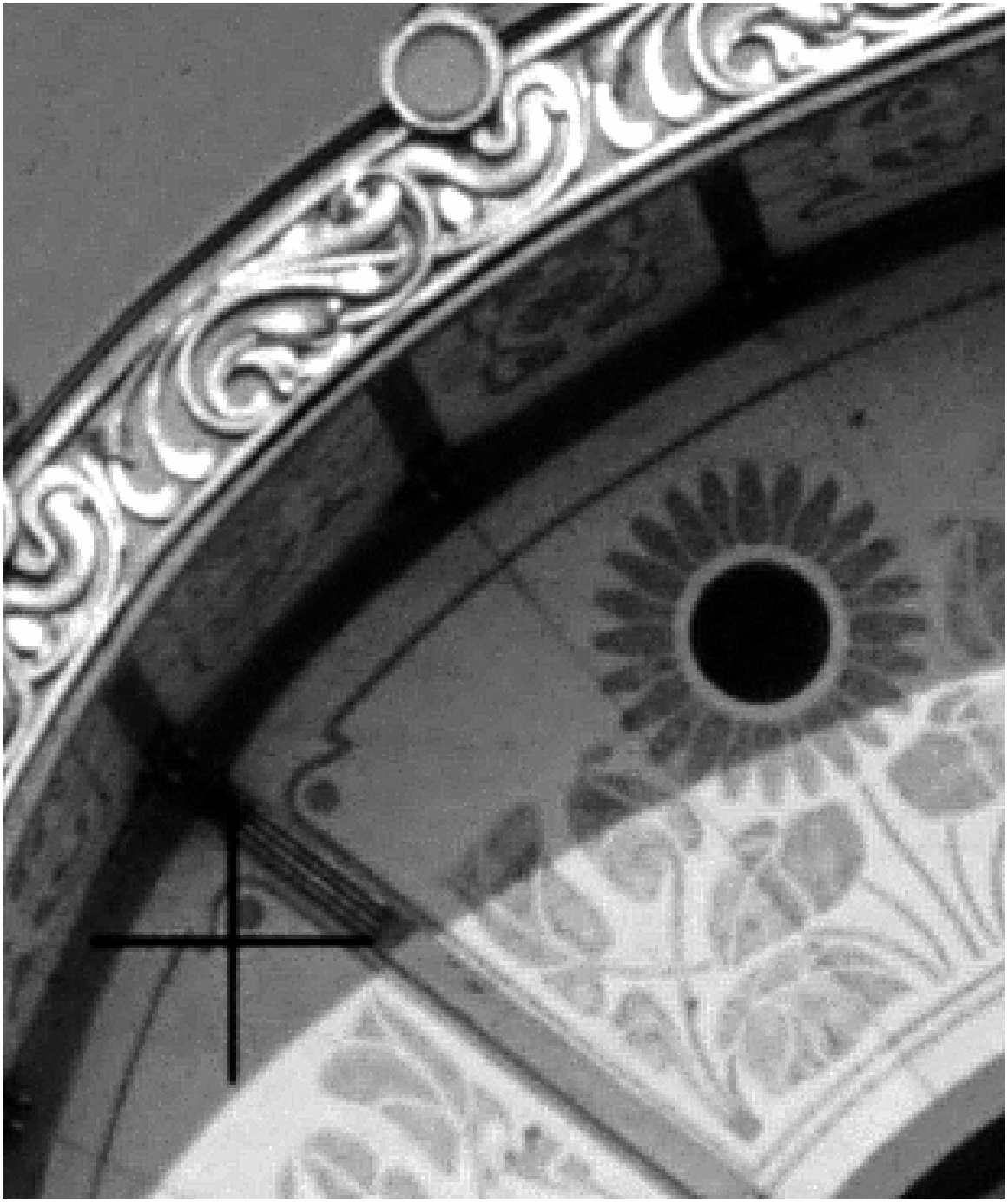


Figure 1: Detail of the test image in the maximum resolution of 2048 x 3072 (Base*16, pixel size 12 microns)

The costs of the system are extremely low. Any compatible PC 386 or Macintosh Computer with a multisession CD-ROM drive (200 US$) and a standard imaging software (700 US$) will be sufficient to read the Photo-CD images. The Compact Disk itself costs about 10 US$ and the scanning will be a 5 US$ per session and another 1 US$ per image. The costs of digital images are this way about the same as for quality paper prints.

3. GEOMETRICAL STABILITY AND ACCURACY

To test the quality of the scanning-process, a set of images of the CIPA test-field "Karlsplatz Vienna" (the small format Leica Elcovision photos by TU Vienna) has been digitized and stored on a KODAK Photo-CD by a ordinary photoshop. One of the images is shown in figure 2. The same photos have been scanned a second time by another photoshop to compare different scanning processes also.

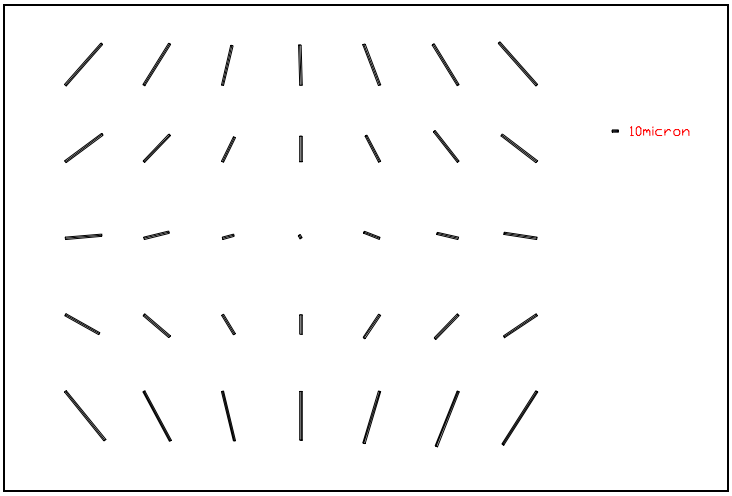
Out of these images the 7 x 5 points reseau pattern was used to test the geometric stability of the scanned images. The measurement was done using a Personal Computer and a common imaging software by manual matching of all 35 reseau-crosses in 3 images of both scans.

Figure 2: One of the images of CIPA test-field Karlsplatz Vienna

To compare the scanned images with the original photos these have also been measured using an analytical plotter. To check local or global differences a 4-parameter Helmert-transformation has been computed. The residuals in the reseau-points of image 212 of both scans are shown in figure 3 and 4. The difference-vectors give very systematic patterns of significant scale-differences between x- and y-axis. The results of the second scan (figure 4) indicate also that, beyond this scale-difference, there is an additional shearing between the two coordinate-axes.

To avoid these effects, both images with their 35 reseau-points each had been transformed by a 6-parameter affin transformation. The r.m.s. error decreased from about 50 micrometer (≈ 4 pixel) to 5 micrometer (≈□0.4 pixel).

Figures 5 and 6 show the residuals of this transformation of scans 1 and 2 of photo 212.



.Figure 3: Residuals of Scan 1 after 4-parameter transformation

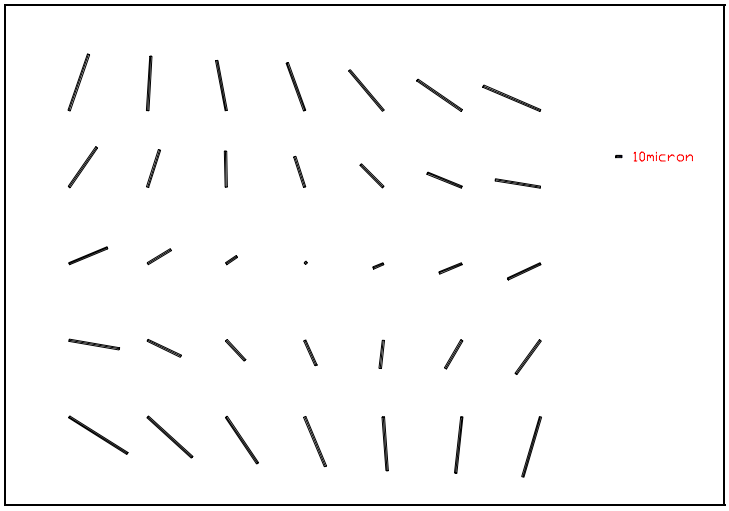


Figure 4 : Residuals of Scan 2 after 4-parameter transformation

The statistical analysis of the transformation parameters (see Hanke, 1988) show that there is a significant difference between x- and y- scales of about 1 % resulting from the scan-process. Depending on the individual scan there may also be an additional shearing between the coordinate axes. In the case of the second scan of photo 212 it has a magnitude of about 0.3 gon.

Anyway the 6-parameter affin transformation is able to avoid these systematic effects. Testing the remaining residuals on Normal Distribution, it is visible that there seem to be no other systematic errors to be in the data.

The comparison of the transformed Photo-CD images with the results of a 4-parameter transformation of the original diapositives (figure 7) show no significant difference in accuracy in the reseau-points. The scanned images of the Photo-CD are provided with the same accuracy as the original photos.

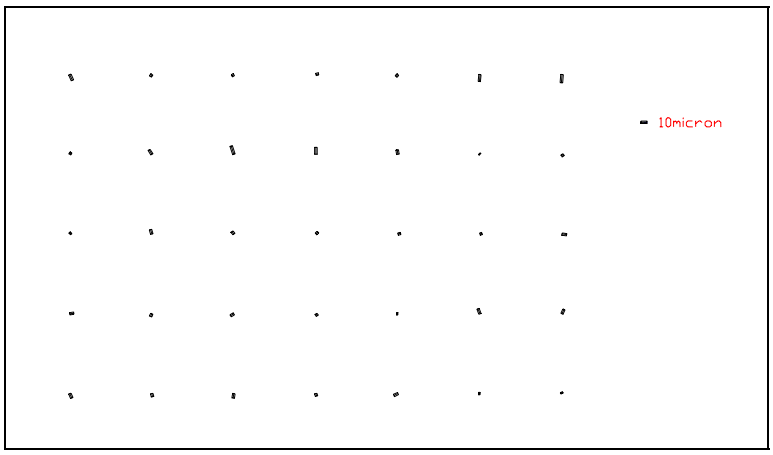


Figure 5 : Residuals of Scan 1 after 6-parameter transformation

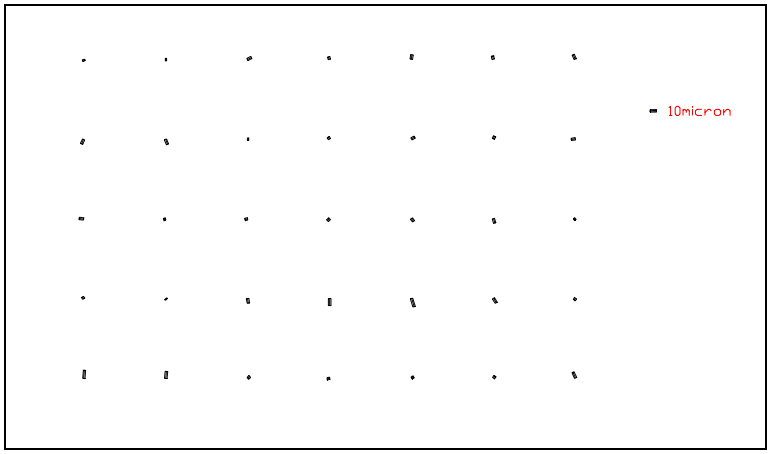


Figure 6 : Residuals of Scan 2 after 6-parameter transformation

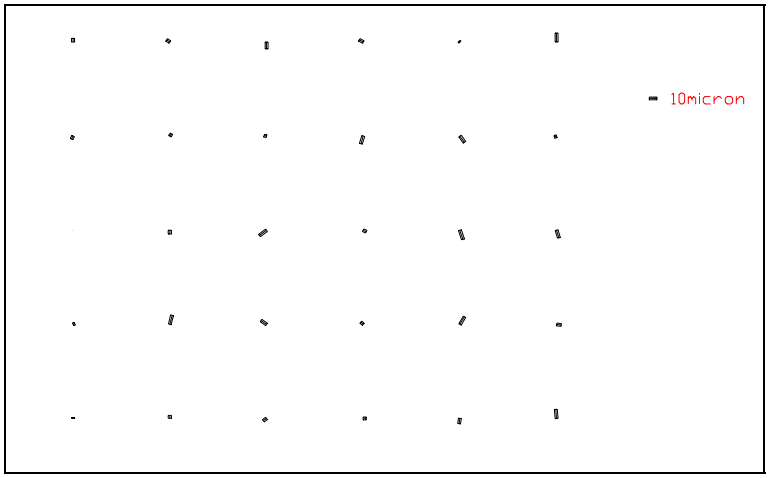


Figure 7 : Residuals of original diapositive after 4-parameter transformation

4. PROSPECTIVE DEVELOPMENT AND VISION

But this is only the beginning of the development of this digital medium. As a next step KODAK projects the introduction of a "Professional Photo-CD" for the beginning of 1994. It will allow the scanning of photos up to a format of 9 x 12 cm with a resolution of 4096 x 6144 pixel.

A special version for medical applications (tomography, X-ray, ...) will become available. "Photo-CD Catalog" will be a medium for commercial purposes of any kind (real estate, mail-order, ...) with up to 6000 images per CD with less resolution.

There could also be a special Photo-CD for photogrammetry. It could combine high resolution images with scanned sketches and coordinate-files of control-points. There are some impressive advantages: It is already an approved medium for many purposes like music recording and software distribution. The image-format will become very common as KODAK is going to promote this medium mainly for the promising market of amateur photography. It is a low-cost way to get digital images of high resolution and high accuracy, so everybody can contribute such images e.g. for archiving the world's heritage (see Waldhäusl, 1992). It is even possible to watch the images on TV using a CDI-player so also museums and schools could be interested in this facilities. It is easy to copy the data digitally (that means without loss of quality) and so multiply its availability (for education or redundant storage). So it could be an ideal medium for long time archiving the data of monuments and sites over decades. The possible combination with text and sound leads to any imaginable use in the field of multimedia.

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