RESTORATION OF DEGRADED PLANETARY IMAGERY. R. Schmidt[1], G. Neukum[2] and the HRSC Co-Investigator Team, [1]Institute of Photogrammetry and GeoInformation, Leibniz Universität Hannover, Nienburger Str. 1, 30167 Hannover, Germany, schmidt@ipi.uni-hannover.de, [2]Institute of Geological Sciences/Planetology, Malteserstr. 74-100, Freie Universität Berlin, Malteserstr. 74-100, 12249 Berlin, Germany.

Introduction: Image data obtained from several space probes orbiting celestial bodies of our solar system currently or in the past are vital tools for planetary researchers. The imagery is used for visual inspection, presentations or for computer based derivation of photogrammetric products such as DTMs (Digital Terrain Models) or maps. Unfortunately, image quality is sometimes degraded by one or even all of the following sources: noise from the incoming signal and camera electronics, compression artifacts, blurring. The objective of image restoration is to enhance the visual appearance of the images or to improve the digital image processing to derive better photogrammetric products.

The author employs digital image matching techniques for the automatic derivation of tie points in HRSC images [5] which are used as input for a bundle adjustment [3] to improve the exterior orientation of the Mars Express spacecraft. Reducing noise and compression artifacts helps to improve the reliability and completeness of the feature extraction and the image matching in areas with a low signal-to-noise ratio by enhancing contrast and edges and smoothing homogeneous regions. Similar investigations for the derivation of DTMs have been reported in [4]. Blurring is not considered in this paper but an investigation regarding this issue can be found in [8]. An overview of the Mars Express mission and the HRSC experiment is given in [2] and [6] respectively.

Noise Reduction: Numerous methods for image denoising have been presented in literature in the past and it is an ongoing research. A good overview of current methods is presented in [1]. For the effective processing of HRSC images the algorithm has to fulfill the following requirements:

1. The noise should be obviously suppressed without introducing new artifacts or blurring edges.
2. The algorithm should be able to handle very large amounts of data in an acceptable amount of time since several thousand HRSC images have to be processed. Additionally, single HRSC images can be very big comprising more than 300.000 image lines.
3. The parameters of the algorithm should be self-adjusting as far as possible to ensure an automatic processing.

Anisotropic diffusion [9] has been found to meet these prerequisites and has been successfully applied to HRSC images to improve tie point matching. A detailed version of this topic with theoretical and practical results is presented in [10].

Reduction of Compression Artifacts: In addition to noise there is another effect which can degrade the quality of the imagery. Because of a limited data rate between the spacecraft and earth it is not possible to transmit uncompressed imagery. Hence, onboard Mars Express the images are compressed on-line with a DCT (Discrete Cosine Transformation) approach known from the JPEG algorithm. The compression ratio is adapted automatically depending on the local spatial frequency of the image which is influenced by local contrast and texture. So, for areas in the image with low contrast and low texture a high compression ratio is attained. In this case visible block artifacts with a dimension of 8×8 pixels appear in the images which disturb image matching.

As with denoising there exist several deblocking algorithms which more or less all enforce miscellaneous smoothness criteria on the compressed image. A different but very effective approach has been developed by Nosratinia [7] which employs shifted versions of the DCT based compression:

1. Shift the image in vertical and horizontal direction by a certain amount (x, y)
2. Apply DCT based compression (DCT, Quantization, inverse DCT)
3. Shift the result back by (-x, -y)
4. Repeat for all 64 possible shifts within range [-3, 4]
5. Average all resulting images

The basic idea behind the algorithm is that the quantization during the DCT compression removes high frequencies but at the same time generates high frequencies at the block boudaries. The shifted versions of the images exposes the block boundaries to the quantization which reduces these artifacts. Newly introduced artifacts are lower and are eliminated during averaging.

It is not necessary to implement the whole JPEG algorithm. The generation of the Huffman tables and the entropy coding can be omitted which improves computing speed. Another option to speed-up computation is to calculate just half of all 64 possible shifts which does not change the result very much compared to 64 shifts.

Results: In [10] it has been shown that noise reduction can significantly improve tie point matching. Because for deblocking the differences in HRSC images are not very striking an example from the famous Lena image is given here. Figure 1 shows a heavily compressed version of the image. The following quantization table has been used which corresponds to a JPEG quality factor of 25:

32	22	20	32	48	80	102	122
24	24	28	38	52	116	120	110
28	26	32	48	80	114	138	112
28	34	44	58	102	174	160	124
36	44	74	112	136	218	206	154
48	70	110	128	162	208	226	184
98	128	156	174	206	242	240	202
144	184	190	196	224	200	206	198

Figure 2 shows the restored image after all 64 shifts. It can be observed that the 8×8 block structure has been successfully removed. Though the reader might notice a slight blur it has to be stated that the high frequencies have been removed during compression of the original image. Nevertheless, those edges still present in the image have been preserved very well after restoration.

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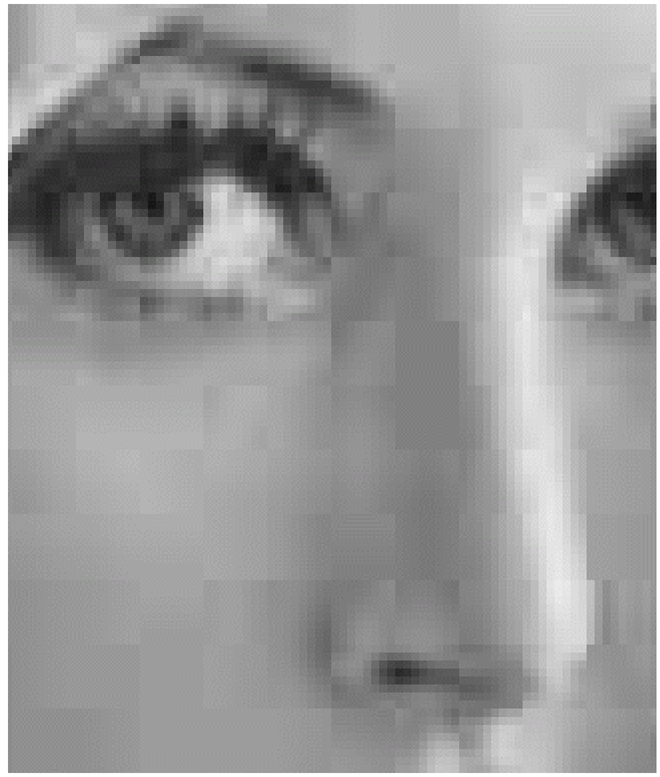

Figure 1: Compressed image with strong block artifacts

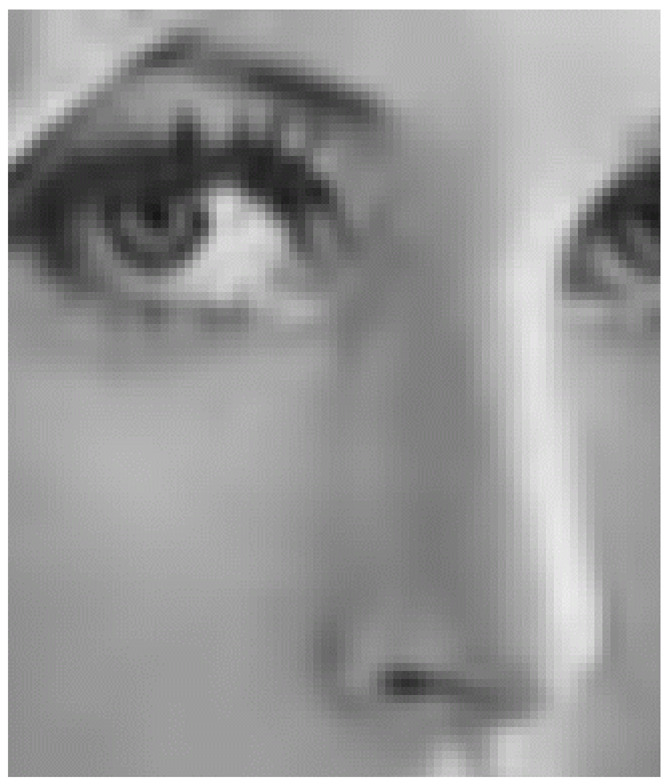

Figure 2: Restored image