DEIMOS – An Open Source Image Database

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Abstract. *The DEIMOS (DatabasE of Images: Open Source) is created as an open-source database of images and videos for testing, verification and comparing of various image and/or video processing techniques such as enhancing, compression and reconstruction. The main advantage of DEIMOS is its orientation to various application fields – multimedia, television, security, assistive technology, biomedicine, astronomy etc. The DEIMOS is/will be created gradually step-by-step based upon the contributions of team members. The paper is describing basic parameters of DEIMOS database including application examples.*

Keywords

Database, image, video, multimedia, television, security, assistive technology, CCTV, optical systems, astronomy, 3D TV, stereoscopic applications.

1. Introduction

The DEIMOS database [1] is created as a result of long-term activities of the team members during over 10 years. There are numerous image databases available – most of them are monothematic. Our idea behind is to create a complex database according to relevant experience covering many different application fields. The critical item in such a case is the organization and structure of the database in order to provide proper orientation and accessibility of images. The other aim is to provide free access to the image data for anybody – so fully open source database. The available records can be used as a comparative material for many different purposes and by many different authors of image processing algorithms.

The DEIMOS database is open and it is/will be filled consequently in various application fields and real applications of interest. This could be specified as television broadcasting from LDTV to HDTV, multimedia streaming and transmission, security images and videos, assistive technology and CCTV, biomedical images, astronomy and material research.

To be more specific, the first important application field is related to general natural pictures and/or videos usually used for the subjective quality evaluation. As we have experienced, the application of very well known image/video/multimedia tests (Lena, Foreman etc.), is affecting in a negative way the results of subjective testing. These well known motifs are very boring during tests and the results are significantly distorted by an extensive fatigue of observers. Their attention is scattered and affected by even minor distracters. Therefore our DEIMOS database offers some different motifs in order to avoid these effects. The optimization criteria in this field are the QoE (Quality of Experience) given by purely subjective perception of an observer. This area is related to television or multimedia systems in general.

The second important field is related to security. We present the test pictures that we have used during our more than 10 years involvement in this area – esp. in terms of IEEE International Conference on Security Technology (ICCST). The image quality is a crucial issue in an applied imaging system for security purposes. The security imaging systems have special qualitative requirements – the general perceptive image quality is not so important compared to the preservation of selected security image characteristics (features) such as identification or classification. The database comprises special content in the area of surveillance videos, car registration plates, noisy images for extreme low light conditions, etc.

The third important field is related to the astronomy applications. Nowadays most of the astronomical images are captured by automatic astronomical systems. Astronomical images contain specific visual data and usually consist of the dark background of sky and bright points, which represent objects (e.g. stars, galaxies, nebulae).

The fourth important field is focused on special multimedia content such as 3D stereoscopic and HDR images. A particular interest of costumers nowadays lies in 3D stereoscopic images or images with high dynamic range HDR (High Dynamic Range). There are numerous image databases but still there is not enough test image data for the special multimedia applications such as 3D stereoscopy and HDR. As an integral part of our database there is a methodology used for capturing available for download. This methodology is based on well established procedures known from literature.

The rest of the paper is organized as follows. The main Section 2 is devoted to the database organization and rules of access. Section 3 deals with the digital video image quality and television broadcasting. Section 4 deals with the multimedia and Section 5 with the security applications. Assistive technology and CCTV are contained in Section 6 and astronomy applications and optical systems are in Section 7 and 8, respectively. HDR (High Dynamic Range) images are discussed in Section 9 and, finally, the perspective application of 3D video is discussed in Section 10. There is intention of the authors to extend the database also to other domains, including e.g. medical image data.

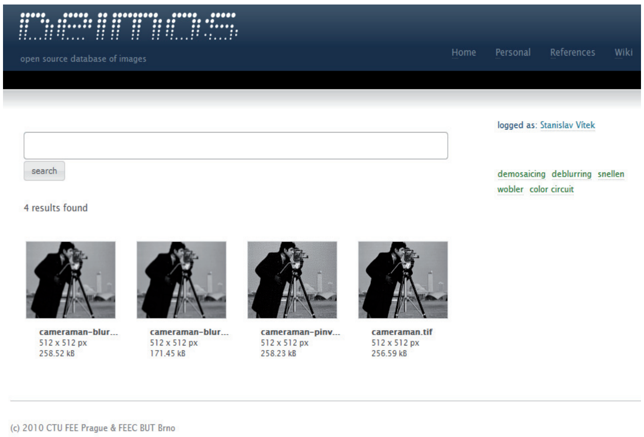

Fig. 1. DEIMOS database - Web and access interface (access at http://www.deimos-project.cz).

2. DEIMOS Database Organization and Rules of Access

The data are considered as a multimedia objects with the same basic set of parameters regardless of whether it is a still picture, video or compressed package containing a set of calibration frames for astronomy (i.e. dark frames or flat fields). These parameters are especially the description, name of the file, physical dimensions, bitrate, ISO or frame-rate, which means the properties that are specific for every single multimedia object. For the complete list of parameters see Fig. 2, table *obj*. The parameters are divided into three groups: basic information (for example size of the file, date of acquisition, author or category), the parameters common to most classes of the multimedia content (width, height, bit depth or color space) and the parameters specific to images or video-sequences (of course it makes no sense to state the duration of still image).

For the other properties that can be common to several objects a labeling system has been created: each label (or tag) defined by its value and the category can be reused by multiple objects and the whole system allows efficient sorting of objects according to various criteria. Very important is the label that creates a set of images obtained for example by applying different compression methods on a reference image – user has an overview of the context of image distortion and can easily get a whole set of images to compare compression methods with each other.

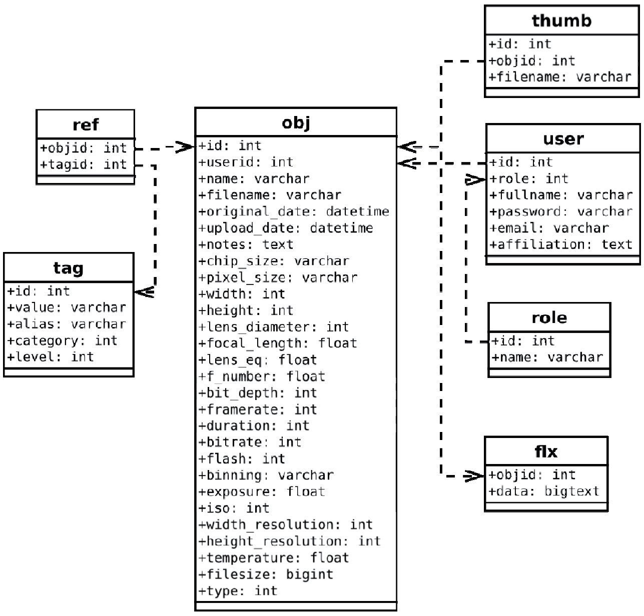

Fig. 2. DEIMOS database – Structure of the data.

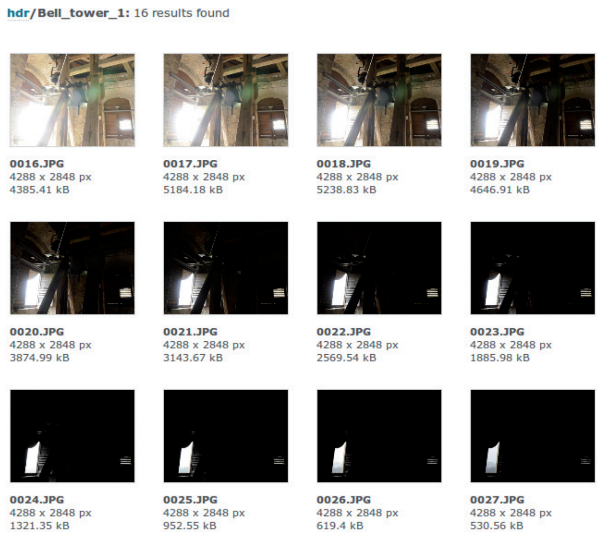

Fig. 3. DEIMOS database – Set of HDR images (example).

The multimedia objects are arranged in groups (sets) and groups with a similar multimedia content are further grouped into so called top level sets. An example of the set may be the source data for HDR images (i.e. a set of images taken with different camera settings, see Fig. 3). One of the images (or multimedia objects) can be labeled as a reference. Users can download any part of the set or the whole set in a ZIP package as is shown in Fig. 4.

The system has four levels of access to data. Without any authorization it is possible to examine all records (i.e.

preview of full-scale data), including full-text search. Authorized users on the first level of authorization have access to a limited set of full-scale data, which are not subject of further restrictions. Data limited due to license terms are only made available to the researchers with established long-term cooperation with the data owners. The decision on the access to these data is a matter of the grant investigators having full access to all data.

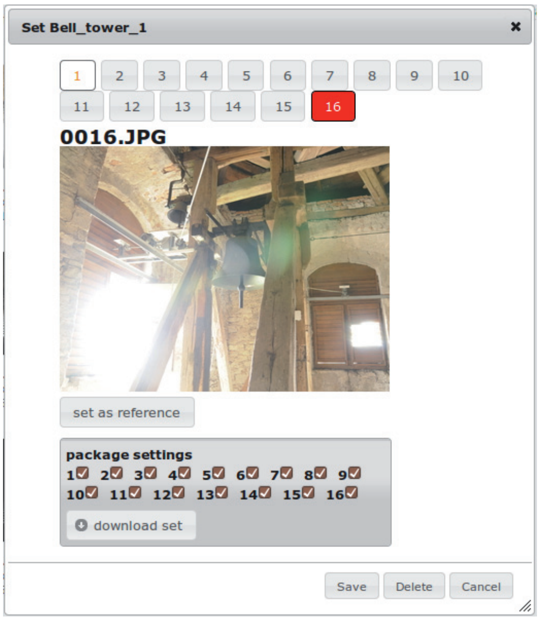

Fig. 4. DEIMOS database – Download of set and package settings (example).

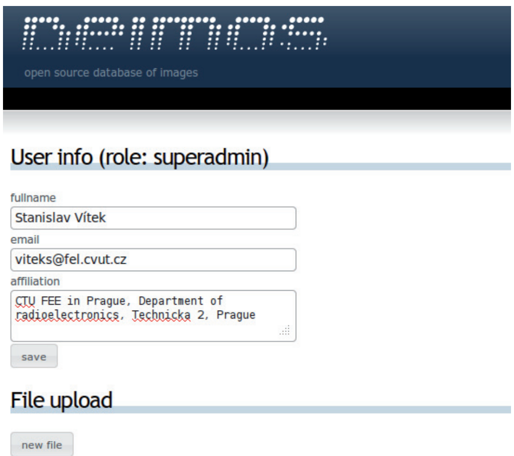

Fig. 5. DEIMOS database – User information (example).

Users (see Fig. 5) on the first level of authorization can upload up to 50 MB of data or 250 MB on the second level. Upload limits can be increased on request. Data uploaded by users should not be subject to license terms of third parties.

Server (HP Proliant DL 160G5 with HP 2012 SC Modular Smart Array) is running Windows Server 2008, Apache (PHP) web server, MySQL database engine. Data are uploaded using a Java applet. Uploading of large files such as uncompressed HDTV video sequences can be done manually with SFTP access and semi-automatic additions to the database. During normal upload from website, the system automatically creates thumbnail images. In case that video is uploaded, sequence thumbnails are created from the first, the last and several other frames of the sequence. Most of the parameters are determined automatically from the headers of the files. The system supports most image formats including FITS used mainly in astronomy.

3. Television

The video image quality in digital television systems is subject to quite different effects and influences than that in analog television systems [2]. There are mainly two sources which can disturb the digital video image quality and which can cause visible degradation of video image quality. These are the source coding and the related compression and transmission link from the modulator to the receiver. The perturbation, noise, transmission channel influence or transmission distortions can cause an increase of channel bit error rate and due to the error protection, e.g. FEC (Forward Error Correction) in DVB (Digital Video Broadcasting) [3], included in the signal, most of the bit errors can be repaired up. It leads to QEF (Quasi Error Free) transmission conditions, and the errors are not noticeable in the video image. If the transmission channel is too noisy, the transmission totally breaks down. This situation is well known as the “fall of the cliff”, or simply “cliff off”. The linear or nonlinear distortion has no direct effect on the video image, but in an extreme case it can also lead to a breakdown. No matter if the picture quality is good, bad or indifferent, it needs to be evaluated differently and detected by different means in DTV (Digital Television) and DVB systems than in ATV (Analog Television).

Test video image sequences are used for both direct measurements, subjective and objective, but in a compressed digital video image system, they can not be used for the compression encoder/decoder part of the system because a comparison of the codec influence on the common test scenes and natural scenes is not possible. To specify, evaluate and compare digital video systems with video image artifacts caused by compression or transmission, the quality of the digital video and image presented to the observer has to be determined. Video image quality [4] is inherently subjective and is affected by many subjective factors. It could be difficult to obtain accurate measures and results. Measuring video image quality using objective criteria results in an accurate and repeatable evaluation, but there is still no general objective evaluation. It should naturally cover the subjective experience of a human observer and performance of a video display and viewing conditions.

The tests in [5] required different video content with different quality levels. As the source video sequences we used short uncompressed video clips in full HD resolution with interlaced scanning at 50 fields per second (1080i). They were retrieved as uncompressed .mov files from the local television broadcasting company Nova TV. In fact, they were subject to lossy compression while being re-corded to the HDCam tapes. Still, this compression does not introduce severe video image degradations. Due to the copyright agreement with the content provider, all video sequences were identified with a time code in the bottom part of the image.

Fig. 6. HDTV test video sequences (example).

Among the available content, we selected five sequences with the most diverse properties - reaching from static (paper) over low motion video (news) to highly dy-namic content (hockey). The length of the sequences varied between 6 and 13 seconds, the shortest being the static newspaper sequence. Screenshots of the video sequences are shown in Fig. 6.

Generally, the test material for the digital television and video broadcasting in the DEIMOS database covers image and video sequences of constant length (typical 10 seconds) in ASI/SDI format and SDTV/HDTV resolution.

The original video is usually non-compressed with: 1) low dynamic content and relatively static scenes (for e.g. landscape, panorama, slow camera transient/zoom/ rota-tion), 2) moderate dynamic content (for e.g. studio news and newsroom, graphical input or in-picture video, inter-view in the studio), 3) medium dynamic content (for e.g. movie or theater record, sport and games, structured image with a lot of details), 4) high dynamic content (for e.g. rapid movement, action movie, video clip, car or bike rac-ing etc.).

4. Multimedia

This part contains reference natural images used for the subjective and objective image quality evaluation and optimization of multimedia image processing algorithms. As mentioned above, this part contains different motifs in order to avoid the distorted subjective evaluation results caused especially by the boring well known motifs like Lena or Lighthouse, Foreman etc.

These novel natural images were used as a reference for evaluation of different demosaicing techniques. So far, four various demosaicing approaches were compared; Hirakawa's [6], Menon's [7], Alleysson's [8] and Chung's [9] approach. All these mentioned demosaicing techniques demand mosaic image with Bayer pattern [10].

Furthermore, this part of database is dedicated to visual attention. The Fixation Density Maps (FDMs) of natural images are available, see the example in Fig. 7. The FDMs were obtained from subjective experiment with Arrington Research View Point Eye Tracker. These FDMs, which are computed from fixation locations and their dura-tions, represent the density of fixation at the image which can be utilized for improvement of image coding [11], subjective image quality prediction [11] or reconstruction computation complexity where authors intend to enhance the demosaicing scheme by utilizing the information from FDM [12]. The computation of these FDM is mentioned in [11]. The area of multimedia images will be successively extended.

Fig. 7. Example of a fixation density map (FDM) superim-posed on the scene used for the eye-tracking experi-ment.

5. Security

This field demands object or action identification as the optimization criteria, therefore the common test images created for the multimedia field cannot be used. The data-base contains two groups of test images; synthetic and real scene images. The first part contains synthetic images generated in graphic program (Matlab, Photoshop, etc.) especially for testing demosaicing or post-processing algo-rithms in terms of object and pattern reconstruction. The recognition of these reconstructed objects or patterns is very important for security field. The second part consists of the images capturing real security scenes. This kind of pictures are taken under bad conditions as low light level, high level of noise, long distance of subject (small area of reconstruction). These real images could contain color artifacts caused by a demosaicing technique.

The first class of images consists of synthetic patterns. The first typical pattern is a sweep chart. This monochromatic image of 256 x 256 pixels has 16 patterns (4x4) containing different spatial frequencies; 4 directions and 4 frequency values at 1/2, 1/4, 1/6 and 1/8 of raster sampling frequency. The pattern at 1/2 of raster sampling frequency is sub-sampled by CFA with aliasing. This image was created for testing of spatial frequency reconstruction. The second example of synthetic images is the Snellen eye chart. This monochromatic image contains 8 lines of letters. The top line contains the higher size of character while subsequent lines contain increasing numbers of letters and decreasing size. The letters in the last line contain finest details to be captured. This image can be used for letter reconstruction. These synthetic patterns are very useful for evaluation of applied security imaging systems especially for testing of demosaicing or post-processing algorithms.

The second class of security images contains real scenes. A typical scene of this class is a human face covered with distracters (sun-blinds). Bad image acquisition conditions; long distance, reflections, dust in the air, direct sun shine leading to high contrast etc. The other examples of the images contained in the database are: traffic signs, car registration plates and similar.

6. Assistive Technology and CCTV

The application of image/video quality evaluation in the area of Assistive Technology (AT) is obvious [13], [14]. Recently, the Assistive Technology is defined in broader sense as all technology supporting human activities esp. for ill, disabled, handicapped and elderly people.

The AT units and systems widely exploit imaging systems in general, both image and video. In contrary to multimedia technology the AT image/video systems are defined as applied (CCTV) and they can be characterized as feature-preserving systems. On the other hand they can serve as an image input for computer vision systems. There are two critical items in AT systems – qualitative degradation of image and subjective evaluation of quality in relation to required image features. The AT imaging systems area overlaps esp. security and safety fields. Now, the Center of Assistive Technology (CAT) is under construction at the Faculty of Electrical Engineering, Czech Technical University in Prague. The important part of this Centre is the Audio – Video lab. Within the CAT a CCTV system is being built and it will be used for the assistive purposes.

The DEIMOS database will serve as a central source and storage of test images and video sequences related to AT. Recently the 3D CCTV applications are studied and the DEIMOS will serve as an extensive database of 3D images and video sequences.

We expect an extensive number of applications in AT. The largest part relates to security and safety and will be devoted to CCTV monitoring of events such as detection of presence, detection of unusual or dangerous activities etc. The AT is included in the EU Action Ambient Assisted Living (AAL), Intelligent Home, e-Health and many other activities.

AAL has already launched numerous programs and projects related to the application of image/video technology. As examples we can mention programs “ICT based Solutions for Prevention and Management of Chronic Conditions of Elderly People”; “ICT based Solutions for Advancement of Social Interaction of Elderly People”, “ICT-based Solutions for Advancement of Older Persons’ Independence” etc. As examples we can list the following projects: Agnes: User-sensitive Home-based Systems for Successful Ageing in a Networked Society, Aladdin: Home Care System for the Efficient Monitoring of Elderly People with Dementia, HOPE: Smart Home for Elderly People, etc.

7. Astronomy

As it was mentioned in the introduction, astronomical images contain specific visual data and usually consist of the dark background of sky and bright points, which represent objects (e.g. stars, galaxies, nebulae).

Astronomical images are a special class of images. They have different parameters from multimedia image classes. The most important distinctions are:

- high bit depth (up to 16 bits),
- grayscale and color different from multimedia RGB system,
- significant noise level,
- sophisticated algorithms for processing of astronomical images.

Important image data contained in our image database can be divided into four groups: FF (Flat Field) - image for correction of non-uniform sensitivity of the whole detection system, DF (Dark Frame) - a map of the dark current of the CCD sensor, LI (Light Image) – the actual image data including special images from wide and ultra-wide field cameras. These images are characterized by the size of objects (especially stars) which does not exceed 10 square pixels.

Three different imaging systems have been chosen as a source of astronomical image data for DEIMOS database. The first one is the international project BOOTES (Burst Observer and Optical Transient Exploring System) [15]. This Czech – Spanish experiment is a system of robotic telescopes in Spain with deep sky and wide fields’ cameras. The second system is deep sky telescope D50 located in Ondřejov (Astronomical Institute CAS). The third test image source is automatic video system MAIA (Meteor Automatic Imager and Analyzer) [16].

8. HDR Image Content

In this section we are focused on description of the HDR image content in the DEIMOS database. The HDR techniques belong to the area of image processing where the detailed technical description of captured test images is crucial for their further analysis. There are also selected examples of HDR images available in the database.

Common digital cameras and displays have a limited dynamic range in respect to the photographed scene. Due to this fact, it is not possible to reproduce the full range of luminance in the scene. One of the methods to increase the available dynamic range of a conventional digital camera is to use multiple exposures with different exposure times. The well known pipeline (Fig. 8) to accommodate the high dynamic range (HDR) of the scene into low bit depth images for display consists of the three main steps: determination of the camera response function [17], [18], [19], calculation of radiance maps of several low dynamic range (LDR) photographs of the same scene, and finally tone mapping [20].

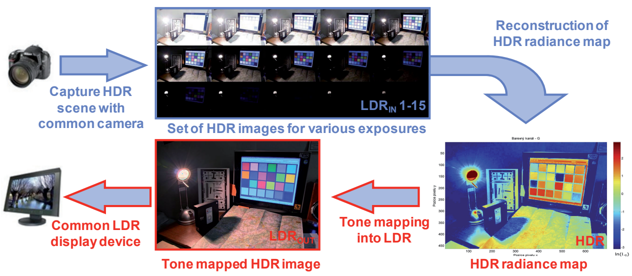

Fig. 8. Typical HDR pipeline with the still digital camera taking a set of low dynamic range images at different exposures.

The largest freely available database of HDR images with camera and scene characterization is the one created under HDR Photographic Survey project by Mark D. Fairchild at Munsell Color Science Laboratory, Rochester Institute of Technology. This survey contains 106 images but detailed camera calibration data is lacking [21]. Our goal is to have approximately 100 HDR images (about 70 are available now) in the DEIMOS database where each image will be presented as a radiance map of the scene but also as a set of all LDR exposures as in Fig. 9.

Fig. 9. Set of LDR images for HDR fusion and details for selected exposure levels.

Thus these LDR sets are accessible for further investigation of image processing algorithms. Most of our images are taken with digital SLR cameras of the two following models i.e. Nikon D90 (12.3 megapixel DX-format CMOS sensor) and Nikon D700 (12.1 megapixel FX-format CMOS sensor) [22]. Both cameras are calibrated using techniques described in [17], [18], and [19].

9. 3D Stereoscopic Image Content

The stereoscopic content is focused mainly on possible utilization in the field of subjective and objective [23] image quality assessment of different lossy compression techniques and stereoscopic displays. The database contains stereoscopic image and video pairs of the real world scenes [24].

Fig. 10. Sliding attachment on a tripod was used to capture stereoscopic pairs.

The acquisition of stereoscopic images and videos for the DEIMOS database was done using sliding attachment on a tripod, see Fig. 10. It was used for parallel image/ video acquisition with two cameras or with one shifted camera used to take images of a still scene. One of the crucial parameters in stereoscopy is the stereoscopy camera base which is defined as a distance between the camera centers. This parameter is the most commonly used variable in the available databases [25] and it is also included in our database. The database also includes test image pairs with uneven settings (focus, aperture, exposure) with intention to be able to evaluate their impact on perceived image quality.

The database content can be divided into stereoscopic videos and stereoscopic images. The test videos were taken using a pair of Panasonic HDC-SD700 camcorders or with the stereoscopic camcorder Panasonic HDC-SDT750EP with stereoscopy conversion lens. The stereoscopic base of the conversion lens is small and it is fixed to approximately 3 cm. On the other hand the pair of cameras did not allow, due to their relatively bulky size to put them closer than 75 mm apart. The stereoscopic images were captured using the shifted DSLR cameras Nikon D90 and Olympus E620. Captured images are focused on architecture, statues, landmarks and panoramas.

Two experiments [25] were conducted to verify the theoretical assumptions for stereoscopic imaging [18]. The first examines how the natural appearance and amount of the 3D effect is affected by the stereoscopic base and distance of the nearest object in the scene. The second experiment focuses on the natural appearance and amount of the 3D effect, depending on the stereoscopic base and focal length of the camera. Captured test stereo pairs were displayed with Miracube G320 monitor with 31.51" (80 cm) diagonal. Stereoscopic monitors Miracube are based on the polarization principle. This passive design requires that observers wear polarized glasses - in this experiment made by RealD Inc.

10. Conclusions

To conclude, the DEIMOS database is created as an open source for video image quality evaluation and scientific purposes. There are (and in the near future will be added) records that can be used as a comparative material for many different purposes and by many different authors of image processing algorithms. The database covers many different application fields as they were mentioned in the application chapter of the paper.

Use of image video material from the DEIMOS database by the other researchers is warmly welcome. For the overall reference please contact prof. Miloš Klíma (Head of DEIMOS team at the Czech Technical University in Prague and Head of Multimedia Technology Group).

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