

RECORDING, DOCUMENTATION AND APPLICATION OF STEREO VIEWS IN CULTURAL HERITAGE

Walter Schuhr^a, Erich Kanngieser^b

^a University of Applied Sciences, Magdeburg (Germany), -professor@post.com

^b HafenCity University (HCU), Hamburg (Germany), -geomatik@rzc.haw-hamburg.de

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ABSTRACT:

This paper promotes recording, documentation and application of objective spatial information of Cultural Heritage objects based on 3D-photographs. Though stereoviews currently are increasingly adopted in CH, the benefit of gaining a complete additional dimension from a systematic monitoring of 3D-photographs for documentation purposes in CH is still underestimated. For Heritage recording and documentation purposes it is intended, to replace subjective manual sketches by objective 3Dimagery. As a homage to the XXI. ISPRS congress in Beijing, initially masterpieces of rare international Heritage stereoviews are presented, including stereoviews of the Silk-Road. Consequently it is reported on International archives and applications of stereoviews. This paper also deals with exposing of new stereoviews, preferable by 2 by 2 photographs, including the use of a commercial digital stereo-camera from a 15m XLITE carbon telescoperod and from a captive balloon to obtain ground based ultra high resolution low altitude aerial stereoviews. This Technology, is an objective photographic documentation tool, well suited under expedition constraints. Recently it was introduced on the African Continent. In the following open research topics concerning CH stereoviews are stated, including an updated list, claiming completeness regarding virtual 3Dimage Techniques, including, e.g., "DOWN UNDER". Like in the early days of 2Dphotography, we are witnesses of early 3Dpresentations in crystal with low radiometric resolution, which might result in an advanced new FELIX3D type PC-Screen generation. The authors, who chair the international RecordIM task Group on Heritage stereoviews like to cooperate in the field of Heritage stereoviews. Their noncommercial website 3dsite.icomos.org also is prepared for contacts.

1. INTRODUCTION

Starting with samples of masterpieces of rare international stereo views and with 3D images for different applications, including 3D documentation for heritage purposes shall give an idea of the brilliance and of the outstanding documentary value of 3D imagery.

As a homage to the ISPRS Congress 2008 in Beijing, China, Figure 1 shows a 3D masterpiece of the famous Xi'an monument indicating the starting point of the silk road in the DOWN UNDER mode.

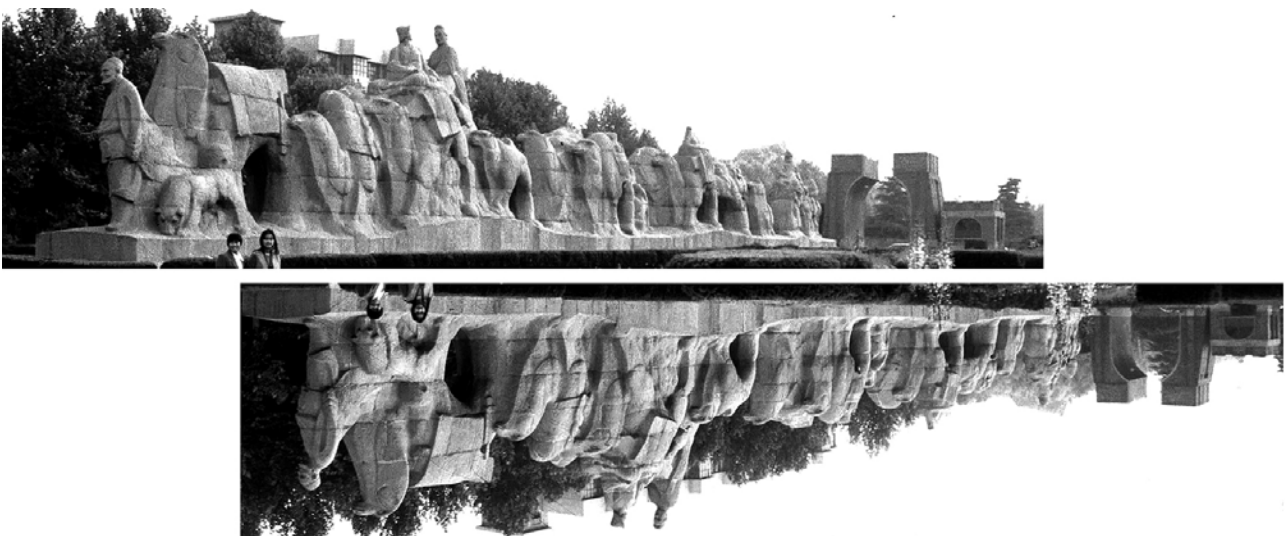


Figure 1. Masterpiece of a 3D strip image of the starting point of the Silk road in Xi'an (China), presented in the DOWN UNDER mode (for Autostereoscopic view use a horizontal mirror to project the right image beside the left image as invented by Schuhr/Kanngieser (2004))

2. APPLICATIONS OF 3D IMAGES

A complete overview of existing Collections of international stereo views is more than overdue. Namely to mention in this respect is the International Stereoscopic Union (ISU) with 900 members from 32 states, compare also Waldsmith (2002). Doubtless the most important international Archive for stereo views is the Keystone-Mast collection, which the UCR (University of California Riverside) runs in cooperation with the CMP (California Museum of Photography), which holds more than 350000 (analogue) stereo views of, e.g., the famous Keystone Company, of Underwood and Underwood and of H.C.White etc., dating from 1892 to 1963. The current digitization rate is approximately 10%.The HAN 3D archive in Seoul (South Korea) is another sample of a very important archive for unique specimen of National stereo views.

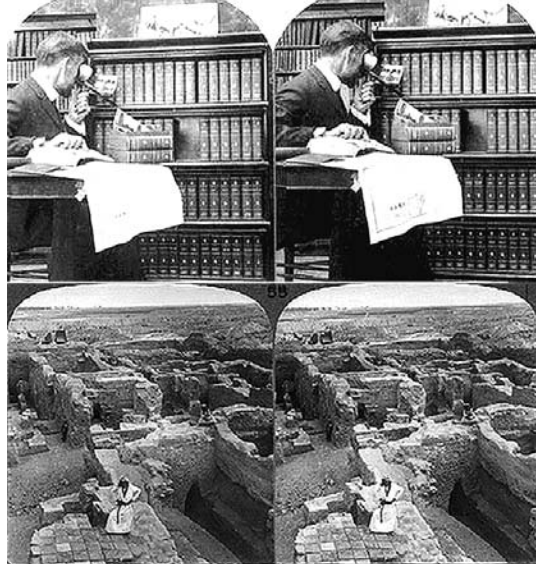
In this context it is also liked to remember the famous historic German Photogrammetrist Meydenbauer, whose archive is still maintained as a part of the Conservation Institute of Brandenburg in Germany. It consists of more than 10000

stereo views on super sized glass, showing important monuments of Germany. These authentic historic stereo views in many cases very successfully have been applied for rebuilding and restoration purposes. Beside their documentary value stereo views contain important detailed 3D geometric and radiometric information.

It is highly recommended, to digitize the available handed down stereo views systematically with at least 500 dots per inch digitization rate and to use a modern storage medium, like Hard Disk, CD-ROM, DVD etc., see Chapter 3. Thus for daily applications the digital data and print of such images can be used, while the original is protected and kept for exclusive operations only.

The quality of the original 3D image can even improve by separate removing of speckles and scratches etc. and by increasing the radiometric appearance of the (now digital) stereo views.

Historic view of the Keystone 3D image Collection :



3D image of the historic Silk road: Ruins of BABYLON

3D image of the flying horse of Xi'an (China) (Pigeon mode) (1996 by the 1st author):



3D image of NEMRUD DAG at the Silkroad (1996 by Cho Gui-Ja)

Figure 2. 4 Masterpieces of the Keystone-Mast Collection representing approximately 350000 3D images (left) and recent digital Heritage stereo views of the Silk road (right)

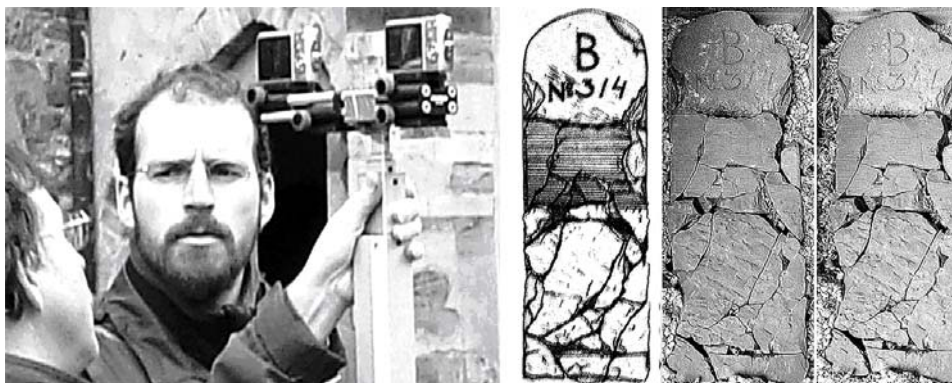


Figure 3. The 10 to 15m telescope-rod digital 3D Camera Lite, to obtain near range digital aerial stereo views (University of Applied Sciences Magdeburg) and comparison of objective stereo mates and a subjective interpreted manual sketch of a historic benchmark (courtesy Amt for Denkmalschutz, State of Saxony-Anhalt, Germany)

Keeping also in mind global archives of satellite and aerial photography, it is estimated, currently easy at least some million historic analog stereo views still wait for digitization, for modern spatial data presentation, for restoration and comparison purposes etc., see samples in Figure 2,3,4,7 and 8.

As a matter of fact, the benefit of a complete additional dimension from systematic 3D photography for documentation purposes is still underestimated and even doubted. For heritage documentation purposes in particular subjective interpreted manual drawings instead of objective high resolution 3D photography at least are preferred partly. Therefore it is the authors' suggestion, for documentation purposes, consequently to replace subjective manual sketches by objective 3D images, compare Figure 3.

3D images often are not directly available or show lack in resolution. For this cases extremely high resolution low altitude aerial (3D) photography from a 15m carbon telescope-rod and from a captive balloon successfully has been obtained. This will more and more become an objective tool for a huge range of documentation purposes, in particular in archaeology. This "3D-niche-photography" is also well suited under expedition constraints and promises a great future, see also [4]! The invention of the telescope-rod camera by the authors has been adopted by Heinz Ruether for detailed stereo image covering of archaeological sites in Africa and of course it is very suitable for Australia as well, see Figure 3 (left).

Depending on the height, the base length of the lite digital camera can vary. Nowadays for serious photographic documentation at least 3D photography should be preferred! It is liked to emphasize, due to the modern camera Technology, single lens cameras of both types, analog and digital, for 3D

photography of static objects even seem superior to old fashioned stereo cameras! Another big advantage of single lens cameras is the relative low price, the light weight, easy handling and the flexibility in base length variation.

3. RESEARCH TOPICS IN 3D IMAGE ASPLICATION

The 3D-Image Application already dates back to the British Physician Wheatstone. Who invented the stereoscope in 1832, compare Gernsheim (1965). The virtual 3D visualization Technology as a part of Geoinformationsystems (GIS) is very advanced, Nevertheless dealing with basic research in this field still leads to a surprising number of open research topics in Technique and/or Arts aspects of 3D image application. Identified open research topics in 3D-image application, which are still not or not yet completely solved are listed and partly described in the following, without claiming for completeness:

Open research topics for Technique and Arts aspects of 3D images:

The stereoscopic perception ability while viewing on 2 corresponding stereo mates is part of the human 3D viewing sense. Independent of the nature of the horizontal parallaxes, also known as disparities, an attempt for a systematic investigation of the complete list of virtually stereo aids according to the state of the art, has been carried out.

Constraints are: at least 2 stereo mates of real and/or synthetic origin, showing the same object, as imaged from different positions, approximately perpendicular to a base line with satisfactory parallel imaging directions.

1. 3D perception of in minimum 2 stereo mates, vertical or horizontal arranged, but "projected without contact"; for "ortho" or "pseudo" as well as for normal and/or cross 3D visualization:
1.1 AUTOSTEREOSCOPIC VIEW of horizontal mounted 3D views, see Figure2 , 4 , 6, 7 and 8
1.2 MAGIC EYE / RANDOM DOT
1.3 HEAD MOUNTED DISPLAY
1.4 LENTICULAR LENSES for vertical, horizontal or arbitrary interlaced stereo mates:(e.g., "3D POSTCARDS") or
1.5 STRIP BARRIER: vertical or horizontal interlaced stereomates appear remind. to 1.4, but without lenses,s.Figure7
1.6 STEREOSCOPES:
1.6.1 LENS STEREOSCOPES , see Figure 7(left)
1.6.2 MIRROR STEREOSCOPES with LENSES
1.6.3 Mirror stereoscopes for horizontal arranged stereo mates; vertical mirror: PIGEON , see Figure 2
1.6.4 Mirror stereoscopes for vertical arranged stereo mates; horizontal mirror: DOWN UNDER , see Figure 1
1.6.5 PRISM-STEREOSCOPES for horizontal mounted stereo mates
1.6.6 Prism-Stereoscopes for vertical arranged stereo mates: KMQ
2. Methods for virtual spatial perception based on stereo mates, "projected in contact", using alternate projection and/or different color:
2.1 ANAGLYPHS (complementary color (green/red or blue (magenta)/red or magenta/yellow separation)
2.2 CROMADEPTHS (spectral color separation)
2.3 POLARIZING FILTER Techniques
2.4 (Liquid Crystal-) SHUTTER glasses
2.5 NuOptix 3D Movies for (relative) moving objects for PULFRICH GLASSES , also used in CYBER SPACE
3. 3D perception Techniques using VIRTUAL 3D MODELS:
(3.1 MIRROR)
3.2 moving screen: - Rotating Screw Shaped Screen (FELIX) 3D - or up and down Oscillating Screen (BOLLOGRAPH)
3.3 (FELIX) 3D – SOLID STATE crystal = new 3D PC/TV-screen generation?
3.4 HOLOGRAM Technologies

Table 1. The updated complete list of virtual spatial visualization Techniques (Status: 2008).

The principles of the 3dimensional viewing technology have been categorized according to

- methods for the spatial visualization of stereo mates projected without contact,
- methods for the separation of spatial presented stereo mates projected in contact and
- methods using virtually 3D models

No part of this exclusive presentation of virtual 3D images are, e.g., methods using simple central perspective effects and/or shadow effects, or "continuous profiling", which are methods for 3D data determination by combining a successive queue of profiles, but not own methods for virtually 3D data perception; similar holds for the Moiré effect. Materialized 3D appearance, including the 3D mirror effect and real models are no methods for virtually but for real 3dimensional presentation. On the other hand so called 2.5 D visualization Techniques are included in the synopsis of table 1, as far as they lead to a real 3D perception by applying the NuOptics method, which already dates back to Pulfrich (about 1900). This sample also indicates, moving back to basics in Cultural Heritage recording and documentation based on stereo views still shows a surprising **potential for further research as well as for advanced practical applications**, like the complete list of virtual 3D perception Techniques, compare table 1 and SCHUHR/KANNIGESER (2004)

It is liked to emphasize, from a consequently dealing with the principals of spatial data perception, even the future of the whole computer industry might change. Here namely the so called FELIX 3D solid state 3D screen seems to become a real candidate for a new spatial PC generation in order to replace or to complete the 2dimensional screen generation. This screen type is suited for 3D Laser projection in color and in real time via 3D Laser for direct model perception without glasses. The FELIX-3D solid state is the successor of well known 3D cylindrical Plexiglas tube.

Another matter of research still is the optimum base length to be applied for stereo views. There is no unique answer for the optimum base length or better, to define the optimum base-to (object-) distance ratio, as the baselines differs due to the preference of near natural or super elevated deep perception, see Figure 4. For ad hoc applications using normal and wide angle cameras for 3D documentation purposes, the empiric baseline to object distance ratio should be approximately 1:10. It is highly recommended, not to take only two shots, but a sequence of stereo mates, so called "**2 by 2 photographs**" with different baselines, and possibly to chose different appropriate stereo mate combinations according to different criteria, but see also WALDHAEUSL/OGLEBY (1994).

To start up taking own stereo views of Heritage monuments, the object at least should be photographed twice with a single lens camera from partly different projection centers



Figure 4. Early queue of **2 by 2 photographs** for optimum 3D perception of the Roman bridge of the ancient silk road near Urfa (Turkey) as carried out by the 1st author.

(positions), which gives the baseline. The same object part in the view-finder avoids vertical parallaxes and on the stereoscopic perception side, the eyes "excuse" about up to 5 degrees deviations from parallel camera axis.

Further open research topics for Technique and Arts aspects of 3D images are, e.g., the market potential including a catalog of sample applications of stereo views. Additional matters of research are the professional potential of existing Archives for 3D-pictures and 3D-movies, as well as the complete history for stereo imagery, including the photo plasticon, see Figure 7 and sample stereo views in figure 2,4 and 8. Also matter of research are the potential of terrestrial stereo image blocks, as well as the potential of stereo-panorama-views. Additional open research topics for Technique and Arts aspects are derived from the combination of stereo mates of different physical character, e.g., the (stereoscopic) effect of the combination of stereo mates showing different pixel size, the benefit of combining day- and night stereo mates, the effects of combination of "before and after" pictures for Change Detection purposes, the manipulation of (existing) real and synthetic 3D-images to achieve a required deep perception and the effects of the combination of different Sensor images (e.g., optical and radar).

Another open research topic for arts aspects of stereo views is the critical dealing with the Genre-3D-photography showing portraits, Heritage Monuments (see figure 2, 3,4 and 8) Architecture, Landscapes (see figure 2 and 4), Nature, Environment, Technology etc.. This in particular holds for the "master pieces", like in figure 1, 2, 3,4 and 8, but also for available stereo views in general, as well as for own stereo views. Other arts aspects in this respect are differences in 2D and 3D exposure from an artists point of view and the (Computer) Generation and/or manipulation of artist stereo views.

Another research topic is the generation of a lost or a so far not existed stereo mate by analog and/or digital means, for, e.g., Monument reconstruction purposes and artificial 3D-images of paintings etc.. A lost or missing stereo mate preferable should be taken from the real object. If at least a 3dimensional model of the object is available, the single picture can be projected onto the real (white) model and the stereo mates can be taken by stereo photographs. Also virtual stereoscopic data presentation using digital stereo mates can follow this idea: The real model is replaced by the 3dimensional model data, while the optical projection of the single photo onto the model is replaced by mathematical projection and the stereo mates are not obtained from stereo photographs but by applying mathematical projection equations calculating the synthetic horizontal parallaxes values.

Within this context it is highly recommended, to use the mathematical model according to Egels and Massou d'Autume of the IGN (Paris) for the generation of stereo mates. This quasi universal model so far has successfully been applied for digital image rectification purposes. It is suited to calculate Digital Terrain Model data and, depending on the situation, it allows partly to neglect equalization approaches. For tasks which require map accuracy, like photomaps (of facades), mosaikings, multisensor imagery and data fusion, a digital Geometric pixel by pixel image restitution is needed, preferably applying the indirect rectification method.

In particular the converting of this kind of filtered image raster data into vector data, as for instance carried out by the ENVI Program system, promises great progress for automated ortho map production, also including the stereo mate.

Open research topics for Technique Aspects of stereo views are, e.g., optimizing the generation of stereo views as well as searching for the geometric and radiometric potential of (available) stereo imagery; including the optimum digitization rate for analog stereo views, see. Figure 5, which shows a 1st result for an optimum digitization rate for existing analog stereo views. In cas of fig 5 an analog stereopair of

conventional aerial photographs in the scale 1:35 000 has been used for interpretation purposes. A first result is, due to the stereo effect the mapping potential of this original 3D-image is high, Approximately the same holds for the digitized 3D-image showing 1.75m groundpixelsize, which, corresponds to a minimum digitization rate of 500 dots/inch. From Figure 5. can be seen, a relaxed groundpixelsize, ranging from, e.g., 3.5m until 28 m, shows a decreasing in the mapping potential of the 3D image. To judge on the geometric potential of available stereo mates, relative spatial object distances of different object points P_i and P_l are obtained from corresponding horizontal parallax values Δp_{xi} and Δp_{xl} , also known as disparities, according to $y_i/y_l = p_{xi}/p_{xl}$. Additional open research topics for Technique aspects are derived from the combination of stereo mates of different physical character. To be mentioned is a systematic considering of the effect of the stereoscopic exaggeration caused by an extremely high base-to-distance ratio near 1 Other open research topics for Technique aspects are considering the effect of the stereoscopic exaggeration caused by a combination of stereomates showing different focus as well as the role of the dominant eye.

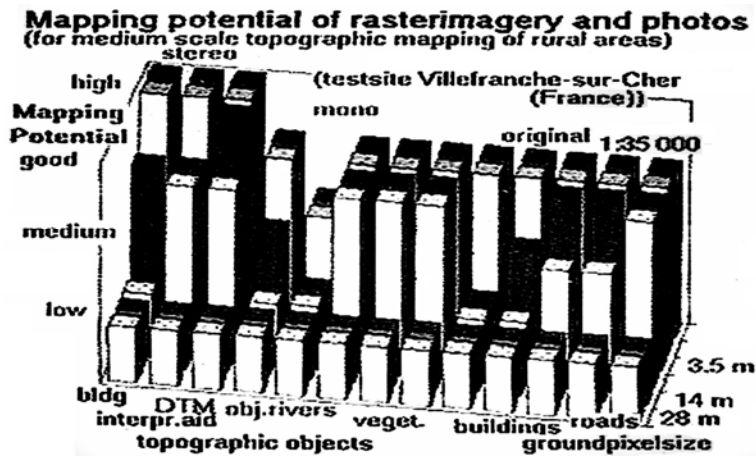


Figure 5. Results of advantages from spatial ("stereo") image data interpretation as carried out by A. Elmhurst

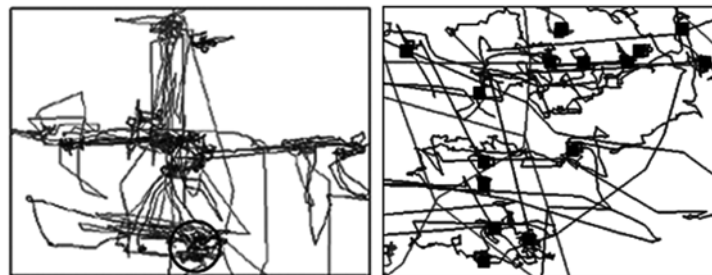


Figure 6. i-Grammetry: paths of homologues points from observing a stereo view (left) and in an enlarged part (right) according to G. Guienko & V. Chekalin

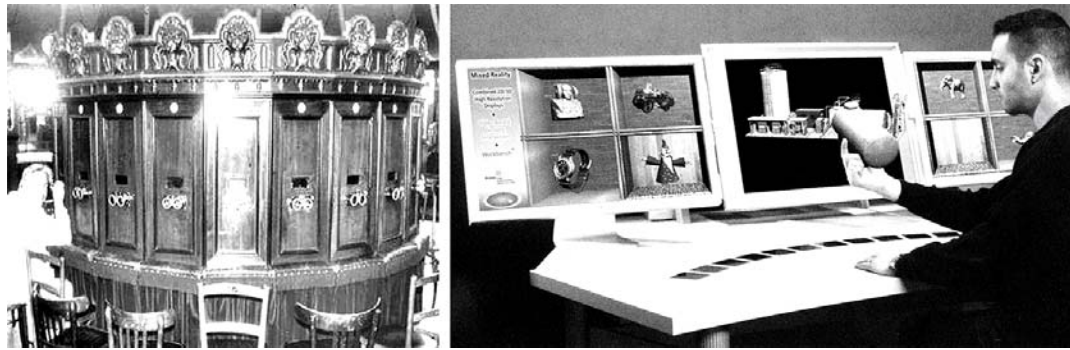


Figure 7. stereoscopes of the past: This is one of only 5 surviving historic photo plasticons, which were common in the 1920th (25 users could view 50 3 D-images)(left). Outstanding innovative 2D/3D-Mixed-Reality-Desktop of Fraunhofer (Germany), based on strip barrier with eye-motion-tracking and gesture interpreter, backed up by about 10 video cameras (right)

Further open research topics for Technique aspects of 3D-images are in particular expected from computational Models and their applications. It is liked to emphasize, in this context algorithms in particular are seen as an important market gap, see also Figure 6.. Additional open research topics concerning 3D-images are the efficient manipulation of raster data to derive sufficient digital vector data.

Though software for the automatic processing of 3D coordinate data from overlapping photographs is provided by different companies (e.g., LEICA, Virtuoso etc.), user friendly low cost software for the automatic evaluation of stereo views is still missing but with e.g., Photomodeler, in development,

Finally even matter of research is the complete list of products derived from 3D-image application, like, e.g., 3D object documentation and interpretation, numeric 3D coordinates, line maps (vector data) and photomaps (raster data) in combination with stereo mates on scale

4. CONCLUSIONS

Though the progress in the field of 3D visualization Technology recently increased, there are still open research topics in 3D image application. A systematic survey to define research gaps in 3D Image application as presented, is highly recommended and stimulates for further progress. It is liked to emphasize, moving back to basics in spatial data processing shows a surprising potential for advanced practical 3D image application, like, e.g.,

- To convince amateurs and professionals of the still underestimated effect in obtaining a complete additional dimension. This holds for the enhancement of spatial structures by suited 3D-visualization Techniques, and for the achievement of extremely high detail resolution as well as for the probative force of forensic 3D-photography etc..

- Receipts and samples for recording, processing and applying 3D images are still required for different disciplines.

- There is still a lack of operational stereo view adopted software, see also WALDHAEUSL/OGLEBY (1994).

- the production of line maps and stereo mates from digital raster data is still a matter of research, as well as the efficient transfer of raster into vector data,

- A survey of existing international 3D image archives, including the archives contents and access is highly recommended.

- A Peer reviewed and definitely complete synopsis of the virtual 3D-visualization Technologies with sufficient information content is still missing. Already from first systematic steps in this field, the “DOWN UNDER” 3D-visualization method recently has been invented by the authors, see Figure 1 and Table 1.

- The authors recommend again, to replace obsolete manual sketches for documentation purposes, preferable by 3D-photographs.

-Intense dealing with “3D-niche-photography” based on telescope-rod and/or captive-balloon promises a great future.

- Another big field for international research is, to manage the problem of digital interpretation in an efficient way. Progress in this field is expected from improvements in algorithms and software, including aspects of artificial intelligence.



Figure 8. The authors, who chair the international RecordDIM taskgroup on “Collecting, Compiling and Sharing Heritage stereo views like to invite the ISPRS community, to cooperate in the field of 3D image application. Their noncommercial webpage 3site.icomos.org as carried out by KIM, SEUNG SUN, is also prepared for contacts.

It is liked to emphasize, the open topics in 3D image application as stated here, do not claim for completeness.

Summarizing, improvements in 3D image application namely are expected from improvements in Analysis and in standards, from modeling and from hardware and softwaredevelopment.

Finally, to emphasize the great future potential of the 3D image application, like in the early days of 2D photography, today we are witnesses of the very first developments of 3D presentations in crystal with low radiometric resolution, possibly resulting into an advanced new 3D PC-Screen Generation.. In this respect the FELIX Solid state type 3D screen is a real candidate to replace the current 2D PC-screen generation, at least partly,. This 3D image screen for the very first time allows stereoscopic viewing from any side, even in color.

As a matter of fact, like in all parts of the daily life, the recent development in 3D image application and in the field of spatial data visualization in particular, must deal with the world wide web.

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