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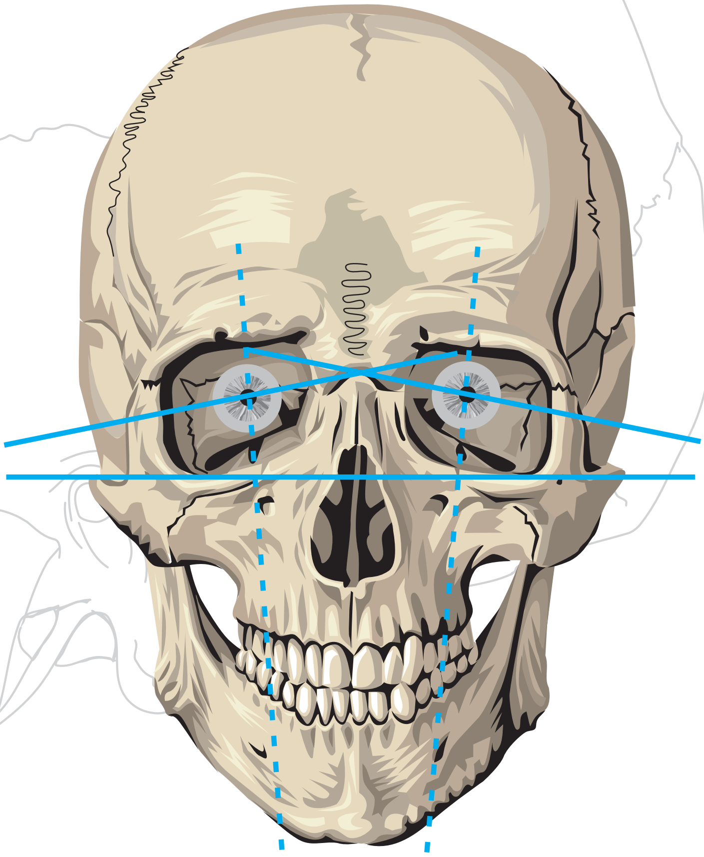
2nd International Conference on

Reconstruction of Soft Facial Parts

(RSFP 2005)

March 17-18, 2005
RheinAhrCampus
Remagen



Book of Abstracts

T.M. Buzug, K. Sigl, K. Prüfer, G. Willems,
P. Hering, R. Helmer, J. Bongartz, A. Hülster (Eds.)

caesar

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Reconstruction of Soft Facial Parts (RSFP2005)
Book of Abstracts

Editors:
Thorsten M. Buzug, Karl Sigl, Klaus Prüfer, Guy Willems,
Peter Hering, Richard Helmer, Jens Bongartz and Anke Hülster

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Book of Abstracts – RSFP 2005

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Editors:

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Foreword and Acknowledgements

"Mystery of dead woman in Winkeler Bay solved" – After ten years, a female body found mutilated beyond recognition has been identified thanks to a technique known as facial reconstruction. Thanks to the information obtained as a result of the reconstruction, searches for the potential murderer have now been initiated. – Reports of this type were rare in the past. Today, however, a revolutionary progress in computer-aided methods has also made its way into the reconstruction of the soft tissues of the human face.

Based on the findings of traditional facial reconstruction, more and more complex software programs are being designed and applied. In combination with state-of-the-art medical imaging and laser scanning technology, detailed 3D-images can be created with different facial expressions.

The conventional, manual 4-step approach of i) *examination of the skull*, ii) *development of a reconstruction plan*, iii) *practical sculpturing* and iv) *mask design* is very time consuming. However, even with the use of modern imaging and computer tools, the general workflow has not been changed. It is still a 4-step approach of

i. Computed Tomography or Laser Scanning of the Skull Find

This step includes the taking of skull measurements. The methods may use above all anatomical landmarks, which first have to be selected and entered into the computer. Digitalisation by the computer tomograph offers the advantage that further, and even very complex marks of the skull form, e.g. so-called "crest lines" or other structural features defined by differential geometry, may be determined.

ii. Selection of a Soft-Tissue Template or a Landmark Set

The development of a reconstruction plan aims at identifying the "correct" soft tissue template in a (magnetic resonance, computed tomography, ultrasound or laser scanning) database or selecting appropriate landmarks. Additional information which should originate from the results of the forensic and anthropological examination and CID (*criminal investigation division*) finds at the place where the body was discovered (e.g. hair fragments) is still indispensable and is also used in preparation of step *iv*.

iii. Warping or Morphing a Skin onto the Skull-Find CT Data

In this step the computer carries out an elastic warping of the soft-tissue template from a database onto the skull find or uses the landmarks as basis for a surface spline reconstruction. Usually, subsequent interactive corrections of individual parts of the face are necessary.

iv. Texture Mapping

Texture mapping includes the application of patterns, shading and colours to surfaces. Today, computers are very well able to carry out this task. The real problem is rather the scope for artistic design. As for the manual method the decisions in this field are still left to the medico-legal expert and the anthropologist. But decision-making can be supported by the computer, and wrong decisions can be easily corrected.

These basic steps aim at supplementing and above all at accelerating traditional procedures.

RSFP 2005 is a scientific conference on new face reconstruction procedures in all forensic, anthropologic and medical application areas. The conference will bring together scientific, medical, anthropologic and forensic experts from university and clinical departments as well as criminal divisions and commercial sites.

As chair of the conference I would like the thank the institutional co-organizers, partners and their representatives: German Federal Criminal Department, Bundeskriminalamt, BKA (Prof. Dr. Jürgen Stock, Vice Predident; Klaus Prüfer; Karl Sigl; Dr. Bernd Rieger); Caesar Bonn and University Düsseldorf (Prof. Dr. Peter Hering); Katholieke Universiteit Leuven, Departments of Orthodontics and Forensic Odontology (Prof. Dr. Guy Willems); Institute of Criminalistics Prague (Dr. Hana Eliasova); IEEE Joint Chapter EMB – German Section (Dr. Thomas Lehmann); NEC Europe Ltd., C&C Research Lab (Dr. Guy Lonsdale); Nederlands Forensisch Instituut, Rijswijk (Prof. Dr. George J.R. Maat); Landeskriminalamt Brandenburg (Dr. Bernd-Ulrich Straube); University of Freiburg (Prof. Dr. Ursula Wittwer-Backofen).

Many thanks go to the members of the program committee for the selection of works included in this book of abstracts.

I would like to thank all partners organizing the comparative study. I thank Prof. Dr. Jens Bongartz (RheinAhrCampus Remagen) for organizing and chairing the study. Especially, my thanks go to Prof. Dr. Richard Helmer (Institute of Applied Medical Forensics Remagen) for taking over the Study Jury Chair. Last but not least I have to thank Dr. Carsten Tille and Dr. Hermann Seitz (Caesar Bonn, rapid prototyping group) for producing the skull casts.

For producing the proceedings in cooperation with Luchterhand Publishers I would like to thank German Federal Criminal Department (BKA).

For support of the conference I have to thank the Wirtschaftsförderung Kreis Ahrweiler and Förderverein des RheinAhrCampus Remagen.

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RheinAhrCampus Remagen, March 2005

Thorsten M. Buzug
RSFP 2005 Conference Chair

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Preface

As the district governor I would like to welcome you in Ahrweiler County. I also would like to thank you having accepted the invitation of the RheinAhrCampus Remagen and his conference partners here into our “Health and Fitness Region”. I am very proud of having this large and top-class scientific event here in Ahrweiler County.

The Fraunhofer Institute for Systems and Innovation Research in Karlsruhe pointed out, that medical technology is one of the key-technologies with the largest potential for the future worldwide. Germany is leading in this field. The results of our scientists and engineers are forefront in the world.

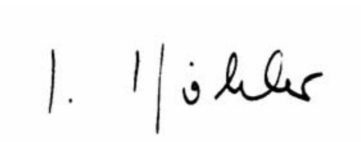
That’s why I am convinced, that Ahrweiler County has certainly backed the right horse with “Medical Technology” as a field of study at the University of Applied Sciences here in Remagen.

The RheinAhrCampus features best conditions for an innovative university education and research on a very high level: a high modern equipment with computer- and magnetic resonance tomograph, ultra-sonic and endoscope technology up to thermography – everything is available. The laser laboratories are internationally appreciated.

Our university of applied sciences is the “flagship” of the health competition in Ahrweiler County. Scientific events like “Reconstruction of Soft Facial Parts” underline our growing significance as an important health and fitness region with numerous establishments and enormous potentials. With our “Innovation Park Rhineland” in Grafschaft and the “Innovation and Start-up Center” in Sinzig we approach the industrial segment of medical technology.

Three medical bathes on high modern standard and famous medical mineral springs, such as Apolli-naris – The Queen of Table Waters – attract as well. Besides the excellent restaurant- and hotel busi-ness, the delicious red wine from the Ahr, – known as the largest acreage of red wine in Germany – the Nürburgring or the new Arp-Museum, designed by the US star architect Richard Meier, are inter-national figureheads of our region.

Last but not least I wish you an interesting conference with many new suggestions, also for your daily employment. I hope, you’ll enjoy our nice “Ahrweiler Health and Fitness Region” and come back again soon!



Landrat Dr. Jürgen Pföhler

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The Facial Reconstruction: Past, Present and Future

J.-N. Vignal

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Paul Broca is considered by many historians to be the first one who started researches on relations between bones and soft tissues thicknesses of the face.

In 1883, Welker studied soft tissues thicknesses on a sample of 13 male dead bodies by driving a knife into face skin, but the first reconstruction method has been used by His in 1895 when he had to reconstruct the face of Jean Sébastien Bach. He increased the sample of Walker and precised the relation between stoutness and soft tissues thicknesses.

Kollman and Buchly (1898) have gone deeper into his's studies in particular his statistical analysis. At the same period, Merkel has reconstructed in three dimensions a human face by sculpting muscles with plastilin.

In 1921, Boule, using the same Merkel's method of made the face of the Neandhertal fossil of the Chapelle aux Saints (France).

But the father of the scientific facial reconstruction is without doubt the Russian Gerasimov. Anthopologist, ethnologist and artist, he was the first produce forensic facial reconstruction.

Later, the American school (Rhine and Moore) improved method with new databases.

Actually, the facial reconstruction is used in several countries with various methods like drawing, sculpture or computer assisted. She allows to resolve forensic cases but she can also review old facial reconstructions of fossils (e.g.: Neandhertal, Homo Erectus, Australopithecus, …).

Medical imagery allows to progress in the knowledge of soft tissue thicknesses of living persons and of the morphology of the face.

What about the future? We can hope for an optimisation of the time necessary to realize a more realist facial with the new developments of the 3D virtual reality and with the increasing precision of the medical imagery.

Computer-Aided Tissue Thickness Measurements in CT-Data Sets of the Head of Living and Death Persons

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Facial reconstruction on the skull for post-mortem identification of unknown persons by physical sculpting with clay or by computer-aided modelling is based on a standard set of statistical tissue thickness values at specific points of the face.

Because of the changes and improvement in nutrition, especially in the last few decades, we expect that the existing standard tissue thickness values are no longer corresponding to the actual facial soft tissue thickness of people in Central Europe.

Measurement of tissue thickness is possible by manual methods like the needle probe technique as well as by radiological approaches. In both, the results are influenced by a number of parameters like water content of the body at the time of measurement, posture of the body or method-specific sources of error.

Initial point for the development of the presented procedure is the fact, that a measurement of the distance between skin and underlying bone from CT-data sets is possible. Using standard software it is possible to extract and separate the data of skin and bones from the CT-data. We have developed a software system that helps the user in measuring corresponding distances at the usual landmark positions. Measurement can be done either in the usual way perpendicularly to the surface of the bony structure or using other mathematic procedures.

The method, first results and influencing factors are presented.

Keywords: CCT, tissue thickness, facial bone

Soft-Tissue Segmentation in Forensic Applications

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A new method for virtual forensic facial reconstruction is proposed. The reconstruction of the face of dead individuals based on the shape of their skull is for interest in forensic, archaeology as well as in anthropology. Several methods have been developed during the last decade.

The aim of the presented method is to extract a facial template from magnetic resonance images (MRI) and fit this template to the computed tomography (CT) of the skull. Currently we are working on an automatic segmentation strategy for MRI fat signal to obtain the template. An active contour or snake algorithm, respectively, is proposed. This approach is well known from image processing applications to locate boundary objects. It was first proposed by M. Kass et al. [1]. Further the gradient vector flow based version of active contours is presented. The flow field leads to a contour which is capable of entering concave regions. As a side effect it will help to avoid the rotation of the snake, as it is intended to adjust the template to the CT data according to the same algorithm.

[1] Kass, M., Witkin, A., Terzopoulus, D.: Snakes: active contour models, Int. Journal of Computer Vision (1987), pp. 321-331.

Keywords: computer modelling, active contours, snakes, MRI, CT

Study of Facial Tissue Thickness of the Finns

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The average tissue thickness of the Finnish face was measured from MRI-scans of volunteered normal-weight adult patients in Oulu University Hospital from Fall of 2003 to Fall of 2004. Patients with medical condition or medication that affected the facial tissues were excluded from the study. This study was done in co-operation with Oulu University Hospital. Radiologist Ari Karttunen was responsible of evaluating whether a patient was suitable to take part in this study. He also asked for the permission from the patients as well as acquired the stature and weight data of the patients. The average tissue thickness information was measured from 26 normal-weight male patients and 25 females patients. Normal-weight was determined by body mass index (weight in kilograms divided by square of height in meters). A person was considered normal-weight, when body mass index fell between 18-25. Smaller sample of over-weight subjects was measured (14 males and 13 females). Thirty-one measurements (49 including paired elements) were taken from axial, sagittal and coronal scans. I had access to all sections taken from each patient, so I was able to determine the right location for measurements from each pack of scans. Hospital machinery for imaging were 1.5 Tesla Signa Horizon (GE Medical System) and 1.5 Tesla Signa Twin Speed (GE Medical System). Patients used in this study were treated according to normal patient protocol; therefore the hospital physicist processed the imaging data to conventional scan images. Radworks-program was used to measure tissue thickness; radiologists in Oulu University Hospital use the same program in analyzing the scans. Measurement points were those used in anthropometry and/or in other facial tissue thickness studies. This enabled comparison of measurements with studies made from other populations.

A sub-sample was re-measured to calculate measurement error, six males and six females. Asymmetries of paired elements were calculated with paired T-test. This test showed statistically significant differences in supraorbital and frontal eminence measurements in males and supraorbital measurements in females. This could be the result of a small sample size.

Some cranial measurements (17) were taken to find out whether there were any indications of cranial size influencing the tissue thickness of the face. Covariance of both soft-tissue to soft-tissue measurements and soft-tissue to bone measurements were calculated.

This sample is biased towards high end of normal weight range, because many patients were just on the border of being normal weight. This may account for some of the differences between Finnish facial tissue thickness and tissue thickness of other populations. Some differences may also account for the different methods employed to measure tissue thickness.

Keywords: Finns, MRI, facial tissue thickness

Creating a Three-Dimensional Skull Model from Two-Dimensional Images: Problems and Practicalities in Computerised Facial Reconstruction

S. L. Davy[1)], D. Schofield[2)] and M. P. Evison[1)]

1) Research Centre for Human Identification, University of Sheffield, Medico-Legal Centre, Watery Street, Sheffield, UK
2) School of Computer Science and IT, University of Nottingham, Nottingham, NG8 1BB, UK

Computer graphics technology is constantly evolving; new methods are being developed to assist in the reconstruction of the face of unidentified persons. In the past, an actual skull or cast was needed in order to reconstruct a face using traditional plasticine methods. Most computerised current techniques utilise accurate three-dimensional models of a skull; however these are often created using expensive laser scanning equipment.

The authors have developed new facial reconstruction techniques, including methods for recreating a 3D skull from two-dimensional photographs. This technique allows raw data and information to be transferred electronically, negating the need for highly sensitive or fragile material (such as the skull) to be transported; reconstructions can even be performed in another country. The technique has also been applied to create facial reconstructions of recent murder victims and wrapped mummies, based on either skull photographs and\or radiographs.

This paper aims to discuss the practicalities of creating a three-dimensional skull model using only two-dimensional images and problems that have been faced. The authors will also briefly describe some general guidelines for measuring and photographing any skull which is to be used in a computerised facial reconstruction.

Keywords: facial reconstruction, facial approximation, computerised, 3D, skull

Facial Image Comparison Using 3D Techniques

A. Ruifrok, A. Scheenstra, M, Goos and J. Bijhold

Section of Image Analysis and Biometrics, Department of Digital Technology, Netherlands Forensic Institute, NL-2497 GB The Hague, The Netherlands

In forensic comparison of a facial image with the face of a suspect, preferably reference images are used in which the head is positioned corresponding to the disputed facial image. Techniques using three or more landmark points on the face have been proposed for matching the face and camera positions to the available photographs. However, these methods can be cumbersome, and require the cooperation of the suspect.

3D imaging techniques, together with 3D modeling software, offer the possibility of flexible and reproducible positioning of the head of a person corresponding to the face and camera position of the 2D facial images. However, a recent study1 has shown that although useful for positioning, matching of a 3D model with a 2D image can not be reliably used for identification based on match-point distance statistics. One of the remaining issues in matching 2D images with 3D models is the correct positioning of reference points by the investigators.

To study the possibilities of automation of the positioning of landmarks, we first performed an analysis to find the landmarks that are best suited for automated facial comparison. We used 3D data from the facial area of 3D whole body scans, acquired in the Netherlands for the CEASAR-survey2. At the time of 3D scanning, 8 facial landmarks were manually annotated, and recorded in the scanning process. We measured the absolute distances between these landmarks in the 3D model. The analysis of the measurements was performed in two ways: First, we analyzed the variance and correlation of distances between facial landmarks. Second, we used the Fisher discriminant analysis to find the most significant landmark distances. The resulting sets were almost equal and can both be used for facial comparison. Of the 22 distances between landmark points analyzed, 17 distances were found significant in the Fisher discriminant analysis with an alpha of 5%. The most informative distances appeared to be the distances from and to the Gonion (posterior point of the jawbone). Unfortunately, the Gonion is found by palpation of the underlying jawbone, and therefore it cannot be found in a 3D model. The next most informative are the distances from and to the Sellion (point of greatest indentation of the nasal root depression) or the Supramenton (point of greatest indentation of the mandibular Symphysus).

To find a measure of the discriminating value of the distance measurements of the CEASAR data, we calculated the probability that the measurements of two subjects are not significantly different. We assumed that the measurements for all subjects are normal distributed. If the measurements of a subject are close to the mean (i.e. a ‘common’ face), there is a probability that the same measurements are found in 1 of 2 subjects. If the measurements of a subject are in the tail of this distribution (i.e. a rare face), the probability that the same measurements are found on another subject is 1 in 12 subjects. The CEASAR data set was not geared towards facial recognition however, and used a relative low-resolution scanning system. Therefore, we are currently studying the discriminating value of distance measures in a data-set scanned at much higher resolution.

[1] Goos, M.I.M., Alberink, I.B., Ruifrok, A.C.C. Facial comparison using 2D-images and 3D-laser scans. In Preparation.
[2] http://store.sae.org/caesar

Keywords: facial comparison, 3D model, point matching, landmark detection

Radial Basis Functions for 3D Nonlinear Soft-Tissue Warping

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We deal with an application of the 3D thin-plate spline method to the problem of identifying unknown persons. It is based on a 3D computed tomography image of the skull find and a 3D magnetic resonance image providing the facial template. Computed tomography (CT) is used, because it yields a 3D scan of forensic skull finds that is free of any geometrical distortion. Generally, there are two possible alternatives to proceed with the 3D CT image stack. As one alternative, which will be described in this article, it is of course conceivable to use the 3D CT dataset as the basis of a virtual soft tissue reconstruction, especially since it is stored in the computer as a representation that can be directly used for further work. The other alternative uses the CT data as the basis for the so-called rapid prototyping technique that produces plastic copies of the skull in its true size; to these the anthropologist can add the soft tissues with traditional clay without putting the archaeological find at risk. Following the first alternative of a virtual soft tissue reconstruction, the method for the elastic matching of a 3D soft tissue template with a 3D reconstructed CT skull will briefly be described. According to literature, so-called B-splines are often attached to the 3D skull; the depth of the soft tissue which varies over the skull is pre-defined by standard distances at characteristic anatomical landmarks. Based on these distances, the B-splines so to speak form a soft tissue tent over the cranial bone. In our case an alternative method is chosen which uses the images created by another 3D modality.

Keywords: radial basis fuctions, MRI, CT, 3D warping, elastic matching

Facial Reconstruction Using Three-Dimensional Mesh Data

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Facial reconstruction for biometric identification of humans from their skeletal remains is a challenging and fascinating part of forensic art. The undiscovered face can be approximated by predicting and modeling the layers of tissue on the skull. This work is still carried out by manual sculpting with clay of experienced artists and each reconstructed facial model will spends hundreds of hours. Recently, computer-aided methods to reconstruct the soft tissues of the human face have widely used and made rapid progress. In this paper, we present a facial reconstruction approach that based on the key features of human faces and skulls, measures the depth of soft tissues and reconstructs the facial mesh model from the 2D slices which cut from the 3D facial and skeletal model. The detailed level of the reconstructed facial model is controlled by the cutting process strategy. To make the facial model more accurate, scattered point data interpolation method is used as a means of warping the mesh model. The approach has many advantages over the traditional process: low computer hardware requirement; reconstruction can be completed less than an hour from acquired skull mesh data.

Keywords: facial reconstruction, forensic art, 3D mesh data, 3D warping, 3D measuring

Case Study of 3D Facial Reconstruction: Problems Developed by Missing Information about the Status of Health and Nutrition

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This work is a case study about three dimensional facial reconstruction.

The part of a subarea should be discussed, wherefore hardly no, resp, no information can be found in the literature. In a theoretical and practical way, the question should be pursued, what kind of bandwidth of the variability of expressivity a face can assume, if there is no helpful information about an anonym skull, which can give the reconstructeur a hint for his work. If only the skull is found without the postcranial skeleton or any objects which can give an indication about the person, identification can become a great problem. If a three- dimensional facial reconstruction should help to identify the unknown person, even for this work it is helpful to collect as much information as possible.

In case there is only the separate skull that can be noticed to find out whether the person was cachectic, normal statued or adipose in lifetime, if he or she had any sickness, which also influences the face or whether the face was influenced by external influences (for example alcohol).

For my work, I got a skull from the Institute of legal Medicine from the University Hospital of Hamburg, but without having any information or photograph of the person. On this skull, I will reconstruct the face five times, wherefore the thickness of the soft tissue is based on the data of Richard Helmer. Even in his tables, some of the landmarks vary more than 2 cm between the minimum and the maximum, what also influences the expression of a face in a reconstruction very much. The basic form of the face in a three-dimensional reconstruction is always the same, but the five reconstructions should point out for example different nutritional statuses (from cachexy over normal condition to adiposity) and clarify them in the direct comparison.

The person to whom the skull belonged in lifetime is identified and known by the police and even some photographs, made by the police, exist. After having finished the reconstructions, a comparison with the photographs will be made. So, one can see, if in spite of missing information, one of the reconstructions comes that close to the photograph that an identification is possible. Further, one can determine, if the person could have also been identified under another physical condition.

During the work of reconstruction, the questions in the following should be discussed:

- Which mistakes are developing while working?
- Why did they develop?
- How could they have been avoided and could they have been avoided at all?
- How can and will they be avoided in the future?
- What can I learn about these mistakes?

Keywords: unknown stature, influence to reconstruction, bandwidth of variability of expressivity

Methods of Forensic Facial Reconstruction

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Preparation:
Using CT-scans of a living person, unknown to the participants in the project, there has been realised an accurate three dimensional model of the skull by means of a technique called "Rapid Prototyping" by the team of H. Seitz and C. Tille, caesar, Bonn. Based on this actual model, several plaster casts in a mould of silicone rubber were made in cooperation with R. Bakker, Manimal Works, Rotterdam.

Two dimensional facial reconstruction, drawings:
The original model was used for digital photographic recordings in frontal and lateral views, of course in the correct "Frankfurt Horizontal" position and certain conditions to avoid perspectivical deformations. These photographs were enlarged to correspond with the actual dimensions of the skull. (scale 1:1) and markers were attached using data from Prof. Helmer, Remagen. Initially with pencil on transparent paper and subsequently using red chalk on Schoellers Hammer drawing board a two dimensional facial reconstruction was elaborated in 2 views (frontal and lateral), based on literature (Taylor, Helmer, Neave).

Three dimensional facial reconstruction, sculpture:
On one of the plaster casts also markers were attached using the same references as in the first exercise. The model then was mounted on a stand and fixed in the "Frankfurt Horizontal" position. Using a terracotta co loured modelling clay (Chavant) a three dimensional reconstruction has been made, following the Gerassimov method, refined by R. Neave.

Two dimensional facial reconstruction-computer superposition:
A digital facial reconstruction was realised at the German "Bundeskriminalamt" Wiesbaden by L. Bellmann, U. Wittwer-Backofen and H. Stratomeier, using the software programme ISIS Phantom Professional. This reconstruction is based on a frontal view of the skull model, photographed digitally. From a database, facial elements or parts of existing faces are fitted into the model until the result is satisfying, at the discretion of the reconstructors.

Three dimensional facial surface rendering-holography:
This technique, developed by P. Hering and co-workers, will be adapted in the future to perform three dimensional facial reconstructions. In this project, however, holography was used as a new modern recording technique. In the final stage of the project, the actual "living owner of the skull", has been invited to the caesar institute. Photographic and holographic recording were realised. A portrait hologram with high resolution and a digital 3D dataset with texture information was produced and compared with the sculpture. A rapid prototyping model of the holography based data set was created in addition.

Keywords: facial reconstruction, holography, sculpture, rapid prototyping

The History of Facial Reconstruction in Turkey

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Identification of skeletal remains of unknown identity is one of the most important topics in Forensic Medicine. Facial reconstruction is one of the procedures used in identification process and this procedure is being used in the Forensic Medicine Council of Turkey since 1994.

Although studies on determination of age, sex, stature, time and cause of death from skeletal remains are as old as the studies of Forensic Medicine in Turkey, facial reconstruction applications in identification efforts have started in 1994. After the first test attempts, facial reconstruction has become a routine application in identification of unknown remains. Facial reconstruction is still a successful method of identification applied on criminal and historical cases either two-dimensional or three-dimensional.

After the test studies consisted of 12 cases in 1994, it became the routine identification process of the Council in suitable cases. In some criminal cases, the facial reconstruction played important roles in solving the cases.

In this study we present briefly all our facial reconstruction works performed in the Forensic Council of Turkey since 1994.

Keywords: forensic anthropolgy, human identification, facial reconstruction

I Know that Face

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The reconstruction of the face of an unknown person, regardless of the technique used, can only be regarded as successful in the event that a subsequently confirmed recognition is forthcoming as a result. The appearance of the final reconstruction when presented to the public will have a major impact upon its success.

A reconstruction based solely on an unknown skull will never be a totally accurate portrait, there being far too many variables. It is essential therefore that only the information, which is likely to trigger a recognition, is shown. The more limited the amount of information that can be used, the less likely it will be for an inaccuracy to adversely influence the outcome.

The purpose of this pilot study was to ascertain how much information could be safely omitted from an image of a known person before they became unrecognisable to those who knew them well. It was also designed in a way that reflects to some extent one of the numerous situations in which a recognition may be forthcoming from a member of the public.

The methods and techniques used in this study will be presented and the results discussed.

Keywords: reconstruction, recognition

Biometroscopy: A New Discipline in Facial Imaging and Craniofacial Reconstruction

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Seit Jahrtausenden beschäftigt sich die Menschheit mit ihrem Aussehen. Nachbildungen der Einmaligkeit von Körper und Gesicht wurden bereits in Höhlenmalereien festgestellt, von den alten Ägyptern und Griechen über die Römer und allen weltweit existierenden Naturvölkern in Zeichnungen und Skulpturen sowie Totenmasken erstellt. In der Neuzeit war es Alphonse Bertillon, der Ende des 19. Jahrhunderts ein anthropometrisches System für die Identifizierung von Personen entwickelte. Mit der stetig voranschreitenden Entwicklung der medizinischen und kriminaltechnischen Forschung und der damit einhergehenden Entstehung technischer Systeme, stehen uns heute nahezu unerschöpfliche Möglichkeiten zur Verfügung, die für sich in einzelnen Segmenten Aufschluss über die menschliche Physiognomie geben. Die Gesichtsweichteilrekonstruktion bedient sich dieser Elemente, ohne dafür bislang einen eigenständigen umfassenden Begriff gefunden zu haben. In einem ganzheitlichen Gedankenansatz ist die „Biometroskopie“ eine neue mögliche Disziplin, die sich aus den Komponenten der

- Biometrie – Wissenschaft von der Zählung und Körpermessung an Lebewesen; biologische Statistik, also die vielfältigen Anwendungen der Mathematik, insbesondere der mathematischen Statistik, in den biologischen und ihnen verwandten Wissenschaften zusammengefasst und beinhaltet ebenfalls die Vermessung des menschlichen Körpers,
- der Biometrik (Biometrie und Informatik) in der die Anwendung der Biometrie in der Informatik in wechselseitiger Beziehung zueinander verstanden werden,
- der Biologie und Medizin mit ihren wissenschaftlichen Feststellungsmöglichkeiten,
- sowie der Anthropologie in Zusammenhang mit der Soziologie und der durch globaler Vermischung neu entstehenden Phänotypen der menschlichen Erscheinungsformen zusammensetzt.

Die Möglichkeiten, die sich für die Gesichtsweichteilrekonstruktion aus der Biometroskopie ergeben, werden in diesem ganzheitlichen Gedankenansatz in derzeitiger technischer Hinsicht beleuchtet und in zukunftsorientierten Aussichten dargestellt.

Biometroskopie setzt sich aus den Begriffen „bio“ = Leben, „metro“ = vermessen und das aus dem griechischen stammende „skopein“ = betrachten/ansehen und bedeutet die kriminalistische Vermessung und Verwendung von Körperbetrachtungen. Vereint sind hier alle phänotypischen Erscheinungsformen der Menschen. Maßgeblich für die Zuordnung zu den Kategorien und Leittypen ist das tatsächliche Erscheinungsbild, das heißt die erkennbaren Merkmale, nicht eine staatliche oder politische Zugehörigkeit. Weiterhin die Gesichtsvermessung, Ohrunterscheidungen, die Daktyloskopie, die DNA-Analyse, die Iris-, Retina- und Spracherkennung, die Gang- und Geruchsanalyse, Finger- und Handgeometrie, Venenstruktur, Handschriftenanalyse und Tastaturanschlagerkennung – also alle kriminaltechnische Verfahren, die mit dem Menschen, dem Leben und darüber hinaus subsumiert werden.

Diese Verfahren dienen nicht nur der Individualmerkmalbestimmung und Identifizierung von lebenden Personen, sondern geben zudem sequenziell Aufschluss für Rekonstruktionsverfahren von unbekannten Toten.

In der technischen Darstellung wird veranschaulicht, wie Rekonstruktionsverfahren als Handzeichnung, 2- und 3D-Darstellung durchgeführt werden und welche kriminaltechnische Methoden aufschlussreiche Informationen und Verifizierungen liefern.

Keywords: Biometroscopie

Cranio-Facial Correlations of the Orbital Zone Acertained Using Skull-Photograph Superimposion

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Facial reconstruction technique has gained acceptance as a standard technique routinely used by many practitioners (Snow et al. 1970; Cairns et al. 1983; Gatliff 1984; Drewery 1999; Taylor 2001). Although it has been realized that the 'non-reconstructive' photo superimposition method still relies on the same cranio-facial correlates that are basic to the artistic reconstructive method (George 1987; Brues 1957/1958), yet there had been an element of sectarianism in the technical advancements in these two fields. Bringing about a confluence between these two methods, it has been shown that scientific identification of suitable reconstructive correlates seen in the skull and face photograph through a new method termed "Cranio-facial Morphanalysis" and conjoint application of the findings to the comparative method viz., skull-photo superimposition enhances reliability in forensic skull identification (Jayaprakash et al. 2001). It has been indicated by several researchers that there is lack of agreement among the authors who prescribed guidelines for facial reconstruction (Snow et al. 1970, Gatliff and Snow 1979).

George (1987) and Fedosyutkin and Nainys (1993) concede that the details of the eyes are totally unpredictable from the shape of the orbit. Caldwell (1981) suggested placing the outer canthus 3 – 4 mm medial to the 'tiny tubercle', meaning the Whitnall's tubercle. Krogman and Iscan (1986) suggested placement of the lateral corner of the eye slit by extending 5 mm on either side of the biorbital breadth. Taylor and Brown (1998) indicate the differing descriptions by various authors for positioning the ectocanthi and endocanthi in the orbit.

Similar lack of consensus is apparent in the placement of eyebrows. Krogman and Iscan (1986) suggest that the eyebrow will be approximately 3 to 5 mm above the upper orbital margin. Taylor and Brown (1998) express agreement with the suggestion by Krogman and Iscan (1986), while, Yoshino and Seta (2000) suggest that the lower border of the eyebrow is generally located on the supra orbital margin. However, Fedosyutkin and Nainys (1993) indicate the downward shifting of the eyebrows if there is strong development of the brow ridge. It has also been reported that there is, in general, definite downward displacement in the medial part of the eyebrows, the extent of which is relatively lesser in females (Jayaprakash et al. 2001; Jayaprakash 2003).

Regarding positioning the pupil, Fedosyutkin and Nainys (1993) suggest that the pupil is located in the middle of the orbit (by height). Similarly, Taylor and Angel (1998) recommend positioning the prosthetic eye (pupil) midway between the orbit. However, there has so far been no scientific study verifying the placement of the pupil in the orbit.

The limitations in assessing the skull – face relationships using cadaver faces (Hoffman 1982; Hodson et al. 1985) and radiography of the living individuals (George 1987) have been well established.

In this research, skull-photo superimposition images relating to 25 male and 25 female adult south Indian skulls recovered by the police during criminal cases were used. There are grounds to consider these samples as identified collections.

The superimposed images pertaining to the orbital zone were recorded using the oblique wipe mode (for the eyebrow zone) and the circular wipe mode (for the pupil) after ascertaining the superimposed fitness of the skull and photograph in accordance with the revised criteria (Jayaprakash et al. 2001) for establishing identity of skulls. The Whitnall's tubercle was used as the standard cranial landmark for assessing the location of i) the ectocanthi and endocanthi ii) the pupil and iii) the eyebrows in relation to the supraorbital margins.

The singularly important aspect of this research is that, instead of cadaver specimens, face photographs of the living individuals have been used for the first time for cranio-facial morphanalysis of the orbital zone. The findings of this research indicates that the congruence of the components of the eye zone in the face photographs assessed in relation to the corresponding skeletal elements in the orbital zone in the skull during the process of skull-photo superimposition can provide scientific guidelines for the placement of the components of the eye during the process of facial reconstruction. It is suggested that these guidelines can be applied irrespective of ethnicity, since, as pointed out by Fedosyutkin and Nainys (1993), cranio-facial correlations seem to remain common to individuals of different ethnic origins.

References:

Brues AM (1957-1958) Identification of Skeletal Remains. J Crim Law Police Sci 48: 551-563.

Cairns FJ, Smeeton WMI, and Koelmeyer TD (1983) Identification of Skeletal Remains – A Case Presentation. In: Thomas A (ed): Proceedings of the First Asia Pacific Congress on Legal Medicine and Forensic Science. Sept 18-22, Singapore, pp 305-306.

Drewery B (1999) Identity Crisis. New Scientist Feb 1999.

Fedosyutkin BA, and Nainys JV (1993) The Relationship of Skull Morphology to facial Features, In: Iscan M Y, Helmer R P (eds): Forensic Analysis of the Skull – Cranio facial Analysis, Reconstruction, and Identification. Wiley Liss Inc., New York, USA; 199-213.

Gatliff BP (1984) Facial Sculpture on the Skull for Identification. Am J Forensic Med Pathol 5 (4): 327-332.

Gatliff BP, and Snow CC (1979) From Skull to Visage. J Biocommun 6 (2): 27-30.

George RM (1987) The Lateral Craniographic Method of Facial Reconstruction. J Forensic Sci; 32(5): 1305-1330.

Hodson G, Lieberman LS, and Wright P (1985) In Vivo Measurements of Facial Tissue Thicknesses in American Caucasoid Children, J Forensic Sci 30 (4): 1100-1112.

Hoffman NY (1982) "Edith Potter, M.D., Ph.D: Pioneering Infant Pathology". J Amer Med Ass 248 (13): 1951-1953.

Iscan MY (1993b) Introduction of Techniques for Photographic Comparison: Potential and Problems, In: Iscan M Y Helmer R P (eds): Forensic Analysis of the Skull - Craniofacial Analysis, Reconstruction, and Identification. Wiley Liss Inc., New York, USA; 57-70.

Jayaprakash (2003) Cranio - facial Morphanalysis: A New Method to Enhance Reliability in Forensic Identification of Skull by Photo-Superimposition; and an Analysis on the Preadolescent Permanence of Suture Patterns. PhD Thesis submitted to the University of Madras.

Jayaprakash PT, Srinivasan GJ, and Amravaneswaran MG (2001) Cranio Facial Morphanalysis: A New Method for Enhancing Reliability While Identifying Skulls by Photo Superimposition. Forensic Sci Int 117 (1-2) 121-143.

Krogman WM, and Iscan MY (1986) The Human Skeleton in Forensic Medicine. Charles C.Thomas, Springfield, Illinois, USA; 413-457.

Snow CC, Gatliff BP, and McWilliams KR (1970) Reconstruction of Facial Features from the Skull: An Evaluation of its Usefulness in Forensic Anthropology. Am J Phys Anthropol 33 (2): 221-227.

Taylor K T (2001) Forensic Art and Illustrations. CRC Press, Boca Raton London New York Washington, D.C.

Taylor KT and Angel C (1998) Facial Reconstruction and Approximation. In: Clement GJ and Ranson DL (eds): Craniofacial Identification in Forensic Medicine. Arnold, London; 177-185.

Taylor KT and Brown KA (1998) Superimposition Techniques. In: Clement GJ and Ranson DL (eds): Craniofacial Identification in Forensic Medicine. Arnold, London; 151-164.

Yoshino M and Seta S (2000) Skull-photo Superimposition. In: Siegel JA (ed): Encyclopedia of Forensic Sciences, Academic Press, San Diego; 807-815.

Image Track – Biometric Recognition

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The Investigative Image Management System, is a photo imaging application that allows law enforcement agencies to capture, store, organize and manage images and descriptor data essential for investigation and identification services. At this moment the working stations of Romanian ImageTrak system are being installed and put into operation in all the county police units. The system has a central data station, placed in the Forensic Science Institute, at the Romanian Police Headquarters in Bucharest. This central unit is linked with all the 42 working stations, one in each of the county police units and one in Metropolitan Police. For system's networking there is a special police independent network (named Metropolitan Network), completely separated from other communication lines.

Keywords: biometric recognition

The Importance of Dental Restoration in Facial Reconstruction

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One of the most important points in facial reconstruction process is proper insertion, into the joint of the mandible. Proper occlusion is of importance prime when performing facial reconstruction properly. Particularly proper occlusion is very difficult in cases of total dental loss.

In this study the restoration of the teeth has been performed in a skull having no teeth. In this technique at first soft tissue restoration was done on the upper and lower jaws. Then the measurments of the upper and lower jaws was done. The dimensions of the teeth to be used in total prosthesis were calculated. The prosthesis were inserted on the upper and lower jaws. After normal occlusion was established, facial reconstruction was completed. The skull of an unidentified person may have missing teeth or no teeth. The correct dental reconstruction is of great importance when performing a successful facial reconstruction.

Keywords: facial reconstruction, dental reconstruction, forensic odontology

A Novel Method to Train Researchers on Facial Reconstruction Sculpture

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The field of facial recognition is complex and many conflicting views exist as to how we recognize faces. A more general reconstruction without specific characteristics, may trigger a viewer to consider it possible that it resembles someone they know, rather than a photograph-like image of a person they do not recognize. In general, computer generated image resembles an artificial photograph of an individual in life, but a sculpture based on this image would provide a more general and less suggestive appearance, which would enhance recognition. Furthermore, considerable refinement will be required before computers can be used to present images as attractive as those produced by sculptor.

Manual sculpting methods either based on soft tissue depth makers, or based on replicating anatomical soft tissue structures, or a hybrid of previous two, rely on a combination of the ability, anatomical, and anthropological knowledge of the artist and a number of subjective interpretations of the facial form.

Currently, there is no standardized method to train new investigators in facial sculpture. Consequently individual artistic perception dictates the final output, with inherent personal interpretation, leading to wide inter-operator variations.

We propose a novel method to train investigators in the science of facial approximation by sculpture. This standardized method will minimize artistic license and provide consistency amongst investigators in the final representation of the facial approximation.

Methods:

- An un-embalmed cadaveric head (incorporating a measuring scale) will be photographed from a number of different profiles.
- Soft tissue depths at standard points measured and recorded.
- A median skin incision made to reflect and remove skin from left side of the face.
- Left upper and lower nasal cartilages together with fibrous ala nasi will be excised intact, leaving the nasal septum.
- The left ear will be excised at the bony external auditory meatus.
- The left half of the orbicularis oris muscle including the intermingling fibers of associated dilator muscles will be excised intact.
- The entire left orbital contents enucleated and resin injected into the eyeball with a wide-bore needle to restore contour.
- The subcutaneous fat will be discarded and the superficial part of the parotid gland excised.
- The masseter and temporalis muscles, and the buccal fat pad will be removed intact.
- The remaining soft tissue will be removed and discarded, completing the skeletonising of left side of the facial skeleton.
- The whole head will be plastinated.
- Resected soft tissue structures i.e. ear, eye, and half nose and half lips, will be plastinated.

Sculpturing:

- The plastinated soft tissue structures will be placed in their correct anatomical orientation on the skull, and standard soft tissue depth markers will be positioned. The face will then be sculptured using the standard technique with the additional resources of intact right side of the face and original photographs for guidance.
- This procedure will be repeated routinely until the operator proficiency is achievedText

Keywords: facial reconstruction, sculpture, cadaveric, plastination

An Appraisal of Established and Recently Proposed Relationships between the Hard and Soft Dimensions of the Nose in Profile

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This paper tests six methods of predicting external nasal profile proportions using the form and dimensions of the bony nasal (piriform) aperture. A sample of 122 lateral cephalograms was measured and traced before each method was attempted, under blind conditions where appropriate. Error was assessed by comparing predicted to actual proportions. Methods pioneered by the following were tested; Krogman WM, 1986, Gerasimov MM, 1971, Gerasimov MM (Prokopec P, 2002), Macho GA, 1986, George RM, 1987, and Stephan CN, 2003.

Gerasimov's two-tangent method was found to perform best at predicting a point on the nasal tip on male and female preoperative subjects. Regression equations have been derived from this sample, which predict pronasale in the Frankfurt Horizontal Plane from this method, thereby predicting two points that lie on the surface of the tip of the nose. These equations require testing on other samples before their practical use can be justified.

Krogman's method performed poorly, as did Gerasimov's nasal profile determination method (Prokopec and Ubelaker 2002). The other methods, all derived by a process of regression calculations, were shown to perform with variable accuracy on this sample, despite the age range and ethnicity of this sample closely resembling that of the samples from which these methods were derived.

Keywords: facial reconstruction, nasal profile

Computerized Facial Reconstruction – An Accuracy Study

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Many existing computer facial reconstruction systems involve volume deformation and rely upon databases of facial, skull and/or soft tissue templates. These systems assume that the templates bear some resemblance to the target head and many are limited by the constraints of the triangle mesh or polygon surface.

A “virtual” sculpture systems has been developed that introduces haptic feedback as a touch-based application that creates anatomy-based muscle models focusing on skeletal detail. This paper discusses the advantages and disadvantages of the system and illustrates the accuracy and reliability with a blind study using CT data of living individuals.

Keywords: computerized facial reconstruction

CAD Enhanced Soft Tissue Reconstruction in Forensics with Phantom® 3D Touch – An Electronic Modelling Tool with Haptic Feedback

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Computerized methods gradually gain ground in the field of forensic facial reconstructions (Subke et al. 2000, Subke and Wittke 2004). A new approach to computer enhanced procedures in soft tissue reconstruction is based on the functionalities of the software Freeform® and the touch-based input device Phantom® 3D Touch by SensAble Technologies Inc®.

The combined features of Phantom® 3D Touch and Freeform® allow on the one hand the digital freehand sculpturing and crafting of objects and on the other hand digital 3D construction.

Starting point of the reconstruction is the individual digital model of the scull scanned with the help of Streifenlichttopometrie (SLT) that includes all individual landmarks on the scull's surface that are essential for the accuracy of the reconstruction.

In contrast to other computerized methods, digital construction with Phantom® 3D Touch includes haptics. Digital assemblies, their shapes (curves, edges) or physical properties (softness, smoothness, firmness) representing bones or soft tissue material give a haptic feedback on the input device. The materials' properties can be estimated intuitively while working (e.g. cutting, drilling, sculpting, grinding) contours with the Phantom® input device. In addition CAD functionalities can be used to improve the reconstruction e.g. cross sections through the layers of material can be used to survey the depth of the modeled tissue. The computerized models allow in addition the fast and precise creation of variations to compensate the lack of bone structure in areas like nose and ears.

An example of the application of the new procedure will be presented.

References:

Subke J, Wittke M (2004): Digitale 3D Methoden in der Schädel- und Gesichtsrekonstruktion für die Identifikation unbekannter Toter. 13. Internationales Kriminaltechnik-Seminar, Proceedings, Villingen-Schwenningen Sept. 2004

Subke J, Zeller M, Wehner HD, Wolf H (2000): Digital 3D reconstruction of skulls from fragments using Streifenlichttopometrie (SLT) and a special DNA method. 9th Biennial Scientific Meeting of the Craniofacial Identification, Washington. Forensic Science Communications Vol. 2, No. 4, Oct. 2000

Keywords: 3D modeling, face reconstruction, freehand sculptering, haptic feedback, CAD

Landmark Navigation for Forensic Facial Reconstruction

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Mandatory information within the reconstruction of soft facial parts onto a skull find is the knowledge of the spatial distribution of soft-tissue thickness. Today these data must be manually transferred to each individual case. In the traditional clay-based reconstruction procedure certain landmarks are attached to a skull find. Each of these landmarks represents the mean soft-tissue thickness, i.e. a vector normal to the respective skull surface point. This very technique is more or less a straight manual procedure.

Recently, methods have been developed that mainly work with a digital representation of the skull find. A computed tomography or holographic representation is frequently used as core data to be augmented with virtual soft tissue. However, the information of spatial soft-tissue distribution is indispensable for the procedure as well. Often, these landmarks are employed as basis points of spline-based reconstruction methods.

Though the need of this information is obvious, the mounting procedure for the normal-vector landmarks is not clear. Due to the fact that the forensic landmarks have six degrees of freedom – 3 degrees of the origin, 2 degrees of the surface-normal orientation and 1 degree of vector length – two-dimensional graphical presentation is not an appropriate user-interaction interface.

In this paper we present an inherently six-dimensional interaction scheme for a virtual forensic workplace. It is based on a Polaris online tracking stereo-camera system which allows for navigation of the landmarks in 3D. Thanks to a registration of the digital CT-skull data to the actual skull that is fixed with a forensic skull clamp, the movement and orientation of a pointer in real space will synchronously be transferred to the digital coordinate system. To ensure a real-time performance of the interaction system we developed the software for a dedicated graphic accelerator pcb.

Keywords: landmark navigation, virtual workplace, 3D interaction

Ultrafast Holographic 3D Facial Topometry and Digital Reconstruction

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At caesar (center for advanced european studies and research) in Bonn, Germany we are developing a system for topometric measurement using pulsed holography. The main advantages of our method are the short exposure time and the precise 3D digital reconstruction with intrinsic texture information.

The main application of our method is to provide soft tissue information for planning and documentation of craniofacial surgery.

Computer tomography yields the bone structure and a coarse facial surface of the person. We utilize the extracted surface to perform the registration of our textured model with the skull. This combination of skin data and bone structure provides the surgeon with a reliable database for the precise planning of the intervention.

Together with geola, Lithuania we developed a mobile holographic camera based on a pulsed Nd:YAG laser (wavelength 526,5 nm). The recording procedure is in an upright position and eyes-safe for the person. The system records a hologram with the exposure to a single 35ns pulse of up to 2 J pulse energy. The coherence length of 6m allows for holographic coverage of a large volume. The camera works at daylight conditions, is portable and can be set up in the field within 20 minutes.

Consequent to hologram recording the real image is digitized slice-by-slice and numerically reconstructed. As a result, we gain a virtual 3D representation of the face with highly resolved texture information. The accuracy of the 3D models is app. 0.3 mm, while still being under improvement.

Our aim is to build up a database of soft tissue profiles depending on age, gender, ethnic origin. This database can be used for computer based fast craniofacial identification, forensic medicine and archeology

Keywords: topometry, pulsed holography, laser, face, reconstruction

Rapid Prototyping Models for Facial Reconstruction

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Rapid Prototyping is a well-established process to manufacture prototypes from complex three-dimensional datasets. Nowadays, Rapid Prototyping processes are not only used in the technical field for making concept models or functional prototypes but also in promising areas like medicine or archaeology. For instance, in cranio-maxillofacial surgery physical anatomical models made from medical imaging data help surgeons to prepare operations in close detail. Rapid Prototyping allows not only building models of osseous structures but also of soft facial parts. Based on three-dimensional datasets generated by medical imaging or laser scanning technology different Rapid Prototyping processes can be used to manufacture physical models. Since every Rapid Prototyping technology has strengths and weaknesses the best suited manufacturing process has to be chosen depending on the wanted characteristics of the physical model.

This paper presents the application of two different Rapid Prototyping processes for manufacturing soft facial parts of humans. Firstly, the 3D printing process is used to build physical 3D models layer by layer directly from computer data. A box filled with plaster-based material is printed with a binder solution layer by layer. Powder is bonded in wetted regions. Unglued powder can be removed and the printed part remains. The main advantage of this process is, that it is capable of printing in full-color. Thus, it is possible to process for example color facial scans and manufacture full-color models based on these datasets. Furthermore, replicas of skulls made by 3D printing are well suited as models for forensic or archaeological facial reconstruction with traditional plasticine.

Secondly, stereolithography technology is used to build models that can be used directly or as masters for vacuum casting. In the stereolithography, a laser draws the cross section of the model on the surface of a vat of liquid, photocurable polymer. The laser energy solidifies the polymer to create a solid geometry. This process is repeated for every single layer. The resulting models are translucent to view internal structures. Anatomical models for surgical planning also allow the improved visualization of anatomical features, such as tumors by selectively marking within the model in a single color. Stereolithography models cannot only be used directly but also as masters to produce silicone moulds for vacuum casting. The use of the vacuum casting process allows building parts of a master in different materials with variable material properties and colors. Thus it is possible to mimic various types of tissue with realistic haptic and optical characteristics. Furthermore, combined anatomical models with hard and soft tissue representation can realized by combining models made by different Rapid Prototyping techniques.

The presented manufacturing processes have been applied in several medical and archaeological cases. The results are shown and compared with regard to advantages and disadvantages of the techniques for the respective application.

Keywords: rapid prototyping, facial reconstruction, stereolithography, 3D printing, vacuum casting

Child Pornography: Development of a Method for Identifikation of Faces as Childish

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The age of the victims of child pornography is of great relevance for the investigating authorities. It is the key information for the classification of pornography as child pornography and for the identification of unknown victims as a prerequisite for the termination of a continuing abuse and for the identification of the offenders. At the moment there is a lack of sufficiently reliable and reproducible methods for age estimation based on the analysis of films or photographs. Another problem is the enormously increasing number of pictures that have to be checked by the investigating authorities with regard to the question “child pornography?”

To meet these problems, the aim of this work was to develop an objective and scientifically reasonable method for age estimation, applicable to films and photographs and based upon the evaluation of age-specific changes of proportions in the face during childhood.

The first step to reach the above aims was the development of a software for automated face detection in images and a subsequent classification of the segmented facial image as childish or adult.

Based on a training dataset consisting of 600 high resolution images of children in an age range from 3 to 6 years and a comparable database of adult facial images a general model for age independent face finding was created. It could be shown that in the case of frontal poses nearly all faces could be segmented.

The same datasets were used to train several classifiers in order to distinguish between child and adult. The technics are based on methods which are usually applied in the field of face recognition. This reflects the assumption that the average similarity between human faces decreases with the age deviation.

Applied to images of children in the analysed age group and adults not included in the training set, the classification is highly reliable. If the classifiers parameters are set to classify 100% of all children in the images to be analysed correctly, it classifies approx. 95% of all adults also correctly. Face finding and classification work completely automatised without any manpower, and extremely fast (less than 1s per photo).

Future work will focus on the extension of the methods on those age groups relevant for the legal definition of child pornography (e.g. Germany: 14 years).

Keywords: age estimation, face recognition, image processing

The Artist Titus Lerner

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Head Pictures: Pictures of human heads are the focus of the work of the painter and sculptor Titus Lerner. This is no wonder since head and face are not only the most expressive parts of the human body but also a diverse three-dimensional landscape that has determined the history of arts in a unique way.

The head forms a symbiotic relationship between the inside and the outside, and if an artist works with that intensification it is followed by an excessive overinterpretation and lets the spectator form his own opinion and make his own judgment.

Lerner presents a selection of large pictures and opposes them with three-dimensional sculptures. The Illusionism of extensive surfaces matches excitingly with the space filling materialization.

Reconstructing Humans: Hard and Soft Evidence

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Paleoanthropologists investigate human evolution on the basis of the preserved skeletal evidence that documents morphologic change over the past 7 million years. However, the hominid fossil record is extremely scarce, so reconstructing the evolutionary path from ape-like ancestors to humans and Neanderthals is a real challenge. In my talk, I will focus on computer-assisted methods of fossil reconstruction. Specifically, I will ask how we can reconstruct three-dimensional fossil morphologies, and how we can go beyond the skeletal scaffold of our ancestors and explore how they might have looked like. It turns out that this question has many different answers, which depend on the aims and purpose of soft tissue reconstruction. This leads to a comparison of methods and issues of soft tissue reconstruction in paleoanthropology and in forensics, which exhibit interesting differences, but also major commonalities.

Craniofacial Identification: Is it Scientific or Educated Guesswork

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This paper explores the historical backgrounds of identification and science and how the awesome advances of science and technology have contributed to methods which reduce the risk of incorrect identifications with their disastrous consequences. It warns of the limitations of each method and stresses the importance of carefully selecting the method best suited for the particular circumstances presenting in each case. Details of two Australian cases, 'The Albury Pyjama Girl', and 'The Light Beach' Skull illustrate the potential dangers of hastily resorting to 'educated' guesswork in identification.

Keywords: craniofacial, identification, scientific methods, technology, guesswork

Introduction to the Comparative Study of Facial Reconstructions

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Different facial reconstructions based on the same skull could be quite dissimilar depending on the person who did the reconstruction and the technique used. To determine the variability of facial reconstructions a comparative study is initiated within the RSFP 2005 conference. The study is based on a real criminal case: A skull was found in a forest near Celle, a town north of Hannover. The skull is in sound condition and nearly all teeth of the maxilla and mandible are present. No other body parts or artefacts were found in the surrounding. The identity of the person is still unknown.

23 participants from all over the world (New Zealand, China, Canada, Turkey, United Kingdom, France, Netherlands, Belgium, Czech Republic, Romania, Finland, Switzerland, Germany) joined the study. The participants got all available 2D/3D datasets, photos and documents concerning the case on a CD-ROM. Furthermore, plaster replicas of the skull were produced by the rapid prototyping group of the research centre caesar located in Bonn. Altogether eleven reconstructed real 3D sculptures and twelve 2D reconstructions like drawings and virtual 3D computer visualizations are expected to be presented at the conference.

All reconstructions will be digitized by appropriate 2D/3D scanning techniques and statistically analysed to determine the geometric and volumetric variability. Additionally a biometric facial identification software will define the biometrical alikeness between the individual reconstructions. Finally, a commission of experts headed by Prof. Helmer will evaluate the plausibility of the reconstructions.

All facial reconstructions will be exhibited during the whole conference in room F125.

Genetic Typing of DNA Extracted from a Tooth Root for the Identification Purpose

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The skull of the comparative study was examined by the Institute of Zoology and Anthropology of the University of Göttingen in 2003. A genetic typing of DNA from a tooth root and a histological examination of a tooth lead to some further information:

The skull was identified to originate from a male person of age 56 ± 2.4 years. The dead person was with high statistical probability dark haired and had a light insensitive skin type. The regional origin was determined with reasonable probability to be Mid- or South European.

The talk will introduce the techniques and methods used for the DNA examination.

Semi-automated ultrasound facial soft tissue depth registration: Method and preliminary results

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Introduction: Trying to recreate the face of a deceased individual based on his remains, in the hope recognition would be triggered, researchers developed different two- and three-dimensional facial reconstruction techniques. Several of these techniques use soft tissue depth tables.

Aim: We present a mobile semi-automated ultrasound echographic system for facial soft tissue depth registration, the validation procedure and preliminary results for the European Caucasoid.

Materials and method: As a part of an ongoing project on computer-aided 3-D cranio-facial reconstruction approximately 1000 White Belgian volunteers subdivided following gender, age, body mass index and facial profile had to be scanned on 52 different facial landmarks (10 midline + 21 bilateral). For this purpose a mobile and user-friendly ultrasound scanning system was conceived enabling in vivo, fast, non-destructive soft tissue depth measurements.

The system is composed of a compact and lightweight mobile digital ultrasound "A-mode" scanner (Epoch 4B with a 10MHz 0.6mm transducer, Panametrics Inc., Waltham, USA), a database (MySQL) and a self-designed interface program. The interface program controls the bi-directional data transfer between the database and the scanner which allows automatic depth calculation to avoid interpretation errors of the scanner signal, automatic storage of the result and automatic adaptation of the scanner settings for every specific landmark.

Validation: A repeatability test was performed with an interval period varying between 2 and 57 days on a testgroup of 33 volunteers. Intraobserver agreement was statistically analysed using a paired t-test. Only 5.7% (n=3) of the landmarks showed a significant difference ($p<0.01$) between the first and second measurement.

The accuracy of the system was tested using CT-scanning. Twelve patients consented to have their soft tissue depth ultrasonically registered before passing a CT-scan for preoperative osteotomy planning. Prior to the ultrasound registration the 52 landmarks were marked on the face using a blue eyeliner pencil and a 3D picture of the face was taken using the Eyetronics shapecamera® (Eyetronics, Leuven, Belgium). After segmentation of the skull and the outer layer of the skin, the 3D picture was automatically fitted on CT-based skin surface in order to determine the exact landmark locations measured with ultrasound. Subsequently an extra interface program was conceived enabling virtual "A-scan" echography, allowing to determine the soft tissue depths at the 52 different landmarks locations as registered by the CT-scan. A paired Wilcoxon ranksum-test was performed on the obtained Ultrasound- and CT-results. Only three landmarks (occlusal line (L&R) en mid-masseter (L)) showed on a significance level of $p<0.01$ a difference between the two measurement methods

Conclusion: This new scientifically sound registration method allows relatively fast and reliable soft tissue depth measurements and renders repeatable and accurate results in order to update the facial soft tissue depth data for the European Caucasoid. This revised dataset will hopefully lead to more accurate, manual as well as computer-aided, facial reconstructions.

Preliminary results of the tissue depth measurements on the 52 anatomical landmarks and a comparison with former soft tissue datasets of Caucasoids will be presented.

Keywords: cranio-facial reconstruction, soft tissue depth data, computer-aided

Low-Dose CT-Based 3D Soft Tissue Thickness Model for Craniofacial Reconstruction

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In forensic facial reconstruction, facial features of an unknown individual are approximated based on a mixture of experimentally obtained guidelines on the relationship between soft tissues and the underlying skeleton.

Previously, we proposed to investigate the feasibility of improving craniofacial reconstruction by a statistical approach using skin surface models (measured using a 3D camera) and associated soft tissue thickness (measured at 52 landmarks (LMs) using a portable ultrasound device). While this is a reasonable and very important extension of existing databases, which collect either skin surfaces or tissue depths, but never simultaneously, in this paper, we investigate the possibility of using full 3-D cross-sectional CT images for obtaining densely sampled surfaces of the external craniofacial skeleton and skin.

In order to minimize the radiation dose involved, we first determined a low-dose CT acquisition protocol, derived from a clinical multi-slice CT protocol (Siemens Sensation 16 (Erlangen, Germany)) by lowering the X-ray source current and voltage and increasing the pitch (table feed per rotation). The effective radiation dose for the different protocols was measured on a Rando Alderson anthropomorphic head phantom. The image quality for bone segmentation was measured on the European Spine Phantom (ESP (1)) and a skull phantom. The low-dose protocol yielded a dose reduction from 1.5 mSv to 0.18 mSv for a multi-slice CT scan of the whole head. On the other hand, the noise in the low-dose CT images increases. For bone segmentation purposes, this noise can be reduced to an acceptable level by use of a non-linear edge preserving smoothing filter. The tests on the ESP and the skull phantom indicated that the accuracy of the measurements on the low-dose CT is still acceptable (95% percentile <= 1mm).

Second, we implemented a number of segmentation routines (ranging from hysteresis thresholding in combination with morphological operations to level-set based segmentation) to accurately and robustly outline the outer skin and skull surfaces. The images corresponding to the volumes encompassed by both surfaces respectively were transformed into distance maps (representing for each image voxel the closest distance to the nearest object/background border), which were then sampled at either (skin/skull) boundary to collect distance values between both surfaces.

The thus obtained distance measures sampled at a discrete number of manually indicated landmark positions (both on the skin and the skull surface) were compared to manually measured values (mimicking the ultrasound soft tissue measuring procedure) for a set of 7 patients, planned for maxillofacial surgery for which both low-dose and clinical-dose spiral CT images were acquired.

The distance values measured on the clinical- and low-dose images (both skull and skin LMs) showed no significant differences (Wilcoxon Rank Sum test, $p=0.01$). 95% Confidence Intervals (CI) on the differences are for all but 4 LMs (maximal CI half size 2.2mm)) smaller than 1mm.

Although the Wilcoxon Rank Sum test did not report any significant differences ($p<0.01$) between the manually and automatically obtained distances (probably because of the very small (7) sample size), median values of the absolute differences were smaller than 1mm for the skin LMs except for 8 LMs (max diff < 11mm) and ranged typically between 1mm and 2mm (with a bias towards larger automatic measures) for the skull LMs with smaller outliers (max diff < 4mm).

Keywords: Computer Tomography, craniofacial reconstruction

Improvements in Soft Tissue Data for Facial Reconstructions

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Facial reconstructions are based on soft tissue thickness. Until now, soft tissue thickness data are available for not more than 34 facial landmarks, subdivided by sex and age-decades. Thus, practical work has to model the facial relief between these points manually and, therefore, keeps a field for experienced specialists.

Besides age and sex, it is known that facial soft tissue thickness differs between ethnical groups, body constitution, and body weight. The quantitative influence of these variables are not known yet.

We present our project in preparation, which will deliver standard soft tissue data for specified subgroups and to improve the fitting of the reconstruction to the real person, a major aim for the recognition process.

For that purpose, a fairly large number of individual soft tissue datasets are needed for subgroups, which fulfil the requirements of the above mentioned criteria.

This can be reached using CT datasets, acquired from medical departments for the purpose of medical diagnosis. Classical CT scans, however, produced in horizontal position of the patient, deliver distorted soft tissue thickness compared to an upright position. New CT systems, applied in an upright position of the patient can be used instead. To get access to a larger number of individuals in the subgroups, we intend to calculate the quantitative influence of the body orientation by comparing hologram datasets to the horizontal CT datasets. Hologram pictures in upright position will be acquired for a limited number of patients, who have to undergo a CT treatment. If systematic distortions result, a large number of CT datasets can be used to calculate specific soft tissue thickness data.

Keywords: soft tissue thickness, CT, hologram

Forensic Assessment on the Multiple Spiral CT (MSCT) in Measurement and Markers of the Craniofacial Soft-Tissue Thickness

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With regard to the measurement and markers of the craniofacial soft-tissue, experts has been carrying out and adopting various kinds of research and methods respectively. In some cases, for the purpose of obtaining the craniofacial soft-tissue thickness for some individuals, many detecting devices and method need to be relied on. In order to seek for a quick and scientifically accurate method in which the craniofacial soft-tissue thickness for different parts, the morphological features and markers of the craniofacial bones can be measured, we carried out the measurement and markers to the craniofacial bones and soft-tissue thickness of Chinese adults of different ages by adopting the Multiple Spiral CT from GE company and applying the software AW4.2 in 3D imaging.

In those cases of research measurement, the 3D imaging, the accurate soft-tissue thickness, and craniofacial markers designed can all be shown simultaneously. With implementation of this method, we could measure and collect data of the craniofacial soft-tissue thickness and the morphological features for each of the categorized group of different ethnic races, ages, and genders. This facilitates the forensic craniofacial identification by providing reliable and accurate data evidence.

Keywords: Multiple Spiral CT (MSCT), craniofacial soft-issue, measurement

Linear vs. Non-Linear Physical Models for the Simulation of Facial Tissue Deformations

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The simulation of biological tissues and their dynamics is a crucial ingredient of successful facial surgery simulation and facial reconstruction. Most of these simulations are done by using Finite Element analysis.

In oder to perform an appropriate and precise FE analysis, the user has to choose a physical model for the biological tissues involved and a mathematical model in order to discretize the physical equations.

One of the basic properties of such a physical model is linearity or non-linearity. In many cases the user decides to use a linear model, since linear models are in general much easier to implement and run much faster than non-linear models.

In our paper we give an overview over the basic mathematical criterias for making the decision between linear and non-linear models, and we give some numerical results that show how critical this choice can be for the success of the underlying facial simulation.

Keywords: Finite Element method, biological tissues

Combined Statistical Modeling of Tissue Depth and 3D Facial Outlook for Computerized Facial Approximation

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In forensic facial reconstruction/approximation, facial features of an unknown individual are approximated in order to aid in recognition and identification. All facial reconstruction techniques are based on a mixture of guidelines concerning the relationship between soft tissues and the underlying skull.

Current computerized techniques are limited in the model and method used for reconstructing the complete facial outlook: a generic skin surface or a specific best look-alike according to the skull is fitted or deformed to a set of interactively placed virtual dowels on a 3D digitized model of the skull. The dowel lengths represent averages of ancestry-, gender- and age-matched tissue depths at a limited number of predefined cephalometric landmarks. However, skin surface shape is directly defined at the dowel positions only, and inferred by generic interpolation (Spline-based, e.g.) in between. These interpolations are nicely defined mathematically, but are not face-specific. Furthermore, when a specific skin template or model is used, the final reconstruction is strongly biased towards the used template. Finally, there is no direct correlation between the reported measures of tissue depth and skin surface shape of an individual.

In this work, we reduce these shortcomings by maintaining the direct statistical relationship between skin surface shape and tissue depth for each individual and use it explicitly in a combined statistical template of skin surface shape and tissue depth. This requires the acquisition of skin surfaces and associated tissue depths, measured over a sufficiently large and diverse population and storing them in a database. A combined statistical template, modelling the population-dependent variation and correlation of skin surface shape and tissue depth, is obtained from the database and can be represented as an elastic mask with elastic dowels at particular locations on the inside of the mask. This mask is subsequently fitted to the external surface of the individual craniofacial skeleton and an estimation of the nose tip, such that all the dowels approximate the skull at the, currently manually indicated, corresponding skull landmark locations. The elasticity of the mask and the dowels is defined as the statistically allowable variation as learned from the age-/gender-/race-corresponding database, resulting in face-specific deformations of the mask towards a given skull. The average face from the database is used as initialization of the mask and as such no bias is introduced into the final reconstruction.

Experiments were performed on a test-case and a real-case. The test-case is based on the leave-one-out principle and is used to analyze the performance of the method based on a limited database of 118 persons. The real-case is used to compare the method with a manual reconstruction and an alternative statistical method that we developed, where tissue-depths are manually estimated and set-out on the skull and a statistical template based on face-surfaces without tissue-depths is used. In the proposed method the tissue-depths are unknown and are resolved by the combined surface/tissue-depths statistical template.

Keywords: computer statistical reconstruction

Statistically Motivated 3D Face Reconstruction

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Facial surgeons require a vast amount of knowledge about the human face, in order to decide how to reconstruct an injured or traumatized part.

Does this knowledge consists only of explicit notions about face anatomy, or is there also an implicit knowledge of the normal appearance of a face?

And if the answer to the latter question is affirmative, is there a way for a computer to automatically learn this implicit knowledge and exploit it to predict the optimal reconstruction of part of a face?

It has already been shown how a set of examples of human faces, acquired as 3D surface, can be used to build a statistical model, which can be used to generate synthetic faces or analyze novel ones.

Such a model can also be used to reconstruct the missing part of a face in a statistically meaningful way: any face which can be generated by such a model has a certain probability, and the optimal reconstruction can be defined as the one which maximizes it, given the available data.

However, since the model is built from a finite set of examples, it cannot generate any possible face, and therefore the purely statistical reconstruction will not perfectly fit the available data, leading to discontinuities at the boundary between the missing and the available data.

This problem can be solved by using the statistical model not to directly reconstruct the missing surface, but rather to get an estimate of its curvature.

Then, the missing surface can be reconstructed as the one which satisfies continuity at the boundaries and has a curvature as close as possible to the one of the statistical reconstruction.

As an example, we show how this method performs reconstructing the noses of a set of test faces.

Keywords: surface reconstruction, principal component analysis, poisson equations, 3D morphable model

Statistical Skull Models from 3D X-Ray Images

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We present 2 statistical models of the skull and mandible built upon an elastic registration method of 3D meshes. The aim of this work is to relate degrees of freedom of skull anatomy, as static relations are of main interest for anthropology and legal medicine (see for example Kähler, Haber et al. 2003) . Statistical models can effectively provide reconstructions together with statistical precision.

In our applications, patient-specific meshes of the skull and the mandible are high-density meshes, extracted from 3D CT scans. As each skull shape should share the same mesh structure with the same number of vertices, all our patient-specific meshes are registrated in a subject-shared reference system. These shared meshes of our patients are obtained by matching low-density generic meshes of the skull and mandible to the subject-specific meshes using our 3D-to-3D elastic matching algorithm. Registration is based upon the minimisation of a symmetric distance between the 2 meshes, defined on the vertexes, in a multi resolution approach. It consists basically in deforming the initial 3D space by a series of trilinear transformations applied to elementary cubes. The variability of the position of the vertices of the shared meshes will figurate the specificity of each high-density mesh, thus reflecting the anatomical differences of each subject.

Due to jaw different aperture on the original CT scans, mean skulls and mandibles configurations are computed separately using Procrustes alignment and normalisation. A Principal Component analysis is performed on the normalised data to build a statistical linear model of the skull shape variation. The model is compressed to a few principal modes of deformation. The accuracy of the reconstruction using is under the millimetre in the shape space (after rigid registration). Using the same procedure, a linear model of the mandible shape variation is build. Last, a shape variation model of both skull and mandible is created, using the shape parameters of both models. Scan data from test individuals are then processed, and their modes values and reconstruction error are respectively below standard deviation and registration noise, our model can describe any individual of our test base.

To take in count the articulated aspect of the skull in our model, Kernel Principal Component Analysis is applied, extracting a non-linear parameter associated with mandible position. Therefore a statistical articulated 3D model of the skull has been build.

Another aim of this work is to relate these detailed shape models to feature points - such as cephalometric points (e.g. glabella, porion for the skull) or motion capture data of speakers.

Keywords: statistical skull model, PCA, KPCA, elastic registration

A System on Chip For Medical Image Restoration And Filtering Using A Neural Network Model

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In this Paper, the problem of Blind image restoration using a neural network learning approach is addressed. Instead of explicitly specifying the local regularization parameter values, they are regarded as network weights, which are then modified through the supply of appropriate training examples. Once this is achieved a System on chip may be designed to have a hardware implementation.

The desired response of the network is in the form of estimated value for the current pixel. This is obtained using weighted order statistic (WOS) filter (median filter). This estimate is used to modify the network weights (regularization parameters) such that the restored value produced by the network for a pixel is closer to this desired response. In this way, the single WOS estimation scheme can allow appropriate parameter values to emerge under different noise conditions rather than requiring their explicit selection in each occasion.

The SOC once designed can serve as add on chip for various medical instruments where in image transmission corrupts the image due to various reasons.

Keywords: **i**mage restoration , SOC , neural netwrorks

Stone Age People in Hospital

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The main goal of an archaeological facial reconstruction is education, in contrast with forensic ones where it is identification. Another difference between archaeological and forensic cases is the conservation of the skeletal material.

Hence, the reconstruction method for each can differ slightly.

Archaeology deals with ancient craniums that are often very fragile, incomplete and damaged. This poses a whole series of problems which can be partly solved by CT-scanning the skull. In this way the shape of the skull is transferred into digital data, which can then be manipulated. The complete data is used to make a three-dimensional copy using 3D-printing techniques.

After the cranium is thus reconstructed and copied the method to reconstruct a face is the same as in forensic cases. Gathering as much relevant data as possible (physical-anthropological, odontological, cultural). Selecting the method and tables of average tissue thicknesses most appropriate for this individual. There is one difference: the archaeological facial reconstruction strives for life-like realism in its sculpting, painting and hair work.

For forensic cases such detail is not necessary, or even desirable. Guessing the eye- or hair colour, hairstyle and adding details for which there is no strong evidence lessens the chance of identification.

Here are some examples of archaeological cases and the problems encountered during their reconstruction:

This cranium (6000 years ago, New Stone Age, male, aged 25-45), was missing its right cheekbone. Conservation was poor, so it was taken to a hospital where it was scanned in the CT-scanner. In the computer the left cheekbone was mirrored to complete the cranium. Because this was a man who lived outdoors, I’ve given him a weather-beaten face. And because archaeologists have never found any evidence of stone-age shaving equipment, a beard seemed a plausible addition.

Another example involves the oldest burial ever found in the Netherlands, dating from 7000 years ago (Middle Stone Age). It was from a female, aged 40-60. This skull was also very fragile so it too was scanned. Because the left side of her calvarium was caved in, the right side was mirrored. A part of her jaw was slightly distorted, so it was cast in a temporarily pliable material in order to correct this afterwards. This facial reconstruction was completed with a body laid out in the same position as it was found during the excavation.

This is the skeleton of a young woman, (aged 25-34, 5000 years ago). Her skull was caked with the surrounding earth and her jaw was displaced. After digitising the skull, it became apparent that the density of the encrusted earth was nearly the same as that of the bone, and the earth had to be removed pixel by pixel. The jaw could then be replaced in its proper position.

And so, by using new techniques, 21st-century man can meet these Stone Age people face to face thousands of years after their demise.

Keywords: facial reconstruction, archaeology, Stone Age, CT-scanning

One man with many faces. Facial reconstruction of Man X

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Introduction: Contemporaneous principles of facial reconstruction methods stand on two not too stiff pillars. The first of them is based on average values of soft tissue depth measured at defined points of face. The second pillar is constituted of several guidelines to determine the size and the shape of facial features. But the crucial question is the accuracy of techniques of facial reconstruction.

Design of study: We arranged an experimental study to examine the most common methods of facial reconstruction and we tried to evaluate the accuracy of published prediction guidelines. Material used in this study was one skull of recently deceased individual and also a photography of that person when alive was available. But it was unknown to the author of facial reconstructions. We were given only a skull without any information.

Material: The skull which became a base for facial approximation was anthropometrically ant morphoscopically examined. It belongs to a white male. Age at the time of death was estimated as 45 - 55 years.

Methods: To realize the facial approximation we followed the published instructions. We have made eight drawings (according to Lebedinskaya 1998, Neave 1997, Taylor 2001, George 1987, Stephan et al. 2003). To create three sculptural facial reconstruction we used three classical techniques, the Russian one, the British one and the American technique. To enable comparison between reconstructions we used only one and the same set of soft tissue values in each case.

Results: Using various techniques and guidelines for facial approximation we created more or less different faces based on one and the same skull.

We used five several prediction guidelines to approximate nose from lateral view. Mutual comparison have revealed that we can distinguish three types of profiles of Man X. Then we chose published prediction guidelines for determination width of the mouth, width of the nose and height of the lips and we have applied them to the skull of the Man X. Determining the width of the mouth we obtained several values ranging from 42 mm to 63 mm. So two extreme values differ 21mm! Results of estimation the width of the nose extend from 29,5 mm to 42,2 mm. It indicates the difference 12,7 mm. Then we made a visual comparison of the reconstructions by approximative superprojections and partial comparisons of faces.

Discussion: Our effort has resulted in eight approximated faces of one and the same man. Which of them is the right?

The most important thing is that there exist several guidelines to determine the same facial feature which give diverse results, so it is logically impossible to be all of them correct. That is one of the reason, why another tests of facial approximation principles is needed.

Conclusion: Even if reconstructed faces of Man X vary more or less from each other, they represent one similar type. The aim of this study was to reveal a base of facial reconstruction method, to indicate to some problems, inaccuracies and great deal of subjectivity, which is integral part of this method at the present state of knowledge.

Keywords: facial reconstruction, facial approximation, forensic anthropology

Identification of the Past

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As a forensic odontologist and artist, I got the opportunety to reconstruct 24 Neanderthalers for the exposition: Neanderthalers in Europa. Such reconstructions are not evident with our classical forensic techniques. Different problems had to be solved, different choices had to be made: our solutions, our choices, our results.

Keywords: forensic facial reconstructions on Neanderthalers

3D Analysis of Soft Tissue Changes Following Maxillary Distraction Osteogenesis

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Maxillary distraction osteogenesis (DOG) is a new procedure in the treatment of severe maxillary hypoplasia and retrusion. By now most investigations have focused on questions regarding the procedure, bony changes, and dental occlusion . Therefore an investigation was started to look after the concomitant soft tissue changes associated with large bony maxillary advancements.

Methods: 20 patients treated by way of maxillary DOG were analyzed, most of them suffering from cleft lip and palate. Pre- and postreatment CT scans were compared using a novel tool chain based on rigid and non-rigid registration which has been evaluated for bony changes in time-series analysis. This tool chain allows to extract data for individual anatomical landmarks and displays changes in a colour pattern. Furthermore soft tissue and bony changes could be compared. To assess precision of the tool chain, cadaver studies were carried out. In addition to the time-series analysis, a 3D cephalometric tool is integrated into the tool chain which permits pre- and post-operative comparison to control groups.

Results: Our novel tool chain permits an excellent overview over bony and soft tissue changes. Looking at the soft tissue after an average maxillary advancement of 14 mm, similar changes could be seen in the middle and lower facial regions. Facial appearance was altered towards a harmonic relation. Cadaver studies showed that the tool chain works well within the limitations of the CT-data. To investigate on long-time changes further 3D-data has to be integrated like surface scanning or MR.

Keywords: distraction osteogenesis, soft tissue analysis

Computer Assisted Reconstruction of Face and Skull – 8 Years of Clinical Experience

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The use of computer-assisted preoperative planning and simulation has become a clinical routine in our department. Intraoperative navigation then allows tranformation of virtual templates to the intraoperative situation. Postoperative image fusion of CT and/or MRI data sets achieves detailled analyzations of the postoperative surgical outcome.

Since 1997 virtual templates and preoperative simulation followed by intraoperative optical navigation of surgical instruments were used in the treatment field of Cranio-Maxillofacial Reconstructive surgery.

Over 200 patients have been treated. Complex posttraumatic orbital reconstructions (primary and secondary), resection and reconstructive procedures in the treatment of midface and skull base tumors and complex craniofacial and orthognathic surgery has been performed to create ideally shaped hard and soft tissue reconstruction of face and skull in trauma and tumor patients.

We will demonstrate the clinical use of computer-assisted simulation to perform virtual face and skull reconstruction, which is then used for as a virtual template intraoperatively by navigational surgery

Keywords: virtual reconstruction, reconstructive surgery

Assessment of Image Quality of Low-Dose Multi-Slice Spiral CT and Cone-Beam CT Imaging for 3D Image Based Maxillofacial Surgery Simulation

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Introduction: A framework is presented for the assessment of image quality of low-dose multi-slice CT and cone-beam CT imaging in the context of 3D image based maxillofacial surgery simulation. Image quality is assessed by comparing thickness measurements of bony structures segmented from the image under study with similar measurements at corresponding geometric positions in a reference image, derived either from a CAD description of the imaged object if available or from a reference CT image of the object acquired using a standard (high-dose) protocol.

Material: The framework has been applied to two datasets: a dataset consisting of a CAD model and a multi-slice spiral CT-image acquired with a maxillofacial protocol of the European Spine Phantom (ESP) (Siemens Sensation 16, Erlangen Germany), a dataset consisting of a CAD model and a multi-slice spiral CT-image acquired with a protocol with lower radiation dose of the ESP. And is currently being applied to a third dataset consisting of a multi-slice spiral CT-scan (Siemens Somatom, Erlangen Germany) and a cone beam CT-image (NewTom DVT 9000) of a skull phantom. The first image of each dataset is the reference image; the second image is the object image in the description of the framework.

Method: The image quality is assessed by comparing thickness measurements of the bony structures in the object image and the reference image. These thicknesses are calculated across measure lines perpendicular to the bone surface. These measure lines are calculated in the reference image and transformed to the object image by a rigid registration with the following steps.

1. In the first step, the measure lines perpendicular to the bone segmentation in the reference image are calculated. If the reference image is derived from a CAD description of the object, measurement lines are defined directly in this model. Otherwise, the bone is segmented using thresholding and mathematical morphological operations. A triangulation of the resulting bone segmentation is calculated. Measure lines are defined as the normal along a subset of triangles of the triangulated surface.
2. The measure lines are transferred from the reference image into the object image after rigid registration of the reference image to the object image by maximization of mutual information.
3. Intensity profiles along the transformed measure lines are extracted from the object image using trilinear interpolation, after reducing the noise by gradient anisotropic diffusion filtering in case the object image is a low-dose CT-image. Across these measure lines, the bone is segmented by 1D thresholding.
4. The results of the thickness measurements are summarized in the mean value and the standard deviation of the absolute difference of thickness measurements.

Results: The application of the framework to the dataset of the ESP with the clinical protocol yielded a mean absolute difference smaller than 0.25 mm and a standard deviation smaller than 0.35 mm and for the dataset with the low-dose CT a mean value smaller than 0.35 mm and a standard deviation smaller than 0.3 mm. Results of the skull phantom are still preliminary

Keywords: low-dose CT, bone segmentation, image quality

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Der Kreis Ahrweiler – die Gesundheits- und Fitnessregion mit ihren zentralen Bausteinen

Der Landkreis Ahrweiler profiliert sich als die Gesundheits- und Fitnessregion in Deutschland. Im Zuge des Bonn-Berlin-Ausgleiches wurde seine Wirtschaftsstruktur um zentrale Elemente bereichert, so dass das Gesundheitswesen inzwischen den Kern der wirtschaftlichen Entwicklung im Kreis Ahrweiler bildet. Im Kur- und Gesundheitsbereich verfügt der Kreis Ahrweiler über zahlreiche Einrichtungen und enorme Potenziale. Die drei zentralen Projekte des Bonn-Berlin-Ausgleichs haben ihre Schwerpunkte in den Gesundheitsbereich gelegt:

- der Innovationspark Rheinland (IPR) in Grafschaft,
- das Innovations- und Gründerzentrum (IGZ) Sinzig sowie
- der RheinAhrCampus Remagen der Fachhochschule Koblenz.

In unmittelbarer Nähe zu dieser technologieorientierten „Troika“ gelegen sind die Forschungsvereinigung der Arzneimittel-Hersteller (FAH) und das Zentralinstitut für Arzneimittelforschung (ZA) in Sinzig als Technologietransfer- und Weiterbildungsstellen für mittelständische Unternehmen, die in der Pharmaindustrie als Arzneimittelproduzenten, Rohstofferzeuger und Zulieferer tätig sind.

Innovationspark Rheinland in der Grafschaft

Lage	Gemeinde Grafschaft (Rheinland-Pfalz) 4 km nördlich von Bad Neuenahr-Ahrweiler 25 km südwestlich von Bonn
Leitbranchen	dienstleistungs- und technologieorientierte Betriebsansiedlungen aus den Bereichen Biotec, Life Science, Protec, IT und Ingenieurtechnik
Anbindung	BAB 61 – eigene Anbindung
Nutzfläche	42 ha, davon 22 ha sofort bebaubar
Bebauungsplan	rechtskräftig – erlaubt hohe Grundstücksnutzung und variable Gebäudekonzeption
Telekommunikation	flächendeckender DSL-Anschluss
Grundstücksgrößen	ab 3.000 m², individuell parzellierbar
Grundstückspreise	ca. 25 Euro / m² voll erschlossen
Anmietung / Mietkauf	möglich, Preise nach Ausstattung

Der Innovationspark Rheinland ist eingebettet in eine hochverdichtete Wissenschaftslandschaft und ein wissenschaftlich-technologisches Umfeld von Weltgeltung (Bonn, Köln, Aachen). Daraus resultiert ein enormes Arbeitskräftepotenzial im natur- und ingenieurwissenschaftlichen Bereich. Die großen europäischen Märkte befinden sich in Reichweite.

Weitere Pluspunkte: ein abgestufter Mix aus zusätzlichen Miet- und Mietkaufflächen, eine hochflexible Modulbauweise, individuelle und kostengünstige Mitwachsmodelle. Das Parkmanagement bietet umfangreiche Serviceleistungen, wie Finanzdienstleistungen, Marketingkonzepte, privates Risikokapital, Bauberatung und -betreuung.

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IGZ - Innovations- und Gründerzentrum Sinzig
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Mit der Zielsetzung der Förderung von Unternehmensgründungen steht Existenzgründern und mittelständischen Unternehmern aus den Bereichen

- Pharmazie,
- Medizintechnik,
- Lebensmittelchemie,
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