AESOP 3D imaging in a South African context workshop Abstracts

DR ZEELHA ABDOOL

3D - 4D Ultrasound in Obstetrics and Gynaecology

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Recent technological advancements in ultrasound equipment has enabled 3D and 4D imaging as a clinical reality in both obstetrics and gynaecology. 3D foetal images were first reported in 1984 by processing 2D images, and real-time volumetric scanning was subsequently introduced in 1991. Foetal facial anomalies were first reported by 3D transvaginal scanning, followed by skeletal and central nervous system abnormalities. Advantages of its use include maternal bonding, improving accuracy of invasive diagnostic investigations such as amniocentesis, cordocentesis and intrauterine transfusions. Its use in gynaecology ranges from foetal sac volume measurements, endometrial assessment, ovarian tumour volumes and more interestingly real time evaluation of the pelvic floor. This session will highlight advancement of 3D technology focusing on the pelvic floor.

DR ABDULJALIL ADEBESIN

Body proportions of South African Black children age 0 to 6 years

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This study investigates the growth of Black children in Johannesburg, in the context of a larger project assessing the relative development of long bones and deciduous dentition. Skeletal growth patterns indicate the social wellbeing of the general population. Preschool children have similar growth potentials within the constraints of their genetic makeup. However, growth is influenced by infections and poor nutrition, resulting in different outcomes in body proportions. Lower limbs of Black children are generally longer than those of White children; this had been attributed to differing biological histories. However, Black children in poor socioeconomic environments often grow slowly, have shorter lower limbs, and exhibit diminished adult stature. Most studies on body proportions are based on anthropometric variables. Precise bone measurements are usually unavailable because of the difficulty in obtaining them for living subjects. New imaging techniques make bone measurements possible for non-skeletonized subjects. For this research**,** full body CT scans of 55 children aged 0-6 years from the Paediatric Cadaveric Collection of the Wits School of Anatomical Sciences were used. 3D surface rendering of long bones was carried out using VG Studio Max software. The extracted region of interest was saved as a .DCM file and transferred to Aviso 9.0 software for measurement. Right diaphyses were mirrored to approximate the form of antimeres. Each diaphysis was transformed, aligning it in the principal axis such that in Z view, the dorsal surface was parallel to the horizontal axis. The diaphysis was then measured from the distal to the proximal point in the XZ view. Preliminary data on the femora and tibiae will be presented. Future work will involve comparisons with anthropometric studies of South African children and international growth standards.

RIAZE ASVAT

User-specificity of anatomical landmarks of the cochlea for use in computational models

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Cochlear implant (CI) users experience great variation in sound perception which may, in part, be due to individual variations of the cochlear anatomy. The anatomy of the cochlea has been described as being as distinct as a "fingerprint". This person-specific design of the cochlea must be taken into account when inserting cochlear implants as it creates difficulties for the facilitation of the electrode array without causing trauma. The numerical description of insertion trauma to cochlear structures in terms of the effect it has on neural excitation and consequently hearing performance is important to optimize clinical benefit for persons with cochlear implants. Understanding the microstructure of the cochlea could assist in developing geometrical templates of these structures that may be used to create accurate person-specific computational models. Such models may be used to inform and quantify factors that underlie the vast differences in user-specific performance outcomes that are presently observed. Micro-focus X-ray computed tomography (µCT) was used to scan a sample of forty-four dry human skulls housed in the Department of Anatomy, University of Pretoria. The skulls were scanned at Necsa (South African Nuclear Energy Corporation) which houses the Nikon XTH 225 ST micro-focus X-ray tomography facility (MIXRAD). The volume files from the µCT scans were imported into VGStudioMAX-2.2 visualization software (from Volume-Graphics) for the three-dimensional rendering, segmentation, visualization and of the reconstructed volume data (Volume Graphics, 2010). Each cochlea was orientated in the cochlear view where the basal turn of the cochlea was used as the x- and y-axes and the centre of the modiolus as the z-axis. A total of 50 landmarks were identified at 5^0 intervals on each mid-modiolar section to describe the cochleae. The results of these outcomes will be presented and compared with data published in the literature.

DR. BRITT BAILLIE

Rock Art and cultural landscapes – imagining uses for 3D imaging in South African heritage and tourism

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The two examples mentioned in the title serve to indicate the potential of 3D imaging in the field of heritage and cultural tourism in South Africa. Rock 'Art' has been identified as 'heritage at risk' by ICOMOS South Africa. It is under threat from weathering, erosion, fire, flooding, vandalism and theft. Although the majority of examples date from the last 3000 years, the tradition stretches back at least 20,000 years. The value of this 'art' lies not only in the beauty of the elusive images of hunters, animals and other symbols, but also in its capacity to provide a window into San and other communities intangible heritage. Professor Silvia Tomášková is currently in the process of constructing a 3D database of South African rock art. This presentation explores the database's potential for heritage preservation, increasing public access (these sites are often remote, hard to reach, and widely spaced), improving archaeological and public understanding and valorising the past of indigenous peoples by placing this database in the context of other similar international projects.

PROF. CHRIS BOONZAAIER

Rock Art and cultural landscapes – imagining uses for 3D imaging in South African heritage and tourism

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The two examples mentioned in the title serve to indicate the potential of 3D imaging in the field of heritage and cultural tourism in South Africa. As far as landscapes are concerned, the divide usually made between natural and cultural landscapes is a European construct which does not reflect the indigenous perceptions of the African landscapes. In fact, in the indigenous worldview 'nature is culture'. 3D imaging provides the opportunity to illustrate this worldview by means of the identification of natural phenomena and the cultural meanings attached to it. This implies that 3D imaging provides the opportunity to visualise intangible cultural heritage. By means of 3D imaging, students and tourists get access not only to natural attractions endowed with cultural significance but also to the worldview of a people. The Masebe Nature Reserve in the tribal area of the Langa Ndebele in the Waterberg region of the Limpopo Province serves as case study.

PROF. MARIUS BOSMAN

3D imaging and Anatomy in a South African context

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For centuries Anatomy has been regarded as the firm foundation of the whole art of medicine and its essential preliminary (Vesalius, 1543). Today, Anatomy remains the backbone and common ground for all health science specialties and we are therefore not surprised to be considered as co-hosts of this cutting edge 3D imaging workshop. Imaging techniques permits Anatomy to cut apart in a virtual environment to reveal aspects of structures seldom seen. Imaging techniques allow for non-destructive imaging of inner structures. Measurements are then possible in a 3D context and enable registration of 2D or 3D structure to compare groups or individuals. Shape variation or associations between groups can be appreciated in this manner. It is also ideal for studying growth, ageing or other anticipated shape changes, because of an identified biomechanical stimulus, e.g. the change in shape of the mandible when teeth are lost. The Pretoria Bone collection has often been resorted to for both imaging of inner structure and shape analysis. This collection is housed in the Department of Anatomy and is a cadaveric derived collection used to teach medical students and a resource for anthropological research. There are over 1000 skeletons in the collection and the majority are of known age at death, sex and ancestry, originating mainly from individuals who died in the Tshwane metropolitan area. Skeletons in the collection are sourced from donated or unclaimed bodies from local hospitals. In addition to standard imaging techniques, Microfocus X-ray Computed Tomography scanning, delivers more focused images as small as 50 μm^3, which are precluded in living individuals, is possible on skeletal material. Highly focused images derived from Microfocus CT may be useful for precise quantitative analysis of inaccessible internal structures (including middle and inner ears, bony tables and vascular foramina) on cadaveric material. Findings so obtained may then be brought into clinical context by comparison with living references.

PROF. JOSÉ BRAGA

The evolutionary history of the cochlear spiral shape modelled in 3D

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The spiral shape of the mammalian cochlea, the auditory organ which plays the most important role in determining the bandwidth of hearing, enhances the detection of low frequency sounds in humans. However, cochlear shape is particularly difficult to model in 3D for comparisons between individuals or between species. We recently investigated simple cochlear parameters observed through microfocus x-ray computed tomography (micro-CT) and previously considered to be associated with hearing capacities. Several statistical methods allowed us to measure the tendency for evolutionarily related ape species to resemble each other in cochlear morphology due to their recent shared ancestry. We showed, first, that differences in cochlear features among apes' species are explicable by the history of their lineages (the phylogeny), and second, that human cochleae set apart from our living and extinct related species with their relative length and oval window areas larger than expected for their body mass. In a new step to further model the evolutionary history of the human cochlea, we devised a new method to investigate its spiral shape in greater detail. We measured cochlear shape in 3D through micro-CT and we compared individuals at both intraspecies and interspecies levels. Here we present some preliminary results obtained in extant humans and living apes. They indicate the usefulness of our 3D modelling of the cochlear spiral to identify better evolutionary trends during the past millions of years.

DR. NANETTE BRIERS

Facial profiles of children in forensic analyses

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Techniques such as facial approximation require intimate knowledge of human craniofacial anatomy. In children, craniofacial changes due to facial growth complicate facial approximations and require specific knowledge of variation in facial shapes. These have hardly been studied in children of African descent. The aim of this study was to document the lateral profile shape changes between the ages of 6 and 13 years of Black and Coloured South African children. Geometric morphometrics were used to assess shape changes in facial morphology with respect to age, sex and ancestry as seen on lateral photographs with the head in the Frankfurt plane (n=800). The mean shape of an age group was compared to the mean shape of the previous age group on the lateral images of the face. From these comparisons, shape changes at each age from 6 to 13 years were plotted. The mean shape of age groups per sex and ancestry was also determined and compared for shape changes between groups. The results showed differences in lateral face shape between children of various ages, sexes and ancestral groups through the relative displacement of landmarks related to the forehead and lower face. Furthermore, facial profile per age and ancestry was different at all landmarks as opposed to facial profile per age and sex, where differences were seen at the forehead and in the lower face region. Landmark displacement indicated that the brow ridge in Black children is somewhat more pronounced compared to Coloured children, while displacement of the lower face landmarks indicated that prognathism in Black children is more pronounced compared to Coloured children. South African specific face shape data generated from this study will useful in the identification of children as well as the verification of the ages of children involved in pedo-pornographic material.

CAPT. TEUNIS BRIERS

Overview of 3D computerized craniofacial reconstruction methods in the South African Police Service

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Craniofacial reconstruction has been employed as an investigative tool in the context of forensic investigation within the South African Police Service (SAPS) since the 1980's. Methods used included 2D sketches and 3D manual clay sculptures. However, due to increased number of unidentified skeletal remains, a need has arised to obtain a faster method for craniofacial reconstruction. In this regard, the SAPS obtained a 3D computerized system which replaced the laborious process of 3D clay reconstructions. The system comprises of a 3D scanning device (Metrascan 210), 3D post editing software, Geomagic Warp software® with Phantom desktop haptic feedback device as well as a 3D printer (Objet Connex 500). The system was introduced in 2011 and is used on a daily basis. As a result, 38 cases have been processed *via* this system. In addition to forensic cases, the system is utilized for research, and will in the near future be employed for facial reconstruction and ballistic training. Furthermore, it is envisaged that the system will be used as a visual aid in court testimony. In terms of research, male and females skulls were scanned to create a software model in order to predict the mandible size and shape in forensic cases where the mandible is absent. The system is specifically used for facial reconstruction and ballistic training. Currently, the SAPS is the only organization that has the skills and expertise as well as the mandate to perform 3D craniofacial reconstructions in active forensic cases.

DESIRÉ BRITS

Magnetic Resonance Imaging (MRI) to assess stature estimation in Black South African sub-adults

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Stature estimation is rarely attempted in sub-adults due to the general lack of literature and standards available. This is due to the dearth of sufficiently large sub-adult skeletal collections with known demographic information available for research. To bridge this problem sub-adult research mainly employs modern image modalities. In the current study Magnetic Resonance Imaging (MRI) scans were used to assess stature estimation in Black South African sub-adults. A total of 53 Black South African sub-adult males (n=24) and females (n=29) aged between 10 and 17 years were recruited to voluntarily participate in the study and underwent a full body Magnetic Resonance Imaging (MRI). Living stature of each participant was collected with a stadiometer and all skeletal elements that contribute directly to stature, i.e. the skull and vertebral heights, femur and tibia lengths as well as the articulated height of the ankle, were measured from the MRI scans using the image processing software OsiriX. The skeletal measurements were summed to calculate the total skeletal height and a Pearson's correlation was used to assess the correlation between the total skeletal height and living stature. Subsequently linear regression equations were computed for the estimation of sub-adult stature. Results indicated strong statistically significant positive correlations between living stature and total skeletal height in males (r=0.990), females (r=0.981) and a combined sex sample (r=0.982). The computed regression equations were characterised by small standard errors ranging between 1.50-1.84cm and were comparable to that reported for Black South African adults. Based on these results the anatomical method can be used to accurately describe living stature in Black South African sub-adults. Stature estimation is therefore encouraged, as it will add valuable information when dealing with unknown sub-adult skeletal remains.

DR. LAURENT BRUXELLES

3D modeling in the cradle of humankind (Gauteng, South Africa)

L. Bruxelles, J. Braga, J. Dumoncel, J-P. Jessel, B. Lans, R. Maire, B. Moreno, N. Plate and G. Subsol

3D modeling can be used at different scales and for several purposes. For nearly ten years, we have been studying geology, geomorphology and karst stratigraphy in an area called the Cradle of Humankind by UNESCO in 1999. 3D modeling has been part of our approach during each step of the research process. We will present a review of each step. In order to help in our understanding of the landscape evolution, we use Digital Elevation Model from different sources. Some of them are produced from satellite images and give a broad view of the whole area. Others are made by photogrammetry, using high precision pictures taken by a drone along the Bloubank valley. The images provide some very accurate DEM of the slopes and around the entrances of the caves.

In caves, it is not only important to understand the links between the surface and the galleries, but also between the different galleries within the same cave. In Sterkfontein, we mapped the main galleries, which provided us with a 3D model of the cave network. Several cone talus formed under the entrances and their development through the cave system can now be followed into the lowest parts of the cave. 3D can also be used as a memory of the sites, for example, during excavations. In Kromdraai, we usually construct 3D models of the current excavation using photogrammetry. In Sterkfontein, high resolution 3D scans permitted us to scan Little Foot in its stratigraphic context. Even if the fossil is not present in the cave anymore, we are now able to go back to the previous state and study the links with the different layers of sediments.

DR. KRISTIAN J. CARLSON

The unique capabilities of the WITS microCT facility and more

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The Microfocus X-ray Computed Tomography (CT) facility (www.wits.ac.za/microCT) of the University of the Witwatersrand (Wits), dedicated in the first half of 2012, has been serving a wide variety of scientific users. The earlier established Virtual Imaging in Palaeontology (VIP) laboratory at Wits, through its cutting-edge computing resources and intimate connection with the Wits scanning facility, extends this support into the realm of 2D and 3D (quantitative) image analysis. Collectively, these facilities serve a diverse user base in the pursuit of scientific excellence that spans more than ten Schools at Wits alone, plus includes a number of scientists at other South African and overseas institutions. The Wits facilities, being specifically designed to acquire and analyse high resolution image data sets from dense objects, such as palaeontological and geological specimens, thus have unique infrastructure capabilities and operator/user experience within South Africa. To date, the Wits facilities have had integral roles in research published in a number of scientific journals, including high profile international journals such as Science and PNAS. Here, examples of ongoing work by its user base will be presented in order to demonstrate capabilities of the facility, as well as its potential for serving additional users in their scientific pursuits. In line with the theme of the present workshop – 3D imaging in a South African context, these examples feature computer-assisted approaches for exploring, reconstructing, and analysing dense objects, such as fossils. In particular, examples of ongoing work examining internal structure of modern and fossilized bones, and that use advanced quantitative methods of 3D computer-assisted image analysis, will be demonstrated.

DR. VINET COETZEE

Association between body weight and facial features

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The human face reveals a wealth of information about our health. Facial adiposity, for instance, is a particularly salient indicator of Body Mass Index (BMI) and predicts both actual and perceived health. Here we report on several of our previous studies in 2D and 3D facial morphology using a range of different techniques. We identify several facial dimensions associated with BMI and percentage body fat and examine the perceptual thresholds for a noticeable change in BMI. In other words, identify the minimum changes in BMI that people can recognise in 3D facial images. In addition, we identify preferences for the optimum percentage body fat in 3D facial images and show how a visual diet of heavy or light bodies, influences our preferences for facial adiposity. These studies offer a glimpse at the type of research that can be conducted in 3D facial morphology. Many of these techniques can also be utilised to study the 3D morphology of other objects.

FRIKKIE DE BEER

"Reveal the Hidden With the Unseen": Perspectives on the Basics of Tomography

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The understanding how and the successful implementation / application of a tomogram can be achieved only when the basic concepts, the individual components (Source / Sample / Detector / Reconstruction and Visualization) and their integrated functionality is known and very clearly understood. Each one of the components of a tomography research facility, using penetrating radiation as probe, plays an integral part in the outcome of an experiment (3D scan) and should be optimised for best performance to provide best possible results and 3D-quality for a specific sample. This talk will highlight some of the operational aspects of these high sophisticated instruments where instrument scientists at these facilities have to provide the optimum 3D-scanning results for visiting researchers. A basic background to obtain a 3D-tomography result in a research environment using X-rays, neutrons and gamma-rays as probes will be discussed.

JEAN DUMONCEL, DR. CLEMENT ZANOLLI

3D imaging: segmentation, visualization and representation for comparisons

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This workshop aims to inform the state-of-the-art in virtual anthropology methods, techniques and freeware software packages. We will highlight new techniques and applications in biomedical and paleontological imaging. The quantification of morphology and of its variation among individuals, is a classic research topic in (paleo) biology. During the last decade, newly available 3D imaging techniques and the progress of computing sciences opened new possibilities for quantitative analyses of biological shapes. These advances resulted in innovative methods to comparatively render, quantify and extract in two and three dimensions (2D and 3D) the structural signature of a biological material, which now find applications in many scientific fields including paleontology, paleoanthropology, medicine and forensics, biology (from organic to cellular biology), engineering, physics… This workshop is an opportunity to bring together researchers and students and to show some applications in the fields of biology and paleontology imaging, and to discuss about recent developments in the field, as well as of other potential applications. The workshop will combine oral presentations and instructor-led hands-on sessions with the participants working on computers. We will give some introduction concerning various topics (e.g., segmentation using a region growing method using the itk-snap software, shape quantification and comparison with the software meshlab, statistical analyses using landmark and non-landmark methods).

PROF. TANIA HANEKOM

Geometric parameter extraction from 3D imaging for computational modelling of user-variance in live cochleae

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Much variation in hearing performance is observed among users of cochlear implants. To gain an understanding of the underlying factors that cause inter-user performance differences, insight into the functioning of individual implant users' auditory systems is required. An investigation into factors that are responsible for user-specificity starts at the periphery of the implanted auditory system at the physical interface between technology and biophysiology. This includes the unique geometric parameters that describe the cochlear morphology of an individual, variations in electrode geometry and location among users, individual neural survival patterns and variations in electrical characteristics of tissues and fluids through which stimulus currents propagate. While it is not possible to study the response of the peripheral auditory system to electrical stimulation in humans invasively, computational physiology provides a unique simulated invasive view into the workings of the implanted cochlea. Any measuring point or quantity may be simulated or predicted provided that an accurate model of the electrically stimulated auditory periphery is available. The work presented expands on the development of advanced computational models to describe individual CI users' cochleae with the intent to open a unique window onto the electrophysiological functioning of a specific implant. The purpose is to apply these models to (i) study the auditory system at a physiological level that is not physically accessible in human users, and (ii) provide a tool to clinicians to access information about an individual user's hearing system that may contribute to optimal mapping of the implant and/or support diagnostic procedures in the event of deteriorating performance. The application of user-specific geometric data extracted from both conventional and micro computed tomography to support model-predicted mapping (MPM) of implants and model-based diagnostics (MBD) is presented. (www.up.ac.za/bioengineering)

JASON HEMINGWAY

The biogeography of human craniofacial variation in the South African Holocene

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The skeletal material from the South African Holocene presents a unique opportunity for documenting the recent prehistory of human migration. However, there is continued debate of the origins and distribution of these populations, as well as the exact mode of acquisition of some cultural practices, such as pastoralism. This study aimed to test whether spatiotemporal trends in craniofacial variation exist and, if so, whether they support proposed hypotheses regarding replacement, demic diffusion or cultural diffusion. Twenty landmarks were digitised from 138 crania for which radiometric dates and provenience were available. The skeletal remains all originated from the South African coast and coastal forelands. Partial Mantel tests revealed significant associations between both the spatial and temporal data and craniofacial variation. A two-block partial least squares was used to illustrate the associations between the standardised spatial and temporal variables on the one hand, and the Procrustes superimposed configurations on the other. Each orthogonal vector appeared to document something unique. The first indicates a slow enlargement of the maxilla associated with a deepening of the temporal fossa, originating west and moving slowly eastwards with the passing of time. The second shows a complex morphological change with an enlargement of the mid-facial region and a shift in vault shape from round and globular to long and low. This second morphological shift moves westward sometime after ~3000 years ago, but it is temporarily impeded, possibly by geographic and climatic factors. The trends observed do not support either complete replacement or demic diffusion but rather a combination of the two models, at different times.

ERIN HUTCHISON

Dental crenulations: age estimation tool or developmental artefact

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Dental age estimations within forensic investigations have largely been based on the degree of root formation, the presence of the striae of Retzius and circumseptan interval and the mineralization of dental hard tissues. While these measures effectively serve as fundamental components in the process of age estimation, they don't consider the full morphological development of the tooth crown. Thus, by assessing the direction of growth, degree of morphological development and dimensions of the individual crowns of the deciduous dentition in immature mandibles, a holistic and accurate means of age estimation may be possible. Our sample consisted of 45 paediatric mandibles ranging in age from 20 gestational weeks to 4yrs sourced from the Johannesburg Forensic Paediatric Collection and Raymond A. Dart Collection of Human Skeletons. Mandibles were scanned using the Necsa based Nikon XTH 225 ST Micro-focus X-ray tomography system at 100 kV potential and 100 microA beam current and slice thickness of 30 microns. Scans were analysed using VG studio max v2.2. Measurements for each tooth included the maximum bucco-lingual diameter, maximum mesiodistal distance and height of crown. Measurements were analyzed using qualitative (Geometric mean and Mosiman shape variables) analyses. Tooth development was observed to commence along the occlusal surface of the individual crown with general tooth development progressing in a lingual direction. Deciduous molars commenced cusp development anteriorly and this proceeded in a postero-lingual direction. At 22 gestational weeks incisors were observed to have a high degree of crenulation in the tooth enamel. The enamel crenulations progressed towards the apex of the tooth with increase in age. The degree of crenulation and its progression, as well as the observed direction of the crown's morphological development provide valuable insights into the advancement of tooth growth and development. In addition these parameters may significantly contribute to a more accurate means of dental age estimation.

LIEZL KOK

Process and reproduction of rat dissection models utilising additive manufacturing and computer tomography

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At primary and secondary school level as well as university level, rats are usually dissected to teach basic anatomy. This necessitates a large number of rats to be euthanized each year. This practice is considered unacceptable by animal welfare groups and an alternative teaching aid needs to be found. With the aid of specialized software, Computer Tomography (CT) scan data can be translated into a format that is printable through additive manufacturing processes. A CT scan of a rat was used to design a teaching aid that includes all major anatomical parts. The model was printed by means of Selective Laser Sintering (SLS) in PA2200 Polyamide. The printed components were hand finished to improve their appearance and used to cast a master mould in a platinum cure silicone. This master mould was then used to cast multiple copies of the model in a silicone rubber.

PROF. SCHALK KOK

Perspectives on finite element modeling in anthropology and anatomy

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This contribution presents the perspectives of an experienced finite element modeller with regard to the benefits and pitfalls of using the finite element method to solve structural analysis problems in the disciplines of anthropology and anatomy. At the time of the development of the finite element method, the options for stress analysis were analytical solutions for a limited number of problems, or numerical approximations typically based on series expansion. Both these methods are severely limited in the geometric complexity that can be handled. The finite element method removed this geometric restriction, in that the method can easily deal with arbitrary geometries. In conjunction with the rapid development of computational power, the finite element method is now the workhorse for structural analysis. Arbitrarily complex geometries can now be discretized routinely and the analysis codes are embedded within commercial codes with sophisticated pre- and post-processing capabilities. This computational environment is now so powerful that a novice user can set up an analysis and compute results in a matter of hours. In typical engineering applications, the materials are manmade and usually the material properties have a narrow distribution. These material properties can also be measured using formalized testing standards. Similarly the loads imposed on engineering structures can be measured or these are prescribed in design codes. However, in the case of biological structures both the material properties, as well as the imposed loads, are highly variable. Furthermore, it is difficult or impossible to directly measure these material properties or loads. The consequence of using finite element models, for which the material properties and loads are uncertain, is that the uncertainty in the results is much larger than the norm for structural engineering applications.

ASHLEY KRUGER

From cave to fossil: the use of 3-dimensional imaging modalities in the reconstruction of taphonomy, environment and skeletal morphology from the Rising Star Cave, Cradle of Humankind

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This paper highlights the use of multi-modal 3-D imaging systems employed during the excavation of *in-situ* hominin remains from the site of Rising Star Cave, Cradle of Humankind, South Africa. This fossil assemblage, excavated during late 2013 and early 2014, presents one of the largest hominin fossil assemblages found in Africa. However, the excavation environment within the cave represented an exceptionally difficult and dangerous recovery challenge and one where conventional methods of high-resolution spatial data recovery was impossible. Through the innovative use of white-light photogrammetry and laser scanning at scales ranging from landscape level down to individual bone fragments, this project pushed the boundaries of both technology and image reconstruction as applied to the analysis of taphonomy, environment and skeletal morphology. This paper discusses the benefits and limitations of such technological approaches in the light of recent excavations, and presents some of the challenges ahead for future work in the Cradle of Humankind.

TENDAI MUSINDO

The potential of 3D modelling in archaeology and heritage management: The case of Great Zimbabwe monument

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There are various efforts that have made to embrace the latest technologies in various disciplines and archaeology as well as archaeological heritage management are no exceptions. Archaeologists and heritage practitioners are beginning to appreciate the need to embrace some of technologies such as 3D modelling in research and management of archaeological sites. This paper analyses the efforts that have been made to perform 3D modelling of the Great Zimbabwe monument as well as the challenges that have been encountered. It examines the potential of 3D modelling in aiding our understanding of a large archaeological site such as Great Zimbabwe as well as in managing it. It argues that since the Great Zimbabwe monument became known to the outside world, there have been several efforts by amateur as well as professional archaeologists to research, document and preserve the site. Photographs as well as restorations and reconstructions of sections of the site date back to the 1890s. With advances in technology, it is now possible for researchers to take advantage of 3D modelling techniques which can be vital in restorations/reconstructions of the site. Apart from the built structures, it is also possible to present, in 3D models, significant artefacts recovered at the site such as the Soapstone Birds, arrow heads and ceramics among others. Overall, the paper argues that with its non-intrusive and non-destructive nature, 3D modelling has a great potential in both archaeological research and archaeological heritage management.

ALUWANI NEGOVELA

Using micro-focus X-ray scans to document inner ear functional morphology in the rodent subfamily Otomyinae: Preliminary study

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Mobile organisms must have the ability to obtain information about their environment, process and act upon it, as it is essential for their survival. The environment may influence the relative size of different body parts. Previous literature has widely acknowledged an inflated tympanic bulla to be a characteristic feature found in certain rodent species inhabiting extreme environment such as deserts (arid/semi-arid) and the subterranean niche. The study will look at two species of the subfamily Otomyinae (*Otomys auratus* and *Paratomys brantsii*), which are habitat specialists, the former being confined to mesic and/or montane grassland habitats and the latter to arid and semi-arid habitats. Like other desert adapted species *P. brantsii* also exhibits the hypertrophied tympanic bulla. The tympanic bullae size, volume, and internal structure are important parameters related to low-frequency hearing improvement. These are hypothesized to detect sounds emitted by their predators or possibly from con-specific communication including foot drumming. Investigations of the inner ear structure of mesic (*Otomys*) and arid (*Paratomys*) adapted rodents are lacking. This is the first study trying to quantify the size and shape differences in the inner ear of the species in question in relation to the volume of the bony tympanic bulla. In order to visualise the inner structures of the animals, micro-focus X-ray tomography scans were made at the South African Nuclear Energy Corporation (NECSA) of cleaned adult skulls of 20 individuals, of which ten were *O. auratus* and ten *P. brantsii*. VGStudioMAX analytical software was used to create cochlea volumes from internal voids in the inner ear region of the reconstructed three-dimensional X-ray scans. More extensive analyses of these reconstructed volumes are still underway, however, overall area measures of these volumes and external topography seems to show variations between the species.

EDWARD ODES

Use of micro-computed tomography in the investigation of pseudopathology on the skeleton of StW 431 (*Australopithecus africanus*) from Sterkfontein Cave, Cradle of Humankind.

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This paper discusses the use of high-resolution 3-D imaging methods to assist in the analysis of pseudopathological lesions affecting the lower lumbar vertebrae of the 2.4 to 2.8 Mya partial skeleton StW 431 (*Australopithecus africanus*) from Sterkfontein Cave, South Africa. The specimen was originally diagnosed as suffering from skeletal manifestations of the pathogen *brucella* (D'Anastasio *et al.,* 2009) which would mark the earliest manifestation of brucellosis in the fossil record. We here report the use of micro-computed tomography (MCT) on the partial skeleton and comparative clinical specimens to falsify the claims of D'Anastasio and colleagues. This paper will highlight the utility of MCT volume imaging in the differential diagnosis of skeletal pathological disorders, and provide recommendations for best practice when differentiating between true and pseudo-pathology in fossil and sub-fossil remains.

DR. ANNA OETTLÉ

The three-dimensional illustration of anatomical structure and injuries

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Human anatomy forms the basis of medical studies, and therefore it is important for students in this field and clinicians to be able to visualise anatomical structures. However, students at various levels and clinicians find it hard to visualise hidden areas, such as the pterygopalatine fossa or the ventricles of the brain, as they are expected to recreate three dimensional (3D) impressions cognitively often by studying two dimensional diagrams or sections. It is for this reason that three dimensional reconstructions of the hard to visualise anatomical structures are important for learning and teaching purposes. Reconstruction of injuries could further allow for the illustration of how wounds were inflicted. Structure may be three-dimensionally recreated by imaging technologies such as microfocus cone beam computerized technology, so that it's relative position and anatomical features can be appreciated. A skull demonstrating a gunshot wound was scanned at the microfocus facility at SANRAD Necsa. The skull was then reconstructed three-dimensionally from the images gathered. The images were further reconstructed, using VGStudioMax programme at Necsa, into a three-dimensional (3D) fly through video clip which illustrates the entrance and exit wounds. With the 3D images that microfocus cone beam computerized technology reconstructions provide, the understanding of the mechanism of the injury can be enhanced. Other anatomical structures which are difficult to understand and visualise cognitively could be reconstructed in a similar way as a teaching tool.

ALEXANDER PARKINSON

Application of micro-computed tomography to the analysis of forensic taphonomy and entomology of South African burial systems

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Termites are known to affect archaeological deposits and sedimentary contexts in a number of ways and the resultant impact of such activities are quite disparate. The ability of termites to modify bone can bias taxonomic and elemental representation, and MNI and age profiles, whilst the identification of such modifications can positively contribute to taphonomic reconstruction in terms of inferring seasonality and microenvironmental/climatic conditions. The impact of termite bioturbation has varied results; negatively they can affect the position of artefacts within a stratigraphic profile which, if not identified, may bias interpretation. However, the effect they have on the geochemical properties of sediments has, under specific conditions, been shown to impact positively on skeletal preservation. This presentation will focus on a recently identified and previously unreported impact that termites have on cranium vaults within the burial environment. Recent excavations undertaken at an Anglo-Boer War concentration camp cemetery in South Africa suggest that during the course of bioturbation, the activity of termites resulted in the infilling of the cranial vault of a number of specimens, with the termites having adapted the burial context to their own ends. This paper highlights the role of high-resolution 3D imaging derived from micro-computed tomography in understanding termite-driven modifications to the burial environment.

MELISSA PININSKI

An evaluation of cranial variation among modern black South Africans using craniometrics, inter-landmark distances and geometric morphometrics

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A forensic anthropologist aids in the identification of unknown skeletal remains, part of which involves establishing a biological profile based on the estimation of age, sex, ancestry and stature. The estimation of ancestry can be used to narrow the list of possible matches of missing individuals and is based on comparisons with population-specific reference samples. Medico-legal practitioners are often unfamiliar with the range of human variation in South Africa. Previous research has evaluated major population structures in South Africa but because of the complex population it is necessary to understand and evaluate human variation among the ethnic groups. Therefore, the purpose of this study is to assess and record cranial variation among black South African ethnic groups, namely the Zulu, Sotho, Pedi, Venda, Tswana, Tsonga, Swati, Xhosa and Ndebele, using traditional craniometrics, inter-landmark distances and geometric morphometrics. Geometric morphometric analysis is a relatively new method that provides a mechanism to quantify morphological characteristics and allows for more powerful and statistically robust means of exposing morphological similarities and differences between skeletal remains. By developing population specific reference samples, forensic anthropologists in South Africa can aid in the possible identification of the individual to which the reference sample is derived. Additionally, by providing new reference data, more accurate ancestry estimates of black South Africans or non-South Africans may be obtained.

TSHEGOFATSO RAMPHLALENG

The effect of tooth loss on the accurately estimating sex from non-alveolar mandibular morphology using geometric morphometrics

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In South Africa, there is an ever increasing number of human remains that require identification. The identification process includes the estimation of demographic characteristics. One important character is the estimation of sex. Sex estimation standards that are available are those set from full dentition mandibles. Thus the study aimed to determine the effect of tooth loss from estimating the correct sex from non-alveolar mandibular morphology of black South Africans using geometric morphometrics. Adult mandibles (108 males and 88 females; 79 full dentition and 107 with tooth loss) from the Raymond A. Dart Collection of Human Skeletons were sampled. These mandibles belonged to individuals from the Sotho, Tswana and Zulu tribes. The non-alveolar mandible regions were digitised and the level of tooth loss was scored accordingly. Two-sample permutation test and discriminant analysis were performed to determine the sexual dimorphism and accuracy of correctly sexing. A two-block partial least square was conducted to associate tooth loss with mandibular morphology. Mandibles with tooth loss are highly dimorphic ($p < 0.0001$) than those with full dentition ($p = 0.0167$). The mandibles with tooth loss had higher sexing accuracies (overall accuracy = 85.5%) than full dentition mandibles (overall accuracy = 63.3%). Fully dentate mandibles are more variable in morphology than mandibles with tooth loss. These results indicate that mandibles with tooth loss possess sexually dimorphic features and tooth loss preserves sexual dimorphism in the mandible. The mandibular morphology in mandibles with tooth loss is probably less susceptible to external factors, such as diet and muscle action, than full dentition mandibles. The external factors might also be ineffective in those with tooth loss.

DR. PATRICK RANDOLPH-QUINNEY

Imaging the earliest evidence for neoplastic disease in the human lineage: the use of phase contrast x-ray synchrotron microtomography to investigate a primary osteogenic tumor of the spine in *Australopithecus sediba*

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This paper discusses the use of phase contrast x-ray synchrotron microtomography to investigate palaeopathological conditions in Plio-Pleitocene fossil hominins, and specifically the evidence of neoplastic disease in the extinct hominin *Australopithecus sediba* from the cave site of Malapa, South Africa, dated to 1.98 Ma. Historically, tumors of any kind are rare in archaeological or fossil populations and are all but unknown in the hominin record. This paper discusses the methodological and technical challenges associated with accurate diagnosis of pathological lesions in fossilized remains, and highlights the importance of high-resolution 3D imaging methods in the investigation, analysis and identification of ancient pathologies.

VICTORIA RAUTENBACH

3D geovisualization and eye tracking for urban design in informal settlements

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Three-dimensional (3D) modelling and visualization are among the fastest growing application fields in geographic information science. 3D city models are being researched extensively for a variety of purposes and in various domains, including urban design, disaster management, education and computer gaming. However, the development and use of 3D informal settlement models have not yet been investigated. A possible barrier for the use of 3D models is the traditional manual modelling technique, which can be time consuming and labour intensive. We demonstrate the use of a cost-effective procedural modelling technique and the application of visual variables for guiding the design of a 3D model. Eye tracking devices allow researchers to measure and record an individual's eye movements. However, currently the technology is limited to 2D visualizations. We extended the EyeTribe software development kit with an open source tool that captures and analyses a user's eye tracks when interacting with a 3D informal settlement model. The combination of modern technology (i.e. procedural modelling and eye tracking) and traditional cartographic principles (i.e. visual variables) assists with evaluating the effectiveness and usefulness of 3D models for informal settlement upgrading in South Africa.

DR. PAUL RISCHEBIETER AND PROF ZARINA LOCKHAT

3D Imaging in Diagnostic Radiology

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Imaging in Diagnostic Radiology, with advanced imaging postprocessing and software applications, has progressed magnanimously in the last decade. The analysis of anatomy and pathology through 3D Imaging has become a daily component in most Radiology institutions, groups and practices. The spatial mapping of body tissue has led to the rapid development of new methods of diagnosis and therapy and promises much in the future for medical science. 3D Imaging in the Diagnostic Radiology and Imaging context will be explored, with explanation of basic concepts; elaborative illustrations of 3D images and their application to clinical diagnosis and interpretation; applications in research; highlights of future trends.

PROF. HEINZ RUTHER

Spatial documentation and Digital Preservation of Africa's Cultural Heritage

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The presentation discusses the spatial digital documentation of heritage sites briefly outlining concepts and design of the Zamani African Cultural Heritage Database. The database integrates spatial and non-spatial data and focuses on architectural heritage sites and cultural landscapes in Africa. The spatial data generated by the project comprises of Geographic Information Systems for each site, 3D laser scan models of historical architecture, rock art shelters and cultural landscapes, stereo images, photographic panoramas, ground plans, elevations and sections derived from laser scans, contextual photography and videos as well as 3D landscape models. The database is designed as a resource for research and education, conservation and restoration and as well as a record for future generations. Issues associated with the use of laser scanning and Structure-from-Motion of heritage monuments will be briefly discussed

PROF. GERT SAAYMAN

3D imaging technologies in the forensic medical and pathology setting

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For many centuries, forensic medical practitioners have presented verbal testimony in courts of law, pertaining to matters of interpersonal violence. Written reports, supported by annotated sketches, were often produced for the benefit of judges and jurors, and for record purposes. The advent of photography enhanced the opportunity to make available better images and records of injuries and anatomic findings, although it was not until the second half of the 20th century that routine photography came to be used in mortuaries where medico-legal autopsies were performed. Indeed, only after digital photography displaced the use of photosensitive film, did pathologists begin to liberally use photography in support of documenting autopsy findings. The introduction of high quality "point and press" compact cameras and cell phone cameras over the last decade has also greatly added to such use of photography. Despite the availability of digital imaging techniques for diagnostic purposes in clinical medicine and radiology, the application of CT scanning and MRI scanning has been a very late addition to the forensic pathologist's tool chest, largely due to cost considerations. Over the past decade however, there has been much development in forensic radiography and many large medico-legal mortuaries in developed countries now routinely make use of CT scanning as part of the autopsy procedure. A more recent development has been the introduction of the Lodox Statscan, which has also found very beneficial application in the medico-legal mortuary environment. It is however true that the vast majority of medico-legal autopsy reports which are presented to police officials and state prosecutors, are still rendered in paper based format, supported by annotated sketches and to a far lesser extent, printed colour photographs. No standard or convenient method of incorporating radio- images or other graphic support material has been found or introduced for purposes of court proceedings, except in very few centres. Considering the limited anatomical knowledge which judges and jurors typically have, and that they often lack the ability to adequately spatially orientate and visualise human bodies (and the internal contents thereof), it is surprising that a far more liberal and appropriate use of imaging technologies for purposes of legal proceedings and court cases, is still not being made. This presentation will briefly review the scope and nature of imaging technologies which are available in the forensic medical setting and which could readily be applied in countries like South Africa, to facilitate the administration of justice, especially in criminal legal proceedings. The benefits of greater research in the application of this technology within the forensic medical field and expenditures incurred by installing and applying these technologies in identifying and capturing evidentiary material to enhance and optimise criminal proceedings, will eventually greatly outweigh the initial capital costs and investments.

ROELOF SCHOEMAN

Comparison of strategies for the reconstruction of human mandibles from crania

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This study compares two strategies for the reconstruction of human mandibles from crania. The intended application for these strategies is in forensic cranio-facial reconstruction, where a matching mandible is often not available. The study makes use of 30 skull-sets of the South African black male population, obtained from the Pretoria Bone Collection. Triangular surface meshes of the skull-sets, generated from micro-focus CT scans, were used in this study. The first strategy comprised of using anthropological landmarks, where mandibular landmarks were predicted from cranium landmarks. The second strategy comprised of an automated mesh registration based approach. Here a non-rigid iterative closest point registration algorithm (non-rigid ICP) was used to generate heuristic correspondence between skull-sets. Regression methods based on derived input directions were used in conjunction with exhaustive leave-out-one cross-validation to evaluate predictability of both the landmark and registration based strategies. The regression techniques considered in this study include Partial Least Squares (PLS), Principle Components Regression (PCR) and Supervised Principle Component Regression (SPCR). Partial use of the Euclidean inter-point distance matrix with non-classical multidimensional scaling is also considered as an alternative for a rotation and translation invariant prediction model.

CANDICE SMALL

Assessing sexual dimorphism and allometry within a white South African Sample using geometric morphometrics

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Sexual dimorphism is one of four critical factors assessed by forensic anthropologists when compiling biological profiles and therefore, frequently investigated. Numerous skeletal elements have been assessed for sexual dimorphism, with the pelvis, long bones and skull proving most accurate and the skull often also being best preserved. In the last decade geometric morphometric methods have been gaining favour as a means of estimating sex due to its objectivity, aptitude for retaining geometric shape information and its ability to discern shape differences independent of size. The allometric and non-allometric components of sexual dimorphism are rather less frequently studied, yet critically important for the understanding of sexual dimorphism. Hence, geometric morphometric methods were used to study not only sexually dimorphism, but also its allometric and non-allometric components. A sample of 227 white South African crania (114 males and 113 females) aged between 19 and 95 years were used in this investigation. Global analyses were conducted on the cranium as a whole followed by regional analyses on the basicranium, alveoli, zygomatic arches, nasal aperture and orbits. The effect of sexual dimorphism and allometry proved universal, with significant differences being observed between the sexes both globally and in every structure analysed regionally. A significant non-allometric component was however only found to contribute to the shape of the zygomatics. In conclusion, we demonstrated not only the unique ability of geometric morphometrics to detect the subtle nuances of both sex and size dimorphism but also its ability to elucidate both allometric and non-allometric components of sexual dimorphism. These results are significant as they broaden current knowledge about the population under investigation and may help improve anthropological standards in future.

GUILLAUME SUEUR

3D data in GIS

G. Sueur[1]

[1]Neogeo Technologies

Geographic Information Systems are a natural outlet for 3D data. It can help visualize, analyze and compute datasets and terrain. Thus, it may be hard to integrate into a standard GIS software. Because of its accuracy and other particularities, 3D data makes it hard to deal with in the GIS field. GIS has its own culture and shares very few common points with 3D Data. 3D Data is not first intended to be geographicly related. Making those two different worlds speak together can be quite a challenge. We will see the major loopholes and obstacles as well as some tricks and tips to get rid of them.

CHARLOTTE THEYE

The Effects of Aging and Tooth Loss on the Microstructure of the Mandible in South Africans

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The purpose of the study is to describe and quantitatively analyse the microstructural changes in the cortical bone of the mandible of South African individuals with advancing age and across various dentition patterns. Metric measurements (cortical thickness) and histomorphometric parameters quantifying the cortical bone density are assessed on 3D reconstructions of the mandible. The accuracy of the CBCT technique in measuring cortical thickness and density will be compared to the measurements done on the higher resolution micro-CT scans. Micro-Focus X-Ray Computed-Tomography (micro-CT) was used to scan dried mandibles representing both sexes and ancestral groups (blacks and whites). Cone-Beam Computed-Tomography (CBCT) scans of patients from the Oral and Dental Hospital were also analysed. Access to dental records was provided to help understand the effects of restorative procedures (wearing dentures and implants) on the microstructure of the mandible. To investigate the changes caused by aging and tooth loss, individuals from both samples were allocated into different age groups (decades) and into three dentition groups: edentulous, various levels of tooth loss and complete dentition. Measurements were taken on three cross-sections located on the corpus: midline, 1st quarter (across the canine or premolar 1), 2nd quarter (across the first or second molar); and two cross-sections situated on the ramus: minimum breadth and minimum height. Using micro-CT scans of the femoral neck as proxy, age-related changes in the cortical bone microstructure of the mandible was compared to the rest of the skeleton, and gave additional information on the question as to whether mandibular bone loss is associated purely with tooth loss, or whether it is also associated with a generalised tendency of bone loss. Knowledge of the variations in microstructure of the mandible due to aging and/or changes in dentition may prove useful in restorative dentistry and may have forensic anthropological implications.

DR. ANDRÉ UYS

CBCT at the School of Dentistry, Faculty of Health Sciences, University of Pretoria

A. Uys[1]

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Dental cone beam computer tomography (CBCT) provides anatomical image data similar to medical CT, but at a much lower radiation dose to the patient. The 3-D image volume is obtained with a 360º rotation sweep around the patient with a cone-shaped x-ray beam. This results in several hundred isotropic dimensional accurate images from different positions around the scan rotation that the computer reconstructs into the anatomical volume for viewing at a 1:1 ratio. Once reconstructed, multiplanar viewing of the anatomical volume is accomplished with the imaging software. Dimensionally accurate 3-D craniofacial records of the scan volume are obtained. The clinical request dictates the size of the field of view obtained and can range from Ø50x50mm to Ø230x260mm. In the field of dentistry CBCT is used in all the different fields for interpretation, diagnosis and treatment planning. Requests include the assessment of impacted mandibular third molars, unerupted canines, the assessment of the inferior alveolar canal for surgical risk of nerve injury, root resorption, and the identification, evaluation, diagnosis and treatment of pathologic conditions and maxillofacial trauma. For the temporo-mandibular joints, the condyle-fossa position and the dentition can be clearly visualized in the same image field of view, thus verifying the anatomical relationship of these structures. In the last decade CBCT has become an essential tool in the modern dental surgery to achieve optimal long-term results especially in complex cases.

DR. ANDRÉ VAN ZYL

CBCT versus Micro focus in assessment of alveolar bone

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Dental implant surgery has become the standard of care for the replacement of lost teeth. Implants are often placed immediately after extraction of teeth. This practice is popular in the anterior maxilla where aesthetic demands of patients can be very high. Aesthetic success is dependent on an ideal three-dimensional implant position and maintenance of 1-2mm buccal bone over the implant. The study sample consisted of 123 skulls from the University of Pretoria bone collection. Skulls that contained six anterior maxillary teeth with no signs of periodontal bone loss were included in the study. Skulls were scanned at Necsa (South African Nuclear Energy Corporation) which houses the Nikon XTH 225 ST micro-focus X-ray tomography facility (MIXRAD). Micro-focus X-ray tomography is based on the same principle as cone beam CT (CBCT). It utilizes the same amount of energy as CBCT but the spatial resolution obtained is shifted to 1-3 µm instead of 300 µm due to the focal spot size of 0.001 – 0.003 mm vs. 1 – 3 mm for CBCT. To obtain a high quality 3D-virtual image (Tomogram) at this high spatial resolution, the number of 2D projections increases from 375 to up to 8000 (1000 projections for this study). In this study, a spatial resolution of 40- and 90 microns for the respective tomograms of the mandibles and maxilla were achieved which resulted in a higher quality tomogram (3D image) than for CBCT and from which more accurate quantitative analyses could be made. This study demonstrated the buccal bone dimensions in the anterior maxilla to be on average less than 1 mm thick. The palatal bone was thicker than the buccal bone in all positions measured. It is recommended that the palatal and buccal bone dimensions be measured using CBCT to avoid perforation complications in the anterior maxilla.

DR. JANETTE VERSTER

The LODOX® Statscan: A valuable tool in death investigation

J. Verster[1]

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The substantial development of forensic radiology as a discipline over the past few years merits an introduction and overview of the use of the LODOX® Statscan as a relatively new tool in forensic pathology practise. The LODOX® (Low Dose X-ray) Statscan was first introduced in clinical medicine in 1999 at Groote Schuur Hospital in Cape Town, after it was developed to detect diamond theft in the mining industry in South Africa. The value of the application of LODOX® imaging in forensic pathology was subsequently realised, with the first installations at medico-legal mortuaries being done in Cape Town in 2007. A LODOX® unit was installed at the Pretoria Medico-Legal Mortuary in the first half of 2014. The LODOX® Statscan has the ability to perform a full body AP-scan in 13 seconds, rendering a digital full body image on a computer screen within 10 additional seconds. A full body AP and lateral scan can be effectively done in about 6 minutes. Due to the marked reduction in radiation exposure and the robust construction, the LODOX® Statscan can be placed within the autopsy room, without the need for additional or conventional X-ray protective structures. The LODOX® Statscan offers rapid acquisition of digital images, which can be viewed and manipulated on a conventional computer and easily printed in real time. In forensic pathology practice rapid whole body screening of bodies is far preferable to conventional X-ray techniques and C-arm fluoroscopy, especially when assessing bodies for foreign objects and skeletal fractures. Clearly, this technology is not intended to displace other modalities such as CT- and MRI-scan, but the relative ease of use, low radiation and good image quality present a compelling argument for routine use of this apparatus in the medico-legal mortuary.

PROF. MARIZA VOSTER

3D Imaging in Nuclear Medicine

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In Nuclear Medicine, three-dimensional imaging forms an integral part of the majority of studies performed. What started out as the simple addition of SPECT imaging to whole body planar studies, has evolved to include high-end technology such as PET/CT and PET/MRI. These hybrid cameras enable the visualization of both morphological- and physiological processes simultaneously and in three dimensions. Theranostics is another important concept in Nuclear Medicine, which allows for the diagnosis and therapy of certain malignancies by the simple substitution of a radioisotope used for imaging with one used for therapy. This is important in moving towards personalized therapy and is a rapidly growing field. Here, three—dimensional imaging plays a role in staging, selection of the most appropriate form of therapy and follow-up evaluation.Our department has pioneered the use of several theranostic approaches in the country and continent. Departmental research themes include imaging of infection and inflammation (with a particular focus on TB and HIV) as well as various theranostic approaches.

DR. CLÉMENT ZANOLLI

Advanced techniques in Paleoanthropology

C. Zanolli[1]

[1]Postdoc at University of Pretoria

Fossil hominid remains represent the main evidence testifying the life of extinct taxa in a given region and at a given moment. Until recently, knowledge on structural morphology and meso-/microanatomy of extant and extinct hominids was mostly assessed on histological sections and/or fractured specimens, showing that a significant amount of valuable information for assessing the taxonomy, evolutionary pathways and phylogenetic relationships, sex- and age-related models of developmental timing and patterning (life history), eco-related adaptive strategies and dynamics, seasonally-related health conditions, chrono-geographical trends in functional adaptation and fluctuating variation patterns, lie "safely" stored inside bones and teeth. In response to the potentially conflicting requirements of safeguard vs. fruition/exploitation of this record, the available technologies based on X-ray microfocus tubes (X-µCT) and synchrotron (SRX-µCT) microtomography now allow the high-resolution exploration, extraction, "cleaning", and bi- (2D) three-dimensional (3D) rendering and the quantification of the meso-/microstructural signature stored in the mineralized tissues. While developed less than ten years ago only, "virtual paleoanthropology" has revealed its potential as a highly fertile domain of investigation, a sharp "tool" capable to add significant original evidence to the traditional analyses. Nonetheless, depending on their taphonomic history and degree of diagenetic alterations, fossil tooth tissues do not systematically provide a distinct inner signal, preventing the extraction of crucial paleobiological information. Very recently, an innovative approach based on neutron beam, neutron microtomography (n-µCT), was applied to fossil primates showing that it represents a promising and effective investigative tool for imaging the fossil material with a high contrast resolution. This contribution will illustrate, at different scales and through a variety of examples, the potential value of 3D virtual rendering for the characterization of the fossil record when moving from the outer to the inner structural morphology.