September 10th 2020 – 3DGeoInfo Day 2

Contents

Session 9a – AR/VR – 8.30am – 10am **2**
Chair: Sisi Zlatanova 2
Paper #: 23 Interacting with 3D Models - 3D-CAD vs. Holographic Models 2
Paper #: 39 3D Virtual Models for an Early Education Serious Gaming Application 2
Paper #: 56 Interactive geo-information in virtual reality – observations and future challenges 3
Paper #: 62 Architectural Virtual Heritage: Case Studies in Australia and Japan 3

Session 9b – Point Clouds 1 – 8.30am – 10.00am **4**
Chair: Rudi Stouffs 4
Paper #: 48 An optimized SFC approach for nD window querying on point clouds 4
Paper #: 58 The virtualization of CH for historical reconstruction: the AR fruition of the fountain of St. George Square in La Valletta (Malta) 4
Paper #: 66 Visualization of Point Cloud Models in Mobile Augmented Reality using Continuous Level of Detail Method 5
Paper #: 72 4D GIS for Monitoring Riverbank Retreat at Meander Bend Scale: Case of Moselle River 5

Session 10a – Visualisation – 10.30am – midday **7**
Chair: Kelvin Wong 7
Paper #: 2 Visualising detailed CityGML and ADE at the building scale 7
Paper #: 22 CityJSON + Web = ninja 7
Paper #: 24 Visual Analytics Web Platform for Detecting High Wind Energy Potential in Urban Environments by Employing OGC Standards 7
Paper #: 35 Multi-threaded rendering for cross-platform 3D visualization based on Vulkan API 8

Session 10b – Point Clouds 2 – 10.30am – midday **9**
Chair: Thomas Kolbe 9
Paper #: 11 Automatic detection and characterization of ground occlusions in urban point clouds from Mobile Laser Scanning data 9
Paper #: 32 Unsupervised Segmentation of Massive Point Clouds 9
Paper #: 54 Graph CNN with Radius Distance for Semantic Segmentation of Historical Builidngs TLS Point Clouds 9
Paper #: 67 3D Mathematical Morphology for Room Segmentation in Point Clouds 10

Session 11 – Indoor 3D – 1.00pm – 2.30pm **11**
1spatial® YOUR WORLD SMARTER 11
Chair: Jacynthe Pouliot 11
Paper #: 6 Are your IndoorGML files Valid? 11
Paper #: 8 Two New Pedestrian Navigation Path Options based on Semi-indoor Space 11
Paper #: 42 Evaluation of Mobile Mapping Systems for Indoor Surveys 11
Paper #: 63 Integration of IoT Sensors to 3D Indoor Models with IndoorGML 12

Session 12 - Ordnance Survey Tour – 3.00pm – 4.30pm **13**
Chair: Rollo Home 13

Session 9a – AR/VR – 8.30am – 10am

Chair: Sisi Zlatanova

Paper #: 23 Interacting with 3D Models - 3D-CAD vs. Holographic Models

Authors: Gerhard Navratil, TU Vienna, Austria; Philip Konturek, TU Vienna, Austria; Ioannis Giannopoulos, TU Vienna, Austria

A problem with 3D models is that devices used to display them are typically two-dimensional, i.e., computer monitors or printed maps. User interfaces of computer software are based on mouse, touchscreen, keyboards, etc. and are optimized for this dimensionality. However, this causes problems when working with 3D models and the user must adapt her actions by interpreting the missing third dimension. While this might not necessarily pose a problem for frequent users, infrequent users may find this quite challenging. Holographic models, on the other hand, float in front of the user, providing a 3D perspective. Interaction with this kind of models may thus be more intuitive than traditional interaction. In the paper we present the results from a first user test. 15 participants tested interaction with a holographic model visualized using Augmented Reality (AR) technology. The results were compared to those of 15 participants using a traditional 3D-CAD. It was found that the holographic approach is more intuitive leading to a lower frustration level although it is still restricted by technical limitations.

Paper #: 39 3D Virtual Models for an Early Education Serious Gaming Application

Authors: Dimitris Anastasiou, Department of Surveying and Geoinformatics Engineering, University of West Attica, Greece; Theodora Avgeri, Preschool Teacher, Greece; Athanasios Iliodromitis, Department of Surveying and Geoinformatics Engineering, University of West Attica, Greece; Vassilios Pagounis, Department of Surveying and Geoinformatics Engineering, University of West Attica, Greece; Maria Tsakiri, School of Rural and Surveying Engineering, National Technical University of Athens, Greece

Visualization and conceptualisation of 3D objects are complex cognitive processes which are regarded essential from pre-school education to develop abilities linked to spatial and 3D thinking. The focus of this paper is to discuss the use of a virtual 3D environment as a pedagogical serious gaming platform that may help intensify learning processes. Recently, serious games are gaining popularity not only as games, but as promising educational tools too. This paper presents the creation of a simple 'serious game' where several tasks can be constructed that promote the 3D spatial thinking in pre-school education. Specifically, the creation of the virtual environment from a pre-school's indoor and outdoor environment was performed using geodetic and terrestrial laser scanning techniques. To increase the geospatial sense of pre-school children within the virtual environment, an application was developed with simple educational tasks within the 3D environment. The templates, for each section of the gaming application, have been developed using HTML5 and CSS3, in order that they are interactive and accessible to all smart devices. The paper concludes with a discussion on the experience gained towards supporting spatial thinking for pre-school children.

Paper #: 56 Interactive geo-information in virtual reality – observations and future challenges

Authors: Juho-Pekka Virtanen, Aalto University, Finland; Arttu Julin, Aalto University, Finland; Hannu Handolin, Aalto University, Finland; Toni Rantanen, Aalto University, Finland; Mikko Maksimainen, Aalto University, Finland; Juha Hyyppä, Finnish Geospatial Research Institute FGI, Finland; Hannu Hyyppä, Aalto University, Finland

Visualization applications are an increasingly significant component in the field of 3D geo-information. In them, the utilization of consumer grade virtual reality (VR) head mounted displays (HMD) has become a topical research question. It is notable, that in most presented implementations, the VR visualization is accomplished by a game engine. As game engines rely on textured mesh models as their conventional 3D asset format, the challenge in applying photogrammetric or laser scanning data is in producing models than are suitable for game engine use. We present an example of leveraging immersive visualization in geo-information, including the acquisition of data from the intended environment, processing it to a game engine compatible form, developing the required functions on the game engine and finally utilizing VR HMDs to deploy the application. The presented application combines 3D indoor models obtained via a commercial indoor mapping system, a 3D city model segment obtained by processing airborne laser scanning data, and a set of manually created 3D models. The performance of the application is evaluated on two different VR systems. The observed capabilities of interactive VR applications include: 1) intuitive and free exploration of 3D data, 2) ability of operate in different scales, and with different scales of data, 3) integration of different data types (such as 2D imaging and 3D models) in interactive scenes and 4) the possibility to leverage the rich interaction functions offered by the game engine platform. These capabilities could support several use cases in geo-information.

Paper #: 62 Architectural Virtual Heritage: Case Studies in Australia and Japan

Authors: Jack Barton, University of New South Wales, Australia

The digitisation of heritage artefacts facilitates a wider audience to access, experience, and interact with architecturally significant buildings. This paper will describe the workflow for two virtual heritage case studies; the first focuses on the digital capture of an ornate stone heritage façade located in Sydney. The second case study focuses on the digitisation of the career work of Japanese Architect Shoei Yoh. Both these projects have a significant requirement for three-dimensional (3D) digital documentation. Keeping a high-quality digital archive of these buildings can enable a series of operations, from small-scale detailed outputs for exhibition, as a digital asset for visualisation and research, to full-scale reproduction for fabricating replacement components if the building fabric requires repair or entire duplication. This paper will describe the formation of a digital archive by establishing a workflow appropriate for data capture, 3D modelling and 3D printing to assist in the conservation and promotion of architectural heritage sites.

Click here for full abstract.

Session 9b – Point Clouds 1 – 8.30am – 10.00am

Chair: Rudi Stouffs

Paper #: 48 An optimized SFC approach for nD window querying on point clouds

Authors: Haicheng Liu, TU Delft, Netherlands; Peter van Oosterom, TU Delft, Netherlands; Martijn Meijers, TU Delft, Netherlands; Edward Verbree, TU Delft, Netherlands

Dramatically increasing collection of point clouds raises an essential demand for highly efficient data management. It can also facilitate modern applications such as robotics and virtual reality. Extensive studies have been performed on point data management and querying, but most of them concentrate on low dimensional spaces. High dimensional data management solutions from computer science have not considered the special features of spatial data; so, they may not be optimal. A Space Filling Curve (SFC) based approach, PlainSFC which is capable of nD point querying has been proposed and tested in low dimensional spaces. However, its efficiency in nD space is still unknown. Besides that, PlainSFC performs poorly on skewed data querying. This paper develops HistSFC which utilizes point distribution information to improve the querying efficiency on skewed data. Then, the paper presents statistical analysis of how PlainSFC and HistSFC perform when dimensionality increases. By experimenting on simulated nD data and real data, we confirmed the patterns deduced: for inhomogeneous data querying, the false positive rate (FPR) of PlainSFC increases drastically as dimensionality goes up. HistSFC alleviates such deterioration to a large extent. Despite performance degeneration in ultra high dimensional spaces, HistSFC can be applied with high efficiency for most spatial applications. The generic theoretical framework developed also allows us to study related topics such as visualization and data transmission in the future.

Paper #: 58 The virtualization of CH for historical reconstruction: the AR fruition of the fountain of St. George Square in La Valletta (Malta)

Authors: Andrea Scianna, ICAR-CNR (High-Performance Computing and Networking Institute) - National Research Council of Italy, Italy; Giuseppe Fulvio Gaglio, ICAR-CNR (High-Performance Computing and Networking Institute - National Research Council of Italy),, Italy; Marcello La Guardia, Department of Engineering, Polytechnic School of University of Palermo (UNIPA), Italy; Reuben Grima, Department of Conservation & Built Heritage Faculty for the Built Environment - University of Malta, Malta

Improving accessibility to Cultural Heritage (CH) is an increasingly urgent challenge today. It is not only a matter of physical inaccessibility but also temporal, considering that part of CH now lost. Fortunately, the most modern technological tools are helping to break down both space and time barriers. In facts, recent advances in representation, 3D modelling and survey methodologies opened new scenarios for valorization and conservation of CH. In particular, the improvement of quality in resolution and sensor sensitivity of cameras allowed to achieve the right level of 3D reconstruction through digital photogrammetry procedures. In the same field, terrestrial laser scanners (TLS) allowed acquiring dense point clouds of complex environments with a millimetric level of accuracy. At the same time, the application of Augmented Reality (AR) and Virtual Reality (VR) technologies is an excellent solution for improving the accessibility to monuments, museums and archaeological sites. It is possible to share new levels of information about CH, in space and time, for touristic, managerial and scientific aims. This work is focused on the virtualization of CH, considering the study case of the fountain of Wignacourt, today present in St. Philip Garden in Floriana and initially located in Valletta (Malta). The

application presented allows the virtual fruition of the monument placed in its original location, St. George Square. A simplified plant of the square will enable tourists to make a temporal journey in the past with their mobile device. The work is part of the Interreg Italia-Malta European project named I-Access, dedicated to the improvement of CH accessibility. It focuses the attention to the experimentation of new specific procedures in Geomatics necessary to solve big data issues of complex environment visualization.

Paper #: 66 Visualization of Point Cloud Models in Mobile Augmented Reality using Continuous Level of Detail Method

Authors: Liyao Zhang, Delft University of Technology, Netherlands; Peter van Oosterom, Delft University of Technology, Netherlands; Haicheng Liu, Delft University of Technology, Netherlands

Point clouds have become one of the most popular sources of data in geospatial fields due to their availability and flexibility. However, because of the large amount of data and the limited resources of mobile devices, the use of point clouds in mobile Augmented Reality applications is still quite limited. Many current mobile AR applications of point clouds lack fluent interactions with users. In our paper, a cLoD (continuous level-of-detail) method is introduced to filter the number of points to be rendered considerably, together with an adaptive point size rendering strategy, thus improve the rendering performance and remove visual artefacts of mobile AR point cloud applications. Our method uses a cLoD model that has an ideal distribution over LoDs, with which can remove unnecessary points without sudden changes in density as present in the commonly used discrete level-of-detail approaches. Besides, camera position, orientation and distance from the camera to point cloud model is taken into consideration as well. With our method, good interactive visualization of point clouds can be realized in the mobile AR environment, with both nice visual quality and proper resource consumption.

Paper #: 72 4D GIS for Monitoring Riverbank Retreat at Meander Bend Scale: Case of Moselle River

Authors: Mathieu Koehl, ICube Laboratory UMR 7357, INSA Strasbourg, France, France; Guillaume Piasny, University of Strasbourg – LIVE (Laboratoire Image, Ville, Environnement) UMR 7362 – CNRS – Unistra, France, France; Valentin Thomine, ICube Laboratory UMR 7357, INSA Strasbourg, France, France; Pierre-André Garambois, IRSTEA, Aix-en-Provence, France, France; Pascal Finaud-Guyot, HydroSciences Montpellier, Polytech Montpellier, Montpellier, France, France; Samuel Guillemin, ICube Laboratory UMR 7357, INSA Strasbourg, France, France; Laurent Schmitt, University of Strasbourg - LIVE (Laboratoire Image, Ville, Environnement) UMR 7362 - CNRS - Unistra, France, FranceFrance; Pierre-André Garambois, IRSTEA, Aix-en-Provence, France, France; Pascal Finaud-Guyot, HydroSciences Montpellier, Polytech Montpellier, Montpellier, France, France; Samuel Guillemin, ICube Laboratory UMR 7357, INSA Strasbourg, France, France; Laurent Schmitt, University of Strasbourg - LIVE (Laboratoire Image, Ville, Environnement) UMR 7362 - CNRS - Unistra, France, France

The "Wild Moselle" regional nature reserve extends over 13 km at the western foothills of the Vosges Mountains. The hydrological regime of the river is characterized by high flow in winter and spring and low flow in summer. Its average slope is 0.12 % and its average bankfull width is 60 m. The coarse sediment load comes mainly from bank erosion. Although this sector is relatively less affected by past or present human activities, the propagation of morphodynamic adjustments initiated by actions carried out both upstream and downstream of this sector impacts the current functioning of the river. These erosion waves converge today towards the central part of the reserve, which led to the collapse

of the central pier of the Bainville-aux-Miroirs bridge during a 2-year flood in 2011, and could induce potential risks of defluviation which may destabilize infrastructures. In this context, the study carried out aims to characterize and anticipate the morphodynamic evolutions of the Moselle to be able to propose scenarios of management and restoration of the lateral mobility of the river. For this purpose, a 2D hydro-sedimentary model is being built over the entire reserve, combined with a detailed morpho-sedimentary monitoring. In order to improve the understanding of the lateral migration of the Moselle River, a photogrammetric monitoring was carried out along the concave bank of the most active meander of the studied sector. To follow this morphological evolution more closely, it was decided to establish a 4D GIS. The objective of this monitoring is to compare the rate of bank retreat with hydrodynamic parameters in order to estimate the geotechnical properties of the bank. Comparison of the observed and modelled bank retreat must thus allow these different parameters to be calibrated in the hydro-sedimentary model. As part of this work, this paper aims to highlight the use of 4D GIS to monitor bank retreat at the scale of a meander bend and is divided into three different parts: (i) a state of art to situate the study into the current knowledge and technologies, (ii) a presentation of the study area and the measurements carried out and (iii) a description of the different 3D or 4D data produced and the consequent spatial analyses.

Session 10a – Visualisation – 10.30am – midday

Chair: Kelvin Wong

Paper #: 2 Visualising detailed CityGML and ADE at the building scale

Authors: Joie Lim, National University of Singapore, Singapore; Patrick Janssen, National University of Singapore, Singapore; Filip Biljecki, National University of Singapore, Singapore

There is an increasing activity in developing workflows and implementations to convert BIM data into CityGML. However, there are still not many platforms that are suitable to view and interact with the detailed information stored as a result of such conversions, especially if an Application Domain Extension (ADE) is involved to support additional information. We investigated the ease of use and features supported by visualisation software and tools with CityGML and ADE support, and propose an approach to develop a tool that combines useful features using a set of generic rules that can extract CityGML ADE attributes. The work, while generic, is geared towards detailed architectural datasets sourced from BIM. We implemented the approach in a web-based viewer supporting the visualisation of CityGML datasets enriched with ADE features.

Paper #: 22 CityJSON + Web = ninja

Authors: Stelios Vitalis, Delft University of Technology, Netherlands; Anna Labetski, Delft University of Technology, Netherlands; Freek Boersma, Delft University of Technology, Netherlands; Felix Dahle, Delft University of Technology, Netherlands; Xiaoai Li, Delft University of Technology, Netherlands; Ken Arroyo Ohori, Delft University of Technology, Netherlands; Hugo Ledoux, Delft University of Technology, Netherlands; Jantien Stoter, Delft University of Technology, Netherlands

As web applications become more popular, 3D city models would greatly benefit from a proper web-based solution to visualise and manage them. CityJSON was introduced as a JSON encoding of the CityGML data model and promises, among several benefits, the ability to be integrated with modern web technologies. In order to provide an implementation of a web application for CityJSON data, that can be used as a reference for other applications, we developed ninja. It is a web application that allows the user to easily load and investigate a CityJSON model through a web browser. In addition, it offers support for a complex feature of CityJSON: the experimental versioning mechanism. In this paper, we describe the motivation, requirements, technical aspects and achieved functionality of ninja. We believe that such a web application can facilitate the adoption of 3D city models by more practitioners and decision makers.

Paper #: 24 Visual Analytics Web Platform for Detecting High Wind Energy Potential in Urban Environments by Employing OGC Standards

Authors: Athanasios Koukofikis, Hochschule fur Technik Stuttgart, Germany; Volker Coors, Hochschule fur Technik Stuttgart, Germany

We propose a server-client web architecture identifying areas with high wind energy potential by employing 3D technologies and OGC standards. The assessment of a whole city or sub-regions will be supported by integrating Computational Fluid Dynamics (CFD) with historical wind sensor readings. The results, in 3D space, of such analysis could be used for locating installation points of small-scale vertical axis wind turbines in an urban area.

Paper #: 35 Multi-threaded rendering for cross-platform 3D visualization based on Vulkan API

Authors: Charalabos Ioannidis, National Technical University of Athens, Greece; Argyro Maria Boutsi, National Technical University of Athens, Greece

The visualization of large-sized 3D geospatial models is a graphics intensive task. With ever increasing size and complexity, more computing resources are needed to attain speed and visual quality. Exploiting the parallelism and the multi-core performance of the Graphics Processing Unit (GPU), a cross-platform 3D viewer is developed based on the Vulkan API and modern C++. The proposed prototype aims at the visualization of a textured 3D mesh of the Cultural Heritage by enabling a multi-threaded rendering pipeline. The rendering workload is distributed across many CPU threads by recording multiple command buffers in parallel and coordinating the host and the GPU rendering phases. To ensure efficient multi-threading behavior and a minimum overhead, synchronization primitives are exploiting for ordering the execution of queues and command buffers. Furthermore, push-constants are used to send uniform data to the GPU and render passes to adapt to the tile-based rendering of the mobile devices. The proposed methodology and technical solution are designed, implemented and tested for Windows, MacOS and Android on Vulkan-compatible GPU hardware by compiling the same codebase. The benchmarking on multiple hardware, architectures and platforms explores the performance improvement for the different approaches compared to one-thread and showcase the potential of the 3D viewer to handle large datasets at no expense of visual quality and geometric fidelity in the absence of high-end technological resources.

Session 10b – Point Clouds 2 – 10.30am – midday

Chair: Thomas Kolbe

Paper #: 11 Automatic detection and characterization of ground occlusions in urban point clouds from Mobile Laser Scanning data

Authors: Jesús Balado, University of Vigo, Spain; Elena González, University of Vigo, Spain; Edward Verbree, TUDelft, Netherlands; Lucía Díaz-Vilariño, University of Vigo, Spain; Henrique Lorenzo, University of Vigo, Spain

Occlusions accompany serious problems that reduce the applicability of numerous algorithms. The aim of this work is to detect and characterize urban ground gaps based on occluding object. The point clouds for input have been acquired with Mobile Laser Scanning and have been previously segmented into ground, buildings and objects, which have been classified. The method generates various raster images according to segmented point cloud elements, and detects gaps within the ground based on their connectivity and the application of the hit-or-miss transform. The method has been tested in four real case studies in the cities of Vigo and Paris, and an accuracy of 99.6% has been obtained in occlusion detection and labelling. Cars caused 80.6% of the occlusions. Each car occluded an average ground area of 11.9 m2. The proposed method facilitates knowing the percentage of occluded ground, and if this would be reduced in successive multi-temporal acquisitions based on mobility characteristics of each object class

Paper #: 32 Unsupervised Segmentation of Massive Point Clouds

Authors: Florent Poux, University of Liège (ULiege), Belgium; Christian Mattes, RWTH Aachen University, Visual Computing Institute, Germany; Leif Kobbelt, RWTH Aachen University, Visual Computing Institute, Germany

Point cloud data of indoor scene is largely composed of planar-dominant elements. Automatic shape segmentation is thus valuable to avoid labour intensive labelling. This paper provides a fully unsupervised region growing segmentation approach for efficient clustering of massive 3D point clouds. Our contribution targets a low-level grouping beneficial to object-based classification. We argue that the use of relevant segments for object-based classification has the potential to perform better in terms of recognition accuracy, computing time and lowers the manual labelling time needed. However, fully unsupervised approaches are rare due to a lack of proper generalization of user defined parameters. We propose a self-learning heuristic process to define optimal parameters, and we validate our method on a large and richly annotated dataset (S3DIS) yielding 88.1% average F1-score for object-based classification. This permits to automatically segment indoor point clouds with no prior knowledge at commercially viable performance and is the foundation for efficient indoor 3D modelling in cluttered point clouds.

Paper #: 54 Graph CNN with Radius Distance for Semantic Segmentation of Historical Builidngs TLS Point Clouds

Authors: Christian Morbidoni, Università Politecnica delle Marche, Italy; Roberto Pierdicca, Università Politecnica delle Marche, Italy; Ramona Quattrini, Università Politecnica delle Marche, Italy; Frontoni Emanuele, Università Politecnica delle Marche, Italy

Point clouds obtained via Terrestrial Laser Scanning (TLS) surveys of historical buildings are generally transformed into semantically structured 3D models with manual and time-consuming workflows. The importance of automatizing this process is widely recognized within the research community. Recently, deep neural architectures have been applied for semantic segmentation of point clouds, but few studies have evaluated them in the Cultural Heritage domain, where complex shapes and mouldings make this task challenging. In this paper, we describe our experiments with the DGCNN architecture to semantically segment historical buildings point clouds, acquired with TLS. We propose a variation of the original approach where a radius distance based technique is used instead of K-Nearest Neighbors (KNN) to represent the neighborhood of points. We show that our approach provides better results by evaluating it on two real TLS point clouds, representing two Italian historical buildings: the Ducal Palace in Urbino and the Palazzo Ferretti in Ancona.

Paper #: 67 3D Mathematical Morphology for Room Segmentation in Point Clouds

Authors: Ernesto Frías, University of Vigo, Spain; Jesús Balado, University of Vigo, Spain; Lucía Díaz-Vilariño, University of Vigo, Spain; Henrique Lorenzo, University of Vigo, Spain

Room segmentation is a matter of ongoing interesting for indoor navigation and reconstruction in robotics and AEC. While in robotics field, the problem room segmentation has been typically addressed on 2D floorplan, interest in enrichment 3D models providing more detailed representation of indoors has been growing in the AEC. Point clouds make available more realistic and update but room segmentation from point clouds is still a challenging topic. This work presents a method to carried out point cloud segmentation into rooms based on 3D mathematical morphological operations. First, the input point cloud is voxelized and indoor empty voxels are extracted by CropHull algorithm. Then, a morphological erosion is performed on the 3D image of indoor empty voxels in order to break connectivity between voxels belonging to adjacent rooms. Remaining voxels after erosion are clustered by a 3D connected components algorithm so that each room is individualized. Room morphology is retrieved by individual 3D morphological dilation on clustered voxels. Finally, unlabelled occupied voxels are classified according proximity to labelled empty voxels after dilation operation. The method was tested in two real cases and segmentation performance was evaluated with encouraging results.

Session 11 – Indoor 3D – 1.00pm – 2.30pm

Chair: Jacynthe Pouliot

Paper #: 6 Are your IndoorGML files Valid?

Authors: Hugo Ledoux, Delft University of Technology, Netherlands

IndoorGML datasets allow us to represent both (1) the geometry of the interior of a building, which is subdivided into cells (eg rooms, corridors, staircases); and (2) the navigation graph between these cells, which also acts as a mechanism to store the topological relationships between the cells. To be used in applications such as indoor routing or emergency evacuation, IndoorGML files should be valid and structured according to the specifications of the OGC. In practice, achieving this is challenging because two different representations of the indoor space must be modelled and linked together; other 3D formats usually only store one representation. In this paper, I present a new methodology to validate IndoorGML files. It builds upon previous work on the validation of 3D geometries and city models, and it contains six specific tests. These tests have been implemented in the open source software val3dity, and I present and discuss experiments I ran with all the publicly available IndoorGML datasets I could find.

Paper #: 8 Two New Pedestrian Navigation Path Options based on Semi-indoor Space

Authors: Jinjin Yan, The University of New South Wales, Australia; Sisi Zlatanova, The University of New South Wales, Australia; Abdoulaye Diakite, The University of New South Wales, Australia

Navigation is very critical for our daily life, especially when we have to go through the unfamiliar areas where the spaces are very complex, such as completely bounded (indoor), partially bounded (semi-indoor and/or semi-outdoor), entirely open (outdoor), or combined. Current navigation systems commonly offer the shortest distance/time path, but it is not always appropriate for some situations. For instance, on a rainy day, a path with as many places that are covered by roofs/shelters is more attractive. However, current navigation systems cannot provide such kinds of navigation paths, which can be explained by that they lack information about such roofed/sheltered-covered spaces. This paper proposes two roofed/sheltered navigation path options by employing semi-indoor spaces in the navigation map: (i) the Most-Top-Covered path (MTC-path) and (ii) path to the Nearest sI-space from departure (NSI-path). A path selection strategy is introduced to help pedestrians in making choices between the two new path options and the traditional shortest path. We demonstrate and validate the research with path planning on two navigation cases. The results show the two path options and the path selection strategy bring in new navigation experience for humans.

Paper #: 42 Evaluation of Mobile Mapping Systems for Indoor Surveys

Authors: Hugo Salgues, INSA Strasbourg, France; Hélène Macher, INSA Strasbourg, France; Tania Landes, INSA Strasbourg, France

With their high recording rate of hundreds of thousands of points acquired per second, speed of execution and a remote acquisition mode, SLAM based mobile mapping systems (MMS) are a very powerful solution for capturing 3D point clouds in real time, simply by walking in the area of interest. Regarding indoor surveys, these MMS have been integrated in handheld or backpack solutions and

become fast scanning sensors. Despite their advantages, the geometric accuracy of 3D point clouds guaranteed with these sensors is lower than the one reachable with static TLS. In this paper the effectiveness of two recent mobile mapping systems namely the GeoSLAM ZEB-REVO RT and the more recent GreenValley LiBackPack C50 is investigated for indoor surveys. In order to perform a reliable assessment study, several datasets produced with each sensor are compared to the high-cost georeferenced point cloud obtained with static laser scanning target-based technique.

Paper #: 63 Integration of IoT Sensors to 3D Indoor Models with IndoorGML

Authors: Abigail Sarmiento, UNSW Built Environment, Australia; Abdoulaye Abou Diakite, UNSW Built Environment, Australia

Sensors are the vehicle through which Internet of Things (IoT) applications collect timely data of which are communicated to objects, or “Things”, to make them aware of their environment. With multiple sensors within an IoT system sending continuous streams of data, the potential scale of data is large, so efficient data management and useful representation is a key concern. As the information required from sensors benefit from a spatial context, 3D indoor models, such as IndoorGML, have been identified to support this condition. As it stands, a standardised structure to the amalgamation of sensors with IndoorGML has not been defined. The goal of this paper is to explore this opportunity by firstly, reviewing previous approaches to the integration of the two systems. Research into the interpretations of sensor information through existing standards is conducted before narrowing these attributes down into a minimal profile according to identified functional requirements of sensor applications. Finally, this knowledge is organised into a conceptual data model and presented as a thematic module in IndoorGML.

Session 12 - Ordnance Survey Tour – 3.00pm – 4.30pm

Chair: Rollo Home