ISPRS WG IV/7 joint workshop with WG I/2, ICWG II/IV, WG III/2, WG IV/6 and OGC SWG IndoorGML on 3D Indoor Modelling, Modelling, Visualisation and Navigation

Over the last decade the mapping and modelling of indoor and enclosed spaces has received greater attention. Although many concepts and technologies used in outdoor mapping are applied to indoor mapping, nonetheless indoor spaces differ from outdoor spaces in many respects. For example indoor spaces are smaller; there are many acquisition constraints such as walls, doors, stairs, furniture and so forth. To be able to represent indoor spaces in a proper manner many data acquisition concepts, data models, and standards have to be redefined to meet the requirements of indoor spatial applications. Therefore, the acquisition, modelling and navigation in indoor and enclosed environments remain the subject of active research. These research activities aim to 1) advance acquisition systems, modelling, mobile computing and augmented systems, and 2) support indoor application systems such as positioning and navigation or facility management to name a few.

The main goal of the conference was to provide a platform for discussions on the various aspects of 3D indoor mapping, and to stimulate ideas and research collaboration.

The conference attracted 44 delegates comprised of students, academics, industry representatives and vendors. The delegates came from Canada, China, Denmark, France, Germany, Japan, South Africa, Switzerland, The Netherlands, and The USA. Video conferencing was also used in the conference to allow a few who could not be there to participate in discussions.

Group photo on the first day

The conference programme included a welcome address, a keynote speech, presentation of technical papers, invited speakers, talks by vendors, and panel discussions. The welcome address was given by Mr Gavin Lloyd on behalf of the South African Geomatics Institute (SAGI). He spoke about the history of Geomatics in South Africa and the growth of indoor mapping in South Africa. He also noted that the conference was possibly the first ISPRS conference in Southern Africa.

The welcome address was promptly followed by the keynote speech titled, "Indoor Mapping & Location – The Past 10 Years & the Future", given by Dr Kris Kolodziej. He spoke about his interest and research in indoor mapping over the last decade and how he saw indoor mapping evolving in the future. His talk touched on indoor locations services, positioning technologies, indoor mapping infrastructures, indoor navigation, indoor mapping on mobile systems and applications of indoor mapping.

Kris Kolodziej

A total of 19 papers were received. The papers were organised in sessions that dealt with Data Acquisition, Modelling, Localisation and Navigation. The presentations of the papers were spread over the three days of the conference. As was expected the main interest of many of the papers was positioning within indoor spaces and the navigation of indoor spaces.

Tristian Lacroix - Market Trends & Examples
The talk by Tristian Lacroix focused on the potential of indoor mapping in marketing. He began by noting that the average person spends 80-90% of their time indoors and that 70% of cellular calls and 80% of data connections originate indoors; therefore there is great potential for indoor mapping in retailing. He then spoke on revenue generation opportunities and the components of an indoor mapping solution. He finished by giving an example using the application of iBeacons and push services in retailing.

Carl Reed (OGC) - Beyond 2D - OGC 3D Related Standards Activity for InDoor Tracking and Navigation
As co-organisers of the conference OGC were invited to give a talk on their activities in indoor mapping. Carl Reed spoke on behalf of OGC. The talk began with an overview of OGC's activities on developing standards for describing 3D environments and how indoor navigation and tracking

forms a subset of this. He then spoke about the history of GML, OpenLS, CityGML, ARML and IndoorGML. The talk then proceeded to IndoorGML, a modelling language for indoor environments. Carl spoke about the history of IndoorGML and how it evolved from the need to describe indoor environments (outdoors was already provided by CityGML). The differences requiring a separate standard for indoor spaces was motivated (e.g., multi-layered spaces, semantic models, security, etc.,). The talk finished with a discussion on the relationship of IndoorGML to other standards such as IPC, KML, etc. Here Carl, noted how the concept of Level of Detail in IndoorGML is different from traditional 2D/3D and BIM and required greater collaboration with CityGML. Discussions are currently taking place on extensions to IndoorGML (e.g. Facility management) and collaboration with other groups (e.g., POI SWG).

Alain Lapierre (Bentley Systems, Inc) - Location services in the Design/Build/Operate lifecycle of Infrastructures
The presentation started with a talk on the scope of Bentley's work in outdoor and indoor mapping. From here, with use of 'Use-Cases', Alain explained the fit of Bentley's activities in the infrastructure design cycle, Plan, Design, Build, Operate. With regard to the Design phase, various acquisition technologies for indoor environments were reviewed. Of particular interest were the advances in handheld acquisition tools, that are either stand alone or attachable to mobile devices. Also interesting in this regard where tools for on-site Design. In the Build phase Alain explained how Bentley's tools allowed for asset tracking and the importance of seamless outdoor and indoor models. During the Build phase activities such as detecting collisions (and preventing them), near real-time acquisition for verifying construction, and accident prevention were also highlighted as being important. The operations phase concerns post construction activities. This includes as-built surveys, inspection and maintenance, asset tracking, and accident prevention. Alain concluded is presentation by discussing the requirements for locations services. Here he identified four factors that need to be considered, The 3D accuracy and coverage of positioning services, the volume of traffic routing services to be handled by location services, the seamless integration of outdoor and indoor environments, standards, standards and the cost of deploying location services.

Trevor Venter and Brent Godfrey (Optron/Trimble)
Trevor's presentation was titled "Trimble Buildings". The presentation began by noting that generally the application of mapping technologies is horizontal, i.e., the same technology is used various fields, e.g., mining, construction, utilities, etc. The problem with this is that it limits business growth. The trend now is to look at how businesses can be specialised in particular industries, and this requires an understanding of the workflows in the various industries. One of Optron/Trimble's first strategies in this area was the civil construction industry. Trevor provided a use case example of this strategy in the construction industry and the benefits of this strategy. Another industry that Trimble has focused on is the building construction industry. The elements of the building construction workflow that it identified are Positioning and Sensors, Connectivity (between

workflows), Modelling and Analytics. The intent is to offer a system that allows the monitoring of the construction of a building in real-time, and collaboration between all parties involved in the construction. For this purpose an accurate 3D model is essential. Trevor's presentation was followed by Brent who talked on Trimble's 3D data capturing technologies, with particular emphasis on the TX5 terrestrial scanner and the Z1 hand held scanner. Brent then gave practical demonstration of the TX5 and described its benefits over other conventional instruments. The talk then proceeded to a discussion on the Z1 handheld scanner (known as the Zebedee) and the rapid acquisition possible with the instrument.

Panel Discussions

Three panel discussions were included in the programme. The purpose of two of the panel discussions was to offer a dedicated platform for discussing existing and emerging problems in indoor mapping. For this purpose ISPRS WG IV/7 prepared a position paper on this subject.

	Acquisition and Sensors	Data Structures and Modelling	Visualization	Navigation	Applications	Legal Issues and Standards
Existing problems	Variable lighting conditions	Software tool	Web and mobile devices	Navigation models	Indoor modelling for crisis response	Unification of outdoor and indoor models
	Variable occupancy, automated feature removal	Diversity of Indoor Environments	PoI and landmarks strategies	Automated space subdivision	Augmented systems	The diversity of indoor environments
				Optimal routing	Gaming	
	Sensor fusion				Industrial applications	
Emerging problems	Mobility	Real-time modelling		Navigation queries and multiplicity of targets		
	Real-time acquisition of dynamic environments	Dynamic abstraction	Real-time change visualization	Travelling imperatives	Natural description of indoor environments	Security and levels of access
		Discovering the context of space	Complexity visualization	Discrete vs continuous navigation models	Real-time decision support	Privacy
	Learning the composition of space	Integration with GIS/BIM	Aural cues			Copyright

Existing and Emerging problems in indoor mapping as conceived by ISPRS WG IV/7

The third panel discussion was put together to discuss how indoor mapping could be promoted in South Africa.

Masafumi Nakagawa, Susanne Becker, Alain Lapierre, Martin Tamke (video conf), Sander Oude Elberink (video conf) – Acquisition and Modelling

Masafumi began by giving an overview of the acquisition and modelling processes and technologies in indoor mapping. After this three questions were posed to the panel:

1. Which tools are ideal for indoor mapping? Tools and techniques for outdoor mapping may not always be ideal.
2. Is real-time processing required?
3. Who is best suited to acquire and model indoor data?

Acquisition and Modelling Panel

On the first question the panellists expressed the following views: Existing knowledge (structural designs) should be used to support the modelling process; that the choice of tools depends on the environment, the budget, the required accuracy, and the application of the model; laser scanners were considered cost effect but had to be supported by imagery; in the future the use of mobile devices will increase; the registration of indoor point clouds remains a problem; videos should also be considered particularly in environments, e.g., mines, where data has to be acquired in a very short space of time; a distinction should be made between sensors for navigation and sensors for modelling; archiving of data influences the data rate and quantity of acquisition; additional to geometry, semantic must also be considered and here the granularity of semantics and how it is communicated and interpreted remains an important problem; automation for the modelling of the huge datasets is critical.

On the second question the panellists expressed the following views: it's ideal to have 3D representations that support location based services; for navigation (particularly for the visually impaired) up to date indoor models are important, and if possible mobile devices can be used to update the models; there are many problems, e.g., augmented reality, require instantaneous models; real-time registration of imagery to models is also important; in crisis or emergency situations for the purpose of evacuation real-time models are important.

On the third question the panellists expressed the following views: the crowd will in future be an important source of indoor 3D data, but we have to be mindful that the quality of the data won't as reliable and we will have to be augmented by prior knowledge about the objects (e.g., integrity checks); the use of crowds depends on the specifications, cost and task of the project, and crowds may not be suitable in high cost projects; for more reliable data users should be provided with the appropriate tools; the best collectors of data are the users because they know what they want, they only need to supported by tools appropriate to the precisions they require.

Qing Zhu, Alexander Zipf, Kai-Florian Richter, Trevor Venter, Brent Godfrey – Navigation and Applications

Qing began by giving an overview of the modelling and navigation processes and technologies in indoor mapping. After this three questions were posed to the panel:

1. What are the important issues for dynamic navigation models?
2. What are the challenges in optimal routing and navigation?
3. What is the state of indoor and outdoor seamless navigation?

Navigation and Applications Panel

On the first question the panellists expressed the following views: collaboration between academia, industry and developers is important; a wide variety of models can exist in an indoor space and they may be based on different concepts (e.g., geometry, topology, semantics, etc.,) and for the purpose of dynamic navigation real-time transitions between these models has to be accommodated; automatic workflows from the raw data to the dynamic models is needed, particularly in crow sourcing scenarios; dynamic models of the space are needed in special situations, therefore consideration should be on how to interact between the static models and dynamic models (generated by users of the space); there is a convergence of many technologies (e.g., scanning, RFID, WiFi positioning, etc.,) is creating a mass of data and because of this the quality of modelling tools is becoming important.

On the second question the panellists expressed the following views: Contextual routing in outdoor situations are fairly well known, but in indoor situations greater considerations have to be made, e.g., the sensors to be used and sensor fusion, suitable routing tasks and use cases, factors that influence routes, privacy concerns in some use cases, etc.; the behaviour of users' needs to be studied and encoded to develop a better understanding of context and what it means for users; models have to cater for different user perspectives, functions, and access; varying location accuracies have to be accommodated.

On the third question the panellists expressed the following views: it's sometimes difficult to distinguish between indoor and outdoor (e.g., malls may have large open spaces that have the qualities of both indoor and outdoor) and here having seamless navigation becomes important; navigation applications that operate in real-time have to be able to present to users a seamless navigation experience, but the different visualisations/interfaces still have to be investigated; there are technical and communication aspects to seamless navigation; the technical aspect relates to positioning and data; the communication aspect relates to the user experience and granularity of navigation; with emerging mobile position technologies dynamic navigation is becoming an important subject.

Sisi Zlatanova, Brent Godfrey, Francois Stroh, Pieter Louw - Indoor mapping in South Africa

This panel was put together to discuss the potentials of indoor mapping in South Africa and how international collaborations can be started. The discussions began with an introduction of the panellists and each gave a brief account of their professional career and their experiences in industry.

The following views were expressed by the panel: The current uses of indoor mapping in South Africa are in architecture, mining, industrial metrology, and asset management; In the mining industry the acquisition technologies have to be robust because of the extreme environments (e.g., temperatures); In the mining industry safety is of great concern and here indoor mapping and localisation are of great interest; one has to be mindful of users accuracy needs (survey or gis grade); users in the mining industry are very interested in sensor fusion solutions and analytics tools; most mines are fully covered by WiFi because some robotic systems are operated by WiFi; there is a great potential for indoor mapping in retailing and some companies are already starting to use it; there is an interest in the construction industry for augmented reality systems in the design and inspection phases.

Indoor Mapping in South Africa Panel

Overall the conference was considered a success. It brought together people from a wide variety of disciplines and generated useful discussions on acquisition and positioning/localisation within indoor environments, location based services, navigation and applications. Therefore in this regard the goals of the conference were achieved.

However, there were some subjects that were not covered. These subjects include the visualisation of indoor spaces, enclosed spaces in underground environments e.g., mines and tunnels, and augmented reality systems. It is hoped that in future conferences papers will be received on these subjects and that they can be included in the programme.

Participants at the conference

ISPRS Technical Commission IV is holding its symposium in China (Wuhan) during 23-25 May 2014. The plan of Working IV/7 is to host a session on 3D Indoor mapping. Other meetings and activities for 2014 and 2015 are currently under discussion.

Sisi Zlatanova
Chair of ISPRS WG IV/7
Delft University of Technology

George Sithole
Co-Chair of ISPRS WG IV/7
University of Cape Town

Masafumi Nakagawa

Co-Chair of ISPRS WG IV/7
Shibaura Institute of Technology

Qing Zhu
Co-Chair of ISPRS WG IV/7
Wuhan University