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The need to Integrate BIM and Geoinformation

Zlatanova, Sisi; Isikdag, Umit

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Building Information Modelling: Essentials and Issues
The need to integrate BIM and Geoinformation

In the construction industry, business relationships are often short-term and one-off. There are many unique processes and activities. The resulting complexity and fragmentation may obstruct quick and effective exchange and integration of information and thus hamper project progress. Building Information Modelling (BIM) aims at preventing mismatches in information exchange between the many stakeholders. Although BIM has come a long way in this respect, there are still challenges to overcome. The authors explain the essentials of BIM and discuss issues.

By Sisi Zlatanova The Netherlands, and Umit Isikdag, Turkey

Building Information Modelling (BIM) evolved from supporting the design and construction of facilities, such as buildings, bridges and tunnels, to a research area in domains ranging from construction to urban planning and management. In parts of Europe, North America and South Asia BIM-based design and construction has been legally enforced. For example, in the UK public sector projects require BIM for representing, sharing and exchanging information starting from 2016.

BIM

NBIMS (2006) defines BIM as: ‘a digital representation of physical and functional characteristics of a single building. As such, it serves as a shared knowledge resource for information about a building forming a reliable basis for decisions, during its lifecycle from inception onwards’. **<<BIM does not apply abstractions or simplifications** of building components to reduce data volume; **all components are represented with their true 3D shape>>**. Therefore, all volumetric and parametric base components contain the smallest possible details. The location of a smaller component in a larger one, such as a window in a wall, is also indicated. Such base components serve manufacturing of, e.g., prefabricated parts of walls including doors and windows. The information consists of dimensions, type of material and many more. For example, a window may be characterized by the number of glass layers, thickness, colour, thermal transmittance and lamination. Windows and other building components may be extracted from the BIM through semantic selection (Figure 1). Utility elements, such as gas pipelines, are also contained in the BIM. Companies manufacturing the components often play a role in the design. Stakeholders can collaborate across the life cycle of a facility and perform CRUD (Create/Read/Update/Delete) operations. Stakeholders include: designers, manufacturers of building elements, constructors, facility managers or software developers of applications. The terminology and data needs of each stakeholder differ and to avoid the need of remodelling the same facility for different stakeholders, standards have been developed.

IFC

Sharing information across organizations, departments, IT systems and databases requires standardization on semantics, geometry and topology. Such standards have been developed since the mid-nineties and a widely accepted one is IFC (Industry Foundation Classes). IFC facilitates sharing of information cost-effectively and without becoming dependent on file formats, which are product or vendor specific. IFC is semantics-rich and object-oriented. The latter means that each component can be uniquely identified no matter its size. IFC is also truly 3D in which all geometries are topologically valid solids with no daggling edges or unclosed polygons. The hierarchical maintaining of spatial relationships ensures correct ‘inclusion’ and ‘part of‘ relationships. IFC is also data-rich and thus enables comprehensive, detailed description of all physical and functional features of a facility. These characteristics of IFC allow for quick selection and query of parts of the facility as well as creation of views of the facility to serve stakeholders.

Information Management

Information management can be either done by the transitional approach or the central-database approach. In the transitional approach a building is represented as a loosely-coupled collection of sub-models, each providing a portion or a state of the BIM; the representation can either provide a part of the whole model, such as two of the four stories of a building, or a state of the whole model, such as the scheduled construction in the first two weeks. Next, these sub-models are aggregated in a single, shared BIM. In the central-database approach the building model is stored on one server, which allows users to query and immediately see any component and its properties or any design revision made. Both approaches have benefits. The first approach allows stakeholders to exchange their sub-models or domain specific model parts during design and construction, specifically when the workload is divided through many short-term contracts; a subcontractor can work independently of others without needing a detailed view of the entire project. The second approach suites maintenance and facility management in which the changes are less critical and a general view is more important.

Facility Management

Once the facility is erected, in use or in operation BIM offers many advantages for monitoring and maintenance. For example, overdue doors and windows can be identified; walls, slabs, stairs and elevator shafts can be analysed for necessary repair or replacement work. Air conditioning systems or other new components can be ordered precisely tailored and the associated detailed information be brought into the BIM immediately. A central database approach facilitates quick, easy and reliable updating. <<**BIM** also **facilitates the automatic generation of models for supporting indoor navigation and positioning>>.** From these models connectivity networks can be generated for computing an optimal path from a present location to a desired location (Figure 2).

Integration

In the design stage a BIM represents a forthcoming reality through detailed geometry also representing the internals of objects. The BIM is not yet connected to a location represented in XYZ-coordinates. In contrast, geo-information describes reality of the broader area around the projected location of the new facility through XYZ-coordinates. GIS models apply abstractions and simplifications, which leads to relatively less objects, details and properties compared to BIM. While IFC provides an easy determination of ‘inside’ relationship, GIS models are oriented towards neighbourhood relationships. Added to this, objects in GIS models are derived and interpreted from data captured from cameras or laser sensors resulting in representations in the form of bounding surfaces while the internals of the objects are only modelled if required, as this is labour-intensive and thus costly. City model standards such as CityGML also provide more detailed interior representations such as LOD4 but these are not as detailed as in IFC. For example, a wall in CityGML is the *surface* of the wall, while IFC would describe the 3D *solid* of the entire wall. So, one physical wall in IFC would be represented by two surfaces in CityGML. The value of integrating BIM information and geo-information becomes apparent in 'BIM Execution Planning', which formalises the design, construction and maintenance activities of a facility. Site Planning together with 'Design Authoring' and 'Cost Estimation' are BIM uses and these define a series of tasks related to the intended use of the facility. The construction industry appreciates the benefits of BIM uses but seems to underestimate the value of BIM information integrated with geo-information. To respond to all stakeholders' demands, BIM is expanding towards integrating information from the surroundings as has been carried out in a large study conducted in Rotterdam, The Netherlands (Figure 3).

Conversion

As IFC contains more detailed and more complex information than CityGML, the conversion from IFC to CityGML is relatively straightforward and stable, but the other way around requires additional rules and information resulting in complex, yet unsolved problems. These issues have triggered academic research on seamless conversions, ensuing the recommendation to follow first semantics-mapping, and then geometry and relationships transformations. But in-depth investigations are still eagerly required.

Metadata and Big Data

The spatial data infrastructure (SDI) provides a framework for organizing and managing spatial data and its associated metadata. In contrast, BIM is a data and information model without accompanying metadata, although the worth of metadata is slowly penetrating the construction industry. Recently, discussions on the role of BIM as a part of Big Data started to emerge via linkedin.com. This is encouraging since BIMs will stay as unconnected isolated islands of information as long as awareness about its role in the bigger picture of GIS and Big Data does not emerge.

Concluding Remarks

The role of BIM will continue to grow. But next to the opportunities, there are many challenges. Once the challenges and issues have been identified they have to be discussed with the GIS communities to increase awareness and develop solutions.

Authors

Sisi Zlatanova holds a PhD from the Technical University of Graz, Austria. Her research focusses on 3D modelling, integration of BIM / IFC and 3D GIS, 3D topology, spatial DBMS, and Augmented and Virtual reality. She is 2016-2020 president of ISPRS Commission IV Spatial Information Science. She authored and co-authored over 300 scientific papers and (co-)edited 20 books.
Email: S.Zlatanova@tudelft.nl

Umit Isikdag holds a PhD from the Technical University of Graz. His research focusses on BIM / IFC, 3D GIS, Internet of Things, RESTful Architectures, and Spatial Web Services. He is involved in organizing 3D GeoInfo and GeoAdvances Conferences and is member of ISPRS WG IV/1.
Email: uisikdag@gmail.com

Figure Captions

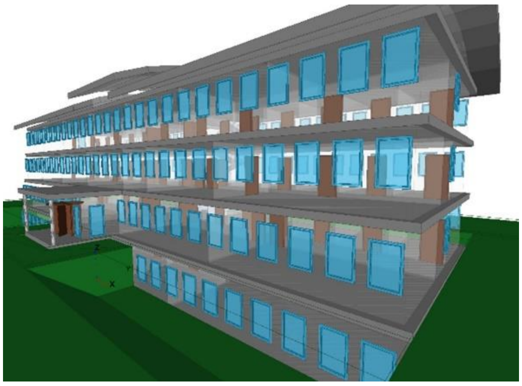

Figure 1, Example of a semantic selection of windows from a BIM (courtesy Shuanfeng Wei)

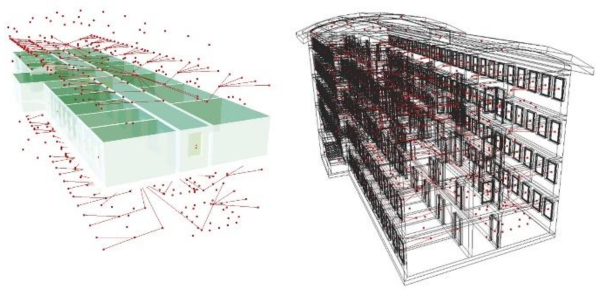

Figure 2, Automatically generated connectivity networks (courtesy Shuangfeng Wei)

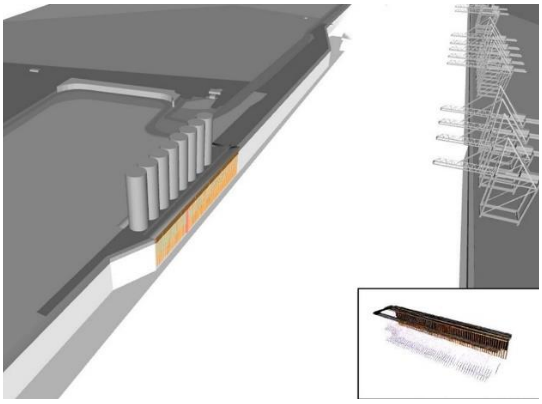

Figure 3, Identification of surrounding quay components for integration in a BIM (demo)

Further Reading

http://public.cbnl.org/61

https://www.linkedin.com/pulse/bim-data-isnt-big-discuss-andy-hamer?published=t

NBIMS (20060 National BIM Standard Purpose, US National Institute of Building Sciences Facilities Information Council, BIM Committee. https://www.wbdg.org/pdfs/NBIMSv1_p1.pdf