A method to Link between BIM and GIS for Early Stage of Building Design

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Abstract

Using geospatial information in the early design phase is crucial because it requires considerable time, money, and effort. We use VWorld, part of the National Spatial Information Distribution system provided by the Korean Ministry of Land, Infrastructure and Transportation, for providing geospatial information to building designers. We provide methods to adopt VWorld geospatial information to building design and develop plugins for a BIM authoring tool to transform and construct necessary BIM data in a user-friendly format. BIM users are benefitted from extra design information supplied from sibling disciplines such as urban design. GIS users are benefited by feedback building information continuously supplied from building projects based upon standard GIS coordinates. We propose the Building Environment Information Modeling (BEIM) concept for more efficient interdisciplinary CAD/BIM/GIS integration.

Keywords: CAD/BIM/GIS Integration, GIS, Architectural Design, BIM

1. Introduction

1.1. Research Background

In most of building projects, site analysis proceeds building design and in most of the cases site related information is supposed to be collected from various sources of distributed informers. This requires incalculable amount of time and efforts for the appropriate search results. One of the information source that facilitates most for the site analysis in building projects the use of Google Earth, which is a kind of 'Virtual Globe'(Wikipedia, 2015), from which designers could acquire geospatial information to proceed building site analysis with simplicity and ease in information usage. In fact, the advent of Virtual Globe such as Google Earth provides designers and architects the opportunity to make the GIS information available in building design, and moreover it becomes possible to extend the border of building designing from a single building to broader regions including urban, metropolitan and national bounds. Also the widely accepted BIM concepts in building industry facilitates the introduction of GIS information in building project in terms of the focus on building information aspects as well as building life-cycle considerations. It results in many discussions on CAD/BIM/GIS integration in various regions and keen eyes are on building maintenance phase of building life-cycle.

The Korean ministry of Land, Infrastructure and Transportation realizes the value of the geospatial information of Virtual Globe and it provides services called VWorld (Ministry of Land, Infrastructure and Transportation(MLIT), 2015B) as a subordinate platform of the National Spatial Information Distribution system (MLIT, 2015A). The VWorld is serviced in two different forms firstly, such as the Virtual Globe as in Google Earth and secondly as a Web service. It provides especially 3D building exteriors in most of domestic metropolises as well as various forms of national spatial information. It is considered appropriate and effective especially for the domestic building design project use because the VWorld provides more credible, richer and wide range of geospatial contents comparing, so to speak, to overseas company based Virtual Globe such as Google Earth.

One certain advantage of well-established Virtual Globe such as Google Earth is the existence of ready-to-use plug-in software for the building design society because of its relatively long history and their thick and royal followers. VWorld currently does not provide this type of software. This deficiency of middleware bridging National Geospatial Information Distribution system and integrated building design BIM tools forms the starting position of our research. This paper suggests Plug-in software development that bridges BIM software that is familiar to building project experts and the VWorld in which various geospatial information is unacquainted to building experts. We

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look for the tangible validation of the CAD/BIM/GIS integration issue from our efforts. Well established existing Virtual Globe such as Google Earth also provides middleware that shows limitations in using only satellite images, however, our GIS/BIM middleware is capable of providing various geospatial property information over the limitation of satellite images, which could lead many building projects toward better opportunities and possibilities..

1.2. Research Scope

The aim of our research in this paper is the GIS data bridging system for the building design support. The scope of our research and development is the system development bridging the government GIS service called VWorld to the BIM authoring tool. We demonstrate in this paper the bridging BIM/GIS middleware using Autodesk Revit. We are planning that the completion of the full API that could correspond with sufficient VWorld data would be followed by implementation of BIM/GIS middleware for other BIM authoring tools.

We demonstrate in this paper the contents covering the extraction of topology and satellite photograph from the VWorld data and the conversion to Revit data format. This would validate BIM/GIS integration from the data conversion point of view, which matches the core functionality of the existing Google Earth plug-in software. The next and future step of our research would cover other data than those topology and the satellite photos. Those could cover such site related information as cadastral properties and land registration information in the VWorld in the form of BIM software data and/or properties such that the geospatial information could be automatically shown to users with simple selection of the building project site. The conversion of the site related geospatial information into a familiar and building design relevant design property format would be supported.

The development of the bridging middleware system we have performed system analysis for the Google Earth – BIM plug-ins, data analysis for the Google Earth and accordingly the data analysis for the VWorld. The system design and system requirements are set, followed by validations and reviews for the system operation, errors, conversion data accuracy, additional development issues and checks.

2. Related Works

We are concerned about a system development research to support building design using GIS data and we have started examining from the CAD/BIM/GIS integration related works for the purpose of enhancing the management efficiency of the building information through BIM data construction using GIS data.

2.1. CAD/BIM/GIS Integration

The OGC (Open Geospatial Consortium) that is a non-profit organization for the geospatial information standards, explains the need for CAD/BIM/GIS integration to suite the purpose of enhancing interoperability of design, construction and maintenance information covering the life-cycles of buildings and infrastructures(OGC, 2010). The National Institute of Building Science (NIBS) that is the national research institute which suggests and manages BIM standards in USA, recently established the National BIM Standard, in which they claim the scope of building information should be extended from the minimum building scale to world scale information covering not only building scale but also city scale and state scale information and those larger scale environmental information naturally requires GIS data. NIBS suggests the hierarchical structure of information scales/scopes and it leads to the subject of CAD/BIM/GIS integration (National Institute of Building Science, 2007).

The CAD/BIM/GIS integration issues are proceeded with a crucial big size information processing issue because it is considered essential to handle big size 3D model based building data. Some of the most efficient approaches to this issue are concepts such as the use of LOD (the level of detail) as well as hierarchical separation of 3D model information based upon the hierarchical structure by the National BIM Standard. CAD/BIM/GIS integration is indispensable for the information system covering cities, states and finally the whole Earth, however current information systems are mostly concerned about building up urban infrastructure information system excluding information about buildings that are the building blocks of city scale information system. The existing and current Google Earth based 3D-City examples (Döllner and Hagedon, 2007; Takase and Sho et al., 2003) provides only the building exteriors without any building related information integrated to them and this emerges as crucial problem and it is caused mainly by big scale 3D data processing

Efforts and solutions are found from system developments for Airport geospatial information management. Denver international airport and Los Angeles International Airport, with the adoption of BIM, applied the GIS in managing buildings and infrastructures scattered across the airport sites not in 3D model base but in 2D drawing base because of big scale 3D data processing. Those airports adopted Revit for BIM software and ESRI ArcGIS for GIS software, and those tools are said not capable of processing 3D data in real-time. Highly contrasted to these airport cases is the Incheon International Airport (IIA) case of integrated space management system. The IIA, just like two other airport cases, consists of more than 180 buildings in a large scale airport site and the real-time processing of big scale 3D lands, buildings and spaces information was crucially required, that pushed them not to choose the existing commercial building design tools but to develop the exclusive software and followed by the design of file format of handling light

weight 3D data and finally the construction of hierarchically structured 3D data based upon this exclusive format. One more special attention was given by the IIA to enhance the strong immersive experience of end users who perform the actual management tasks by adopting 3D game engine based real-time rendered visualization 3D viewer instead of using the existing building design 3D viewers (Kim and Yun et al., 2015)

2.2. The Use of GIS with Virtual Globe

Virtual Globe is known as the main gateway to the GIS information that maximized the contact frequency for the non-expert users because of its convenience in usage and the strong immersive environment for users, such that Virtual Glove, as the search platform of 3D model based GIS information, could be treated as the virtual reality Earth. Among many examples of Virtual Glove applications, there is a BIM related example such as the web based 3D facility and device management system for the scientific station in Antarctica. This example demonstrates various GIS and BIM data as well as functionalities including inquiries for various properties and 3D space search through platform server constructed using WWJ (World Wide Java) which is an open source and the engine of World Wind that is NASA's Virtual Globe (Gaia3D, 2015)

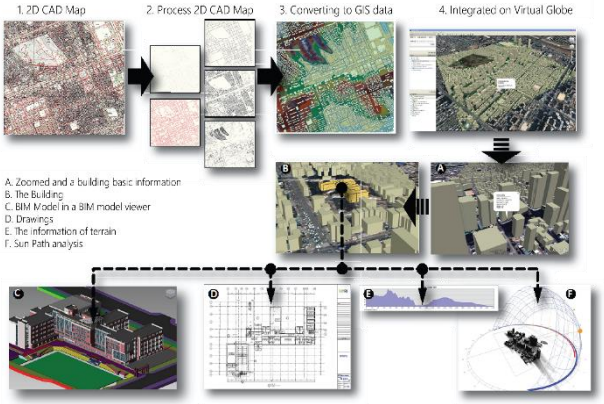

Fig.1. The example of CAD/BIM/GIS Integration with Virtual Globe(Illustrated based on research of Kim and Ju et al.(2008); Kim and Choi et al.(2008)

A research case suggests a method to build up building information using Virtual Globe, which serves as a search platform for building information (Kim and Ju et al., 2008). It also demonstrates a way to produce building mass from the Google Earth information and building heights. It illustrates a way to automatically construct thousands of building data containing GIS coordinates, building outlines, address data, floor data and building names. The research also shows a way to construct building data in Google Earth using BIM model. The search points out that the building mass model works in Google Earth with little trouble however converted BIM model was not working smoothly because of the big size issue of 3D model. A partial solution to this issue (Kim and Choi et al., 2008) suggests the adoption of appropriate Level of model for distinguishing in the Google Earth and a separate link to exterior BIM viewer for more detailed level of building model.

3. GIS Data Application System for Building Design Support

3.1. Vworld Data and API Analysis

VWorld uses its own exclusive data format. It also uses KML data format as Google Earth does but does not adopt Collada format like Google Earth. Especially the VWorld uses its own format called Real3D for 3D building model. DEM (Digital Elevation Model) is the 3D coordinates for the terrain to construction GIS with a set of heights for regular intervals. There are similar data formats such as DTM (Digital Terrain Model), DTD (Digital Terrain Data), and DTED (Digital Terrain Elevation Data). Satellite photography processing adopts an image format called DDS (direct draw surface), which is capable of video image compression to save video memory resources. But there are some problems with this image format. The first is the low image resolution. The next problem is that this is not generic image format such that image format conversion is demanded. Our research uses web site (http://image.online-conve rt.com/convert-to-png) to convert DDS to PNG in this paper. Future studies would cover internal PNG conversion function with further analysis on DDS format.

The VWorld provides various geospatial information covering 132 items. This information is publically served from the Korean governments including the Ministry of Land, Infrastructure and Transportation (MLIT). Those building design related information served from the MLIT are maps of development activity Permit, National traffic information, Urban planning facilities, Industry site, Use districts, Use zone, Use region, District unit plan.

The VWorld provides eight types of Open API (Application Programming Interface) (MLIT, 2015C) for the developers and two types of data lists. The VWorld provides terrain forms and map image through 2D map, 3D map and background map APIs. WMS and WFS APIs provides data in the WMS and WFX layer lists in the form of feature map. The rest APIs are for the support of search operations, through which we could search for address data, road name based address data or new building address. It also provides functionality for Geocoding that converts into GIS coordinates using address and names in the map.

API usage and data structure to be returned could be understood with the example of search function of land registration map among Data List APIs. Shape related information in the land registration map is supported as a form of coordinates without specific file formats in

the VWorld. As a result, the request for the land registration related information returns the data in XML forms in which land registration polygon as well as property information coexists to each other. An example below illustrates the request methods for "N Seoul Tower National Theater Parking Lot" information.

http://apis.vworld.kr/2ddata/cadastral/data?apiKey=46E68FFB-2557-3DB3-AA5E-DA1479542A6D&domain=http://corp.kovi.com&geometry=point(14137619.6359031%204516255.06244297)&output=xml&srsName=EPSG:900913&pageIndex=1&pageUnit=100

The translation of the above description is that using the returned coordinates of the place with search keywords to be used as next search keywords, and returned results are in XML format, and use EPSG:900913 coordinates for coordinate types. APIkey among these values indicates authority for use ID that user needs to get issued from the VWorld.

3.2. System Design and Development

The system implementation in this paper concerns about the Middleware bridging the BIM software Revit and the GIS data in VWorld, and this system works as a Plug-in for the Revit platform. This middleware system provides functionality to search the VWorld using the categories of information such as lot number address, road name address or coordinates (global WGS84 coordinates or domestic KATEC coordinates), to request to the VWorld system using input keywords, and to convert or to create Revit objects from the returned data with shapes and properties that are needed in architectural design. The system also functions for the conversion and mash up so that Revit model generated based upon the search information to be reused in the VWorld Desktop.

The middleware system structure is shown in Figure 2. Major system components are separately divided in terms of A, B, C and D subtitles corresponding to the Middleware which is the system core, VWorld system which is the GIS DB, Revit which is the BIM software, VWorld Desktop which is a type of Virtual Globe and A360 which is a Web-based Revit viewer, respectively so that each components are linked to each other centering around the Middleware. The Middleware consists of search parts that handle the data request to the VWorld, received data conversion part that changes data to fit to be processed in the Middleware, and Revit data conversion part that changes Revit model to the data to be used in the VWorld Desktop. In the search part, even though various forms of keywords for the request is allowed, but it is more appropriate to use lot number address for more precise search results for the land related information. This is due to the land registration map information and its acquirements. In search parts, users can verify the search results using the list and images in the form of 2D map and satellite photograph. Authorization of the search result leads to the next step of separating shape and property information from the received data (including DEM, Real3D, XML, and coordinates) to be converted into shape information that are usable in the Middleware. Shape information consists of 3D terrain, 3D building, satellite photograph, map image and land registration map. Property information consists of properties of land, zoning district, building and others. Data that is received and converted leads to Revit data conversion part to be converted into Revit objects, that include terrain object, mass object for building, and property line for the land registration map. Property information is saved as custom parameters for the related Revit objects.

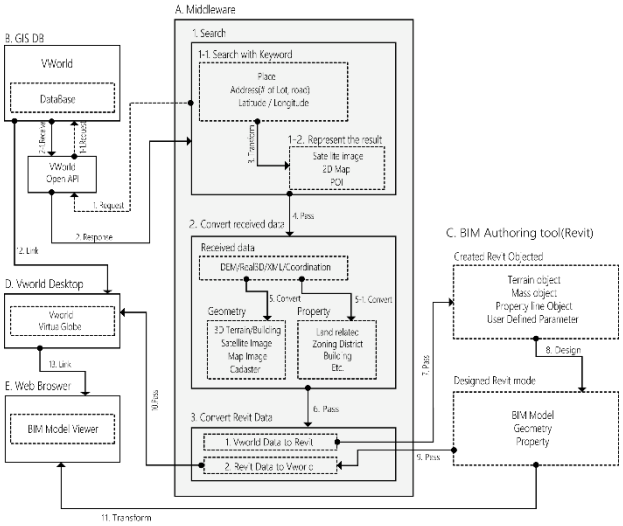

Fig.2. System Structure

Building designers perform design tasks using these Revit objects generated by the Middleware, and those design results are feed back to VWorld Desktop through Middleware Revit Data conversion part. Detailed Revit model are not allowed to send back to VWorld, however these detailed Revit models are accessible through Web-based BIM model viewer. Those data for the Web-based BIM model viewer are generated directly from the Revit platform, not through the Middleware. These are also explained in "2.2 The use of GIS with virtual globe".

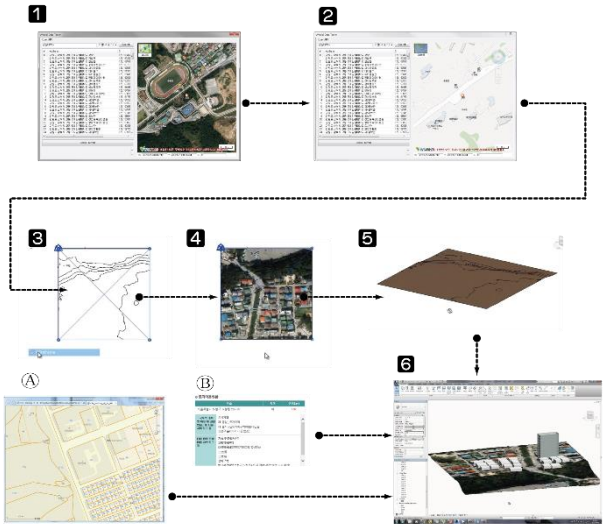

Fig.3. Illustration of system operation

3. Discussion and Vision

Recently and internationally there has been heated discourses about necessity and methods on heterogeneous integration of CAD/BIM/GIS but cases are hardly found that could play leading roles for the integration in real building design projects, let alone building projects with a large scale administrative support in the scope of a nation. On the other hand, the MLIT case of the VWorld is especially meaningful because of those facts that firstly it is initiated by Korean government and secondly it is aimed to bear meaningful fruits in a commercial building and construction industry to be the interdisciplinary joints between building and city and covering larger scaled scope of design environments. At this period of time, Korea could provide perfect test bed for the CAD/BIM/GIS integration research because of its high level of ITC infrastructure. This paper is one of the early efforts for the better and more efficient interdisciplinary building information integration that could possibly put together those seemingly heterogeneous and separate sibling disciplines of building, city and nation.

The advent of BIM – Building Information Modeling – brings the building industry quite a few opportunities with an integrated platform to cover two open-end categories of form and properties. It opened up new horizon of collaboration among existing building work areas of architectural design, building structure and building MEP. However and ironically, BIM, with its strict requirements of information completeness, it rather closed down smooth interdisciplinary information communication with others that are over the scope of building industry. When the attraction of BIM usage is limited to the level of a building or a group of buildings, the BIM boundary would become strong fortress that might prohibit further interdisciplinary communication. The BIM needs to extend its outer shell boundary from a building, to town, to city and to a nation so as to extend its scope and range for better connection. It becomes the best time to consider the next paradigm of breadth extension, as well as the existing depth growth for the BIM. As for the penitence, we are reflecting the glossary of BIM, the Building Information Modeling and we are trying to clarify our vision with a reformed glossary of BEIM that is acronym for Building Environment Information Modeling. Under the concept of BEIM more attention would be given not individual disciplines but inter-disciplinary applications of form and properties of artificial environment. We would anticipate those near future situations such that architectural designers ask for new parameter sets, urban designers also requires new parameter sets and MLIT is also persuaded to set bidirectional or better sets of artificial environment parameters.

This paper is concerned about developing a middleware system that would benefit the existing BIM users – mostly the building designers, who are persistently suffer for the lack of project relevant information – from government initiated public geospatial information databases. We expected in this paper the main group of users for most of the BIM authoring tools are building designers, such that we examined mainly for the information that could be acquired from the VWorld in the forms of familiar formats and project related knowledge such as site terrain object, satellite photos, and various geospatial information ranging from 3D building model with exterior texture, 2D polygons of building outlines to variety of properties of artificial environments including buildings, sites and roads. BIM authoring tools are mainly for building design experts who are mostly showing tendency of paying attention to physical entities and design information for building construction. It is rational for us to start with the BIM/GIS middleware functionality to initially cope with site design issues in building projects. In this paper, we primarily tried to verify the usefulness of our system from the viewpoint of building design experts. That leads us to demonstrate our system as a middleware for two sibling disciplines of building and urban design so that building design results based upon standard GIS coordinates for not only singular building but also for multiple buildings in a large scale project area are supposed to be mutually beneficial to both parties providing appropriate data and information for BIM as well as GIS. This middleware would open up the way to enrich both GIS and BIM information systems and it would save much time and efforts.

4. References

1) AMC Bridge(2015) CADtoEarth for Autodesk Revit User's Guide, http://cadtoearth.amcbridge.com/cadtoearth_manual.pdf
2) Döllner, J., Hagedon, B.(2007) Integrating Urban GIS, CAD, and BIM Data by Service-Based Virtual 3D City-Models, Urban Data Management Symposium, pp.157-170
3) Gaia3D (2015) BIM on GIS project, http://www.gaia3d.com/ko/?work=bim-on-gis

4) Kim, E., Choi, H., Jun, H.(2008) Creating and Sharing GIS based City Information for the Architectural Design Using a Virtual Globe, International Symposium on Architectural Interchanges in Asia, pp.880-884
5) Kim, E., Ju, S., Jun, H. (2008) Study of Establishing the Prototype of the Location-based Space Management for Educational Facilities - focusing on College Facilities, Architectural Institute of Korea Conference, AIK, pp. 37-40
6) Kim, E., Yun, J., Cho, S. (2015) Integrated Space and Asset Management system for Large Scale Airport - The case of Incheon International Airport, CAADRIA 2015, pp. 807-816
7) Ministry of Land, Infrastructure and Transportation (2015) National Spatial Information Clearinghouse, http://www.nsic.go.kr
8) Ministry of Land, Infrastructure and Transportation (2015) VWorld Map Service, http://map.vworld.kr/map/maps.do
9) Ministry of Land, Infrastructure and Transportation (2015) VWorld open API, http://dev.vworld.kr/dev/api.do
10) National Institute of Building Science (2007) National Building Information Modeling Standard, Version 1.0, Part1, National Institute of Building Science
11) OGC (2006) Request For Quotation and Call for Participation in the OGC Web Services 4 Initiative. Annex B: OWS-4 Architecture
12) OGC (2008) OGC Approves KML as Open Standard, OGC Press releases, http://www.opengeospatial.org/pressroom/pressreleases/857
13) OGC (2010) OWS-4 CAD/GIS/BIM, http://www.ogcnetwork.net/node/236
14) Takase, Y., Sho N., Sone A., Shimiya K. (2003) Generation of Digital City Model, Journal of the Visualization Society of Japan, pp. 21-27
15) Wikipedia (2015) Virtual Globe, http://en.wikipedia.org/wiki/Virtual_globe