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Computer Aided Architecture Design and Research Based on the BIM Technology

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Abstract

With the development trend of current economy and the rapid development of computer technology, intelligence is more and more widely applied in the construction industry. According to the actual situation of current society, this paper makes a brief introduction of building information model. Taking its application status at home and abroad and existing problems into consideration, as far as the development of the current field. The paper frames structure and simulates the interface with the help of computer-aided analyzing tools. It applies the computer intelligence factor analyzing method and gets the factors that influence the building information model are: the expected results, human intervention, promoting conditions, adoption intention, the ability to use technology and educational background variables. Then, through model testing, we got the direct link with strong degree between the expected results and adoption intention, human intervention and adoption intention, the expected results and the ability to use technology, promoting conditions and educational background variables. This paper analyzes the factors and the relations of building information model. Is has a certain economic value and practical significance. It can solve the existing problems in practical construction industry and lays a foundation for other related building software.

Keywords*: building information model, analyzing tools, model test, direct link*

1. Introduction

With the progress of society, the improvement of human needs, the integrative development of computer application technology, information application technology and digital application technology, architecture design software based on the computer aided software is more and more widely applied in the product and living, which lead the development direction of whole construction industry. MIM is the short for building information modeling. It is based on the industry foundation, information delivery manual and international framework of terminology, which is a kind of digital expression considering the physical property of equipment and the usability of function. [1]The study begins from 1975. With the introduction of new technology and new method, BIM technology becomes more and more mature. The technology content of the construction industry is more and more higher and the additional information is more and more big. [2]However, there are still many problems such as old form, out-of-date, rework, waste, delay and so on. At present, by using the method of computer, we have built building information model, improved the quality of building through reasonable digital cluster structure of simulated building in order to improve the work efficiency, decrease the environmental damage and improve users' usability. You should ensure a good management, good use and the good use of information. Guaranteeing the fluency of building information has a significant meaning for the overall management and maintenance of the industry.[3]

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2. The Basic Applications of BIM Technology on the Construction Industry

2.1. A Brief Introduction of BIM Technology

BIM technology is the digital cluster of building programs, which is a behavior of perfecting building information. It is a collaborative working environment which can be replicated and checked. It is a kind of parametric model. [3] The sharing environment is built in a three-dimension space which is real-time, consistent. It can support the calculation, simulation and data transmission of multiparty. The bases of design are factors like wall, doors and windows. They join together and construct the components. All the information is united into the database, which is used to complete space analysis, effect analysis and volume analysis and support the rational use of safety circle in the construction industry. [5]It features new concept, new practice, informational innovation, comprehension,high-efficiency, environment protection and economy. With its own characteristics, it fully plays its own additional function, realize the visible design,stay in the internal space, form better design thought, decrease the time for building design concept and shorten the construction time. At the same time, through information collection and information communication, we can find the uncoordinated factors and the problems difficult to solve, analyze the related materials, automatically generate and modify the documents, automatic change, change management, realize high-efficient design evaluation, carry out the work and get the basic information like purchasing list, construction costs and so on. It can eliminate at least 35% of the extra budgetary changes. The cost can be controlled within a range of 10% accuracy. The time consuming also reduces to more than 70%. All kinds of design errors are decreased, which greatly increases the economic benefits and guarantee the cost of the whole building work process. It can greatly decrease the damage and waste during the building process. Primary application items are the LibertyMansion in the United States, New YorkLibertyTower, Beijing Olympic National Swimming Center “Water Cubic”, Eureka in Australia and CenterTower in Shanghai[6].

BIM technology lays more emphasis on building and more professional. While on the design part, CAD has more advantages[7]. The comparison between BIM technology and CAD application software in the same industry is as follows:

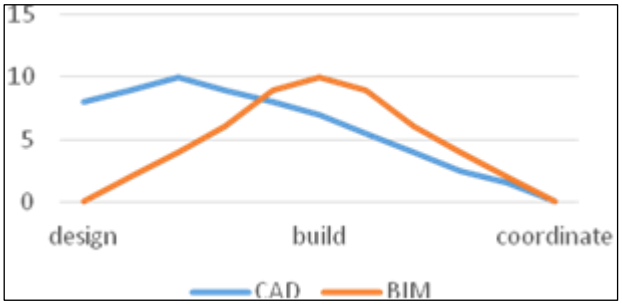

Figure 1. BIM Technology and CAD Technology Comparison

2.2. Present Situation and Existing Problems at Home and Abroad

The development of the construction industry obeys the analysis of market structure and the development trend of the industry. Its development situation is mainly demonstrated in server products, software products, storage products and other products[8].

(1) Present Situation Abroad

Table 1. Foreign IBM Technology Fact Sheet

Example	content
United States	Hungary's Graphsoft company's proposed Based the theory of Virtual Building (Virtual Building) and Benetly company's proposed Signal Building Information concept, Autodesk company in 2002 first proposed the concept of BIM. In the United States, the construction industry has already adopted take all the technical specifications of BIM. By induction statistics: approximately 55% of industry practitioners use BIM, 42% of users are the experts or more; 50% of the contractors use BIM technology tools; 68% of experts use the BIM technology in order to finish 60% of the projects.
United Kingdom	Had failed to BIM technology is fully applied. BIM technology are used by only 50% of practitioners. But the speed BIM technology adoption become more rapid.

(2) Present Situation at Home

Since 2000, Chinese construction industry began to learn about BIM technology. The application of computer technology is mainly demonstrated in the analysis of building place, building planning and design, building project demonstration, three-dimensional visible design and collaborative design. They are stored in three forms of work: single file system, three-dimensional model system and the united system of building information and documents. Designers are the main users. Building information model software that practitioners use can be divided into two parts: design type and construction part. Specifically, there are core modeling software, core design software, geometric modeling software, sustainable analysis software, electromechanical analysis software, structural analysis software, visible software, model checking software, deep design software, integrated collision of model checking software, cost management software, operating management software, two-dimensional painting software and releasing audit software[9]. Generally speaking, BIM technology in China just begins developing. The participants in construction industry are improving their understanding of BIM technology,, who are spreading its depth and width.

(3) Existing Problems

No matter at home and abroad, the application degree of BIM technology in construction industry is still below the expected level. In terms of objective conditions, there exist problems like the production mode of extensive waste and immature BIM technology; in terms of subjective conditions, the effort in business and company management is insufficient. The tine and capital cost is unreasonable. The practitioners don’t have a rught attitude to BIM technology. All these factors influence the study of computer-aided building design under BIM technology.

3. Applied Areas

By realizing building information sharing work, BIM technologies coordinates all majors and coordinate the architecture, electrics, thermal, sunlight, standard inspection, water supply and drainage by using its own technology, making the design plan more reasonable and the quality is more higher. The level of construction industry has been improved on the whole. It guarantees the high-efficiency, preparation and construction workers and smooth development of the constructors and equipment [10]. At present, the construction industry in China realizes the application of building design in three aspects of residential building, tall buildings and green buildings. The main business fields of IBM technology are software, hardware hand service that is the three main fields.

Specific application situation is as follows:

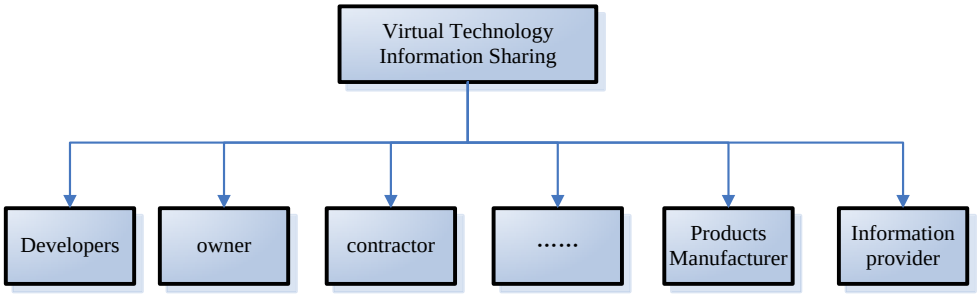

Figure 2. BIM Technology Specific Application Analysis Chart

4. The Model Application of BIM Technology on Construction Industry

4.1. Model Preparation

(1) Energy Analysis Tool

Tool 1: Ecological building design software ECOTECT is used to handle complex picture information, which can directly reflect the feedback of building stage.

Tool 2: Internet service software GBS is used to the building model in the process of virtual design and does the energy analysis. It mainly reflects in the analyses of sunlight, day light, heat, lighting simulation and acoustics.

Tool 3: Energy simulation software Energy Plus is used to the use analysis of reducing the energy of users.

(2) Implementation Framework and Application Analysis

BIM technology implementation framework is based on the law and regulations and technical standards of BIM related technologies, whose system structures are user layer, application layer, service layer and infrastructure layer[11]. Among them, the user layer includes the owner party, designer party, contractor party and construction party. The application layer includes BIM modeling, progress generation and risk evaluation. Service layer includes sharing and exchanging service, safety service and field application support service. Data layer includes data, case, rules and methods. Infrastructure layer includes local area network, internet, public telephone network, public wireless data communications network and operating environment of the system [12].

BIM implementation framework not only constructs standard on the rule of law, but also realizes normal double index in society.

(3) Design Interface and Realization

The design interface BIM mainly applies Visual C++ integrated development environment. It can provide system menu and toolbar menu interface through MFC (Microsoft Foundation Classes) dialog box and toolbar menu.

Table 2. Application Menus and Toolbars Can Be Some of the Features

The main function	Method of operation
File Operations	The corresponding function using BIM data and IFC data interface IFC data analysis and preservation.
Graphics operations	The corresponding function using a graphical interactive interface module BIM interactive graphics to achieve browsing, selection and other operations.
Professional Features	By BIM data management platform, feature development

Computer-aided building design software under BIM technology describes the aggregation relationship, inclusion relationship, quotation relationship and border relationship among space level by using the tree structure. Describe partial entity set and design entity object through entity expression. Access BIM data interface and meet the interactive operation between nodes according to needs. Realize the non-numeric entity attributes and the attribute to express directly with number for the BIM entity objects in practice.

4.2. Modeling and Testing of BIM Technology

(1) The Preparation of Model

model hypothesis：

This paper supposes that there exist relations between all the involved factors in the BIM technology model. That is there exists link path between factors. There exists mapping relations between the independent variables and dependent variables.

model factor：

By releasing and withdrawing the questionnaires, we get the related factors need to study: expected results, expected use, human intervention, promoting conditions, educational background variables, age of technology, adoption technology intention, technology application ability. Among them, after experts discuss and brain storm again, they use the mathematical statistics method and determine the factors of BIM technology: expected results, human intervention, promoting conditions, adoption intention, the ability to apply technology and educational background variables.

(3) Factor Analysis Based on the Computer Intelligent Algorithm

Through logical functions:

$$L = In(\text{odds}) = In\left(\frac{Q}{1-Q}\right) \tag{1}$$

Deformation is：

$$L == In\left(\frac{Q}{1-Q}\right) = \alpha_0 + \alpha_1 K_1 + \alpha_2 K_2 + \cdots + \alpha_N K_N + \chi \tag{2}$$

This paper adopts the regression model to study the factors influencing computer-aided building design, that is：

$$f = \alpha K + \partial \tag{3}$$

Among them, there exist：

$$\begin{cases} H\partial = 0 \\ Var(\partial) = \beta^2 R \end{cases} \tag{4}$$

According to the practical situation, we get the cluster analysis results of factors:

Table 3. The Analysis Table

variable	RMS Standard deviation	From Seed to observation	Distinct between cluster centroids
The expected results	6605	552	5698
Promote conditions	1550	332	2145
Human intervention	2555	364	2214
Adoption intention	1251	661	2979
Using the skill levels	2561	315	6156
Record of formal schooling	2348	315	9856

According to the practical situation, we get the results by combining the charts:

$$f = -652.3 + 0.6541^{*} K_1 + 0.6891^{*} K_2 + 0.5451^{*} K_3$$
$$- 0.8541^{*} K_4 - 0.1441^{*} K_5 - 0.5241^{*} K_6$$

Step 1: checking the reliability of data α

$$\alpha = \frac{n}{n-1}\left(1 - \frac{\sum_{m=1}^{k} \beta_m^2}{\sum_{m=1}^{k} \beta_m^2 + 2\sum_{m}^{k}\sum_{j}^{k} \beta_{mj}}\right) \quad (5)$$

Among them, n is the number of variables, β_m^2 is variance of variables, β_{mj} is is covariance of variables.

Step 2: establish the basis of judging reliability and check

Through analyzing the factors that *C*ronbach's a on BIM, we get the following results:

Table 4. *C*ronbach's a **Judgments**

Cronbach's a	1-0.7	0.7-0.4	0.4-0
Credible degree	High	Medium	Low

By applying the SPSS software, we get the following results:

Table 5. *C*ronbach's a **Value**

Study variables		Cronbach's a
The independent variables	The expected results	0.8784
	Promote conditions	0.7658
	Human intervention	0.7632
	Adoption intention	0.7095
The dependent variable	Using the skill levels	0.8701
	Record of formal schooling	0.8608

From above, the value of *C*ronbach's a are above 0.7 and all are among the degree of good. Therefore, all these 6 variables meet this paper's demand for factors. Next, further discuss these 6 factors. That is through significant analysis, we get the following results:

Table 6. The Analysis Table

variable	result
The expected results	0.0010
Promote conditions	0.0005
Human intervention	0.0025
Adoption intention	0.0001
Using the skill levels	0.2225
Record of formal schooling	0.010

From above chart, on the significant level of standard 0.01, the expected results, human intervention, promoting conditions, adoption intentions, the ability to use technology and educational background variables are below 0.01. They all have significant level and the internal significance and consistence are both higher. Because the results of all factors are

above 0, we know it is a significantly positive correlation. That is the design of computer-aided engineering has proportional changes with the change of these 6 factors.

Step 3: checking the relations between factors of BIM technology

First, establish the relation coefficient between variables, details as follows:

Table 7. KMO Value Relations with Factor Analysis

KMO	<0.4	<0.6	<0.8	>=0.8
Suitability	Lower	Low	High	Higher

Then, conduct KOM sample measurement and Bartlett's Test of Sphericity, the results are as follows:

Table 8. KMO and Bartlett's Test of Sphericity

KMO		0.7869
Bartlett's Test of Sphericity	Approx.Chi-Square	1875.6573
	Df	376
	Sig	0.0000

From above chart, the value of KMO is among 0.6-0.8 that is the degree which is suitable for analysis of factors. Therefore, we can conduct factor analysis.

Step 4: factor analysis of BIM technology

According to the reliability analysis of after checking, we get the formula:

$$L\left(P_0 \middle/ W \in K\right) = \frac{1}{1+\frac{\partial}{1-\varepsilon}} = \frac{1-\varepsilon}{1-\varepsilon+\partial} \tag{6}$$

After analyzing the factor with SPSS software, we establish rotation matrix and get the results as follows:

Table 9. Rotary Table Cost Matrix

factors	The expected results	Human intervention	Promote conditions	Adoption intention	Using technical ability	Record of formal schooling
TT1	0.7895	0.9760	0.8210	0.8007	0.7765	0.7091
TT2	0.7658	0.9011	0.8921	0.7099	0.8700	0.7214
PE1	0.8905	0.7930	0.7091	0.7996	0.7690	0.8210
PE2	0.9807	0.7102	0.7609	0.9034	0.7044	0.7991
EE1	0.8790	0.7609	0.7214	0.7011	0.8009	0.7414
EE2	0.7812	0.7080	0.8210	0.7933	0.7110	0.7889
UB1	0.7632	0.7031	0.8090	0.7081	0.8009	0.7001
UB2	0.7631	0.8790	0.7012	0.8009	0.7780	0.7709

From the results in above chart, after analyzing the factors, values of 6 factors related to BIM are all above 0.7, which is within the acceptance range. Therefore, this paper discusses acceptable convergent validity and discriminate validity of 6factors, which conforms to the discussion regulation.

(3) Checking Results

Structural equation analysis model (short for SEM) uses the relation between variables and does the empirical analysis by the principle of mathematical statistics. This paper

establishes related models through SEM, checks the factors of BIM technology and properly describes the relations between variables. SEM inspection process is as follows:

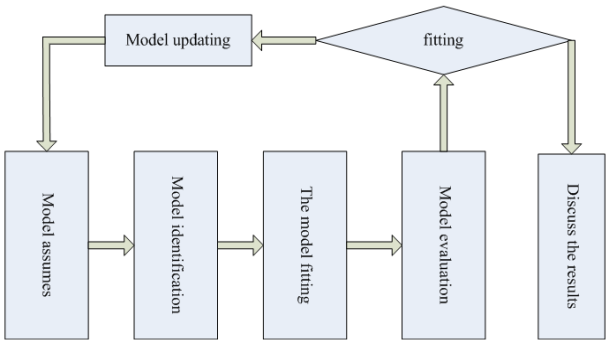

Figure 3. The SEM Flow Chart of Inspection

Through the software, we get significant test of BIM technology factor are: the expected results, human intervention, promoting conditions, adoption intentions, the ability to apply technology and educational background variables.

Table 10. BIM Technology Factors Affecting the Significance Test

Relationship between variables	Regression coefficient	Significance level
Expected results - adoption intention	0.113	***
Promote conditions - adoption intention	0.832	***
Human intervention - adoption intention	0.234	0.321
Expected results - use skills	-0.442	***
Promote conditions - use skills	0.456	***
Human intervention - use skills	0.136	***
The expected results - record of formal schooling	0.753	***
Promote conditions - record of formal schooling	0.256	***
Human intervention - record of formal schooling	0.753	***

In above chart shows the significant relation between independent variables and dependent variables. When the regression coefficient is positive, it represents positive influence; when the regression coefficient is negative, it represents the negative influence. If the significant level is less than 0.01, it shows that there exists direct relation between two variables. In above chart, when the relation between human intervention and adoption intention is weak, the relation between other variables is significantly strong. The degree of direct influence is big.

5. Conclusion

With development of economic situation, social situation and technology level, BIM technology is applied more and more widely in the construction industry and related industries any virtue of its own advantages. This paper use computer's intelligent computing tools and mathematical statistics. Through data collection and factor analysis, we get 6 related factors which influence the development of BIM technology. They are the expected results, human intervention, promoting conditions, adoption intention, the ability to apply the technology and educational background. At the same time of guaranteeing the using frequency of factors, we also test the relation degree between

factors. We get results that there are direct link with strong degree between the expected results and adoption intention, human intervention and adoption intention, the expected results and the application skills, promoting conditions and application skills, human intervention and application technology, the expected results and educational background, promoting conditions and educational background and human intervention and educational background. There are direct link with weak degree between promoting conditions and adoption intention. Therefore, the development of BIM has to give full consideration of above factors and their relation, makes right policy and makes the implementation of the plan most profitable. Based on this, I put forward suggestions as follows:

(1) Have a deep research of the internal rule of BIM technology. Deepen the cognition of the construction industry. Fill the limitations of BIM technology itself. Combine the knowledge in other aspects with the theory of this technology. Open up new areas and provide a certain reference value for the introducing and application of BIM technology in related industries.

(2) Respond to the industry policy. According to the the project management standards guided by the information of the construction industry, echo the national policy, improve the development ability of enterprises, improve the competition level and indirectly increase the work efficiency and guarantee strong development of construction industry.

(3) Make full use of computer technology. Realize the calculation and evaluation of models by using related technologies of computers. Get related feedback information of construction information. Meet data calculation and analysis function of construction industry to the maximum. Make timely and accurate adjustments and feedback on construction project. Meet the requirements of digitalization and automation in building design.

(4) BIM technology needs to take more information and technology parameters into consideration, builds one or several building information databases, utilize effective means of information through more information exchange and information communication, design more plausible and reasonable decision-making plan and realize the system research of risk control and management in BIM technology.

(5) By the principle of maximizing use of technology, it is necessary to introduce new technology and idea, reduce the input of capital and the waste of resource. Realize engineering management and application by utilizing the most favorable technology means. Do the real information communications between multiparty and comprehensive sharing of technology data. Push forward the development of whole industry and drive the realization of goals of whole industries.

(6) Make full consideration of the factors influencing BIM technology and make SWOT analysis in terms of advantages, disadvantages, opportunities and threats of present factors. Guarantee the application degree of BIM technology to the highest degree.

(7) Deal with different needs of BIM technology during different development stages. During the early stages, do well the original development project and streamline. Make efforts to open up market software. Make adjustments of the strategy goal of market. At the same time, it is necessary to manage well in human resources and realize the adjustments of target interest. During the mid period, adjust the organizational structure of companies. Make the service center of company clear. At the same time, improve the business skills and business ability of all individual practitioners. Fro now, under the lead of “intelligent earth” theory, build up “wisdom model” and apply the BIM technology into every aspect of life. Realize the development of cross-industry. Develop and grow the contact network continuously. Make full play of three wisdom forces of induction, effort and insight. Especially in the society where information multiplies, really realize the synchronous progress of energy, environment and sustainable development.

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