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Research on Construction Data Association Management of Urban Rail Transit Based on BIM

L.L. Liu, H.M. Yao, Y.M. Huang & Y.J. Song*

Hope College, Southwest Jiaotong University, Chengdu, Sichuan 610400, China

Email: yu56255@163.com

ABSTRACT: With the continuous expansion of the scale of urban rail transit construction projects, it is difficult to improve the coordination in construction and the relevance of construction data. In order to solve the problem of data association in construction, an urban rail transit construction data association management system oriented to (Building Information Modeling) BIM Technology is proposed. BIM is used to build a dynamic workflow collaboration architecture to manage the data in urban rail transit construction, so as to realize construction collaborative scheduling. In the test and analysis of the system, the comprehensive ability test of the system shows that the minimum response time of the system can be reduced to 1.2 ms. At the same time, the system has ideal visualization effect and obvious practical value in practical application. Therefore, the urban rail transit construction data association management system based on BIM can show ideal results in complex construction environment, which is of great significance to the optimization of construction management in urban development.

Key words: Rail transit, Data association, BIM, Dynamic workflow

1 INTRODUCTION

In urban construction, rail transit is the main object to judge the process and current situation of urban construction. In urban rail transit construction, the construction party needs to start with economy, environmental protection, punctuality and efficiency. In the construction, there are many kinds of rail transit projects. In the construction management, the number of different kinds of construction data is huge, and with the acceleration of urban construction rhythm, the construction difficulty is also increasing. How to carry out collaborative management of construction data and establish an associated management system to improve construction efficiency is an urgent problem to be solved (Zhang et al. 2021; Feng et al. 2020). Construction data is an important content in the construction process. The correlation management of construction data can further improve the construction efficiency. Du B et al. Proposed a new data service system, which uses data management technology to establish the association relationship between data, and verified the effectiveness of the system through experiments (Du et al. 2018). Based on the personnel safety data in construction, Shin D P and other scholars put forward relevant strategies on construction safety management to improve the construction progress (Shin et al. 2018). Dajin and Guo developed a comprehensive control and evaluation system for asphalt pavement construction quality, which cooperatively manages all construction data (Guo et al. 2009). In order to improve the efficiency of data management in construction projects, Hasan A and others analyzed the application of mobile communication technology in construction management, providing theoretical support for the work planning of construction projects (Hasan et al. 2019). Ding Z et al. put forward the dynamic model of environmental benefit evaluation based on the data information of construction waste (Ding et al. 2018). Yang j et al. proposed to use 3D visualization technology for collaborative management of data in engineering construction projects, which effectively improved the project communication level (Yang et al. 2019).

With the continuous improvement of scientific and technological level, information technology shows a trend of rapid development. The application of information technology to urban construction has become the main measure in current construction projects (Maliha et al. 2020). In information technology, in order to deal with the cumbersome nature of construction projects, BIM Technology is proposed. BIM is a three-dimensional modeling technology that integrates data for dynamic simulation and visualization. For the research and development of BIM Technology, akinade O and other scholars first determined the key factors of the application of Bim in construction waste management tools through qualitative data analysis, and the benefits of architectural design have been improved with the support of BIM Technology (Akinade et al. 2018). Wang t applied BIM Technology to railway engineering construction management to improve the synergy of construction data (Wang 2019). Abed H R and team members created a computer model in 2019 by using BIM Technology to accurately determine the risk of falling from the edge and the risk of being hit by falling objects (Abed et al. 2019). In order to improve the stability of Bim and GIS technology integration, Zhu j et al. Realized the geometric transformation from BIM to GIS through automatic polyhedron generation algorithm (Zhu et al. 2019). Meisaroh m and others analyzed the influencing factors affecting the implementation of BIM from the hospital construction and optimized the BIM architectural planning (Meisaroh et al. 2021). D heigermoser and other scholars proposed a construction management tool under BIM Technology, which divides the construction project into multiple work areas, improves the production efficiency and reduces the construction waste (Heigermoser et al. 2019).

Some studies have pointed out that BIM Technology has significant synergy in construction management. The reason is that the digital processing ability of BIM can improve the efficiency of data transmission and help the construction management find and deal with construction problems in time. Therefore, based on BIM Technology, the research will put forward the collaborative management scheme between construction data in urban rail transit construction, and mine the correlation between data, in order to ensure the process of rail transit construction and improve the efficiency of urban construction in China.

There are three innovations in the research. The first point is to propose a data association analysis strategy for the data in rail transit construction. The second point is to introduce BIM Technology to realize visualization of construction data in data association management. The third point is to use the visualization ability of BIM to build a dynamic construction data management model to achieve real-time monitoring of rail transit.

2 DESIGN OF CONSTRUCTION DATA ASSOCIATION SYSTEM BASED ON BIM TECHNOLOGY

2.1 *BIM dynamic workflow model construction*

In order to build the association management system of urban rail transit construction data, the primary task is to realize the information monitoring of construction progress. In the process of project development, the variability and uncertainty of the plan have gradually become the main characteristics of construction (Rodrigues et al. 2019; Dey and Kundu 2019). Therefore, in order to deal with the uncertainty of construction data, BIM Technology is used to process the data. However, in the construction, the construction data manually established cannot be closely combined with the BIM model, so it cannot normally reflect the work progress (Heaton et al. 2019; Vitiello et al. 2019). Therefore, in the research, a dynamic workflow model is proposed based on BIM Technology to realize the automatic operation of business process in engineering construction. In the research, Petri nets is selected as the workflow model because the Petri nets model has certain dynamics and can reflect the work dynamics in time and modification object (Hsieh et al. 2019). In the construction of urban rail transit, the construction data management process based on BIM includes the management of planning data, construction process data and construction progress data. On this basis, Petri nets is used to build an appropriate BIM dynamic workflow model, as shown in Figure 1.

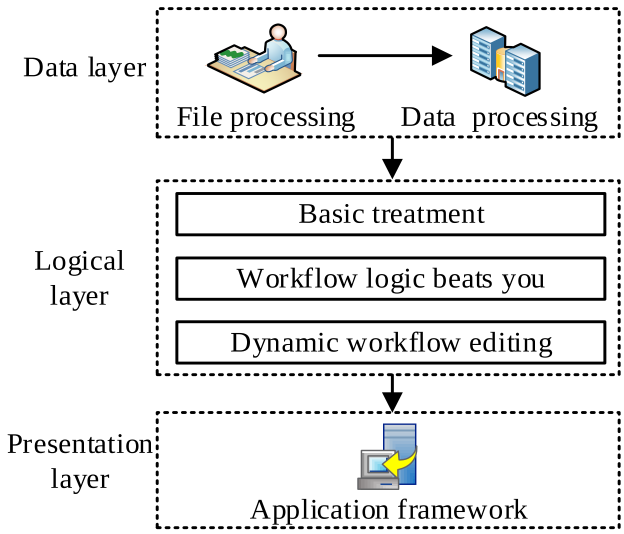

Figure 1. BIM dynamic workflow model

As shown in Figure 1, BIM dynamic workflow model includes data layer, logic layer and presentation layer. In the data layer, the received data information is processed into files. In the file processing, the business files in the construction process are divided into nodes and connection lists, and each node represents business steps. In addition, in the data layer, the received construction data is preprocessed and exported to the logic layer as the output of the data layer. The logic layer includes basic data processing, workflow logic processing and dynamic workflow editing. The basic processing is to analyze the data exported from the data layer, convert it into workflow logic in the system and run it in practice. Workflow operation is a dynamic workflow editing process, which will be activated or suspended according to the change of process parameters. When the rectification process is completed, it will enter the termination state. In the presentation layer of the model, the application model of the workflow model and the external interface are displayed. The presentation layer closely couples the system model design with itself.

In order to ensure the process order in construction and eliminate the sense of confusion caused by manual operation, the workflow is dynamically designed. There are mainly two kinds of dynamic design: one is the dynamic modification of process definition, and the other is the dynamic modification of process instance. In the dynamic modification of process definition, it is aimed at the dynamic changes in operation; Dynamic modification of process instance refers to the process modification of operation according to the change of actual state during operation. In the process modification, in order to further support user operations, it is proposed to use micro services as the core of workflow for model optimization, as shown in Figure 2.

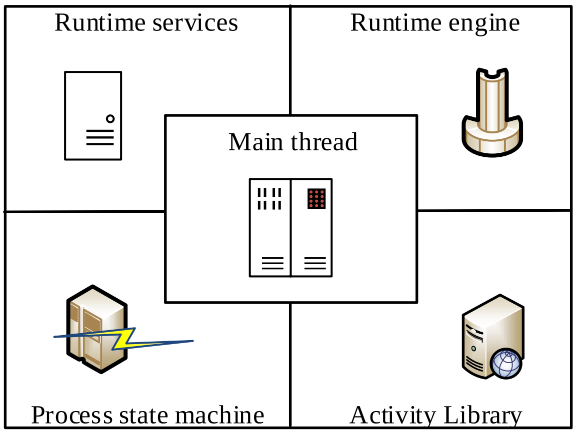

Figure 2. Micro service module in workflow model

As shown in Figure 2, the micro service module includes workflow main thread, runtime service, runtime engine, process state machine and activity library. In the main thread of workflow, all current data will be stored and run in the thread, which is a thread to ensure the independent background operation of workflow. The function of runtime service is to track the running state during the loading process of the main thread of workflow, and to mirror and save the current running state. The function of runtime engine is to execute each workflow instance, and each engine can execute multiple instances at the same time. The process state machine is the key part to ensure the normal execution. In the execution operation, the process state machine can promote the workflow to jump to execution. Compared with the traditional sequential execution, it can jump in a certain number of running states and then end at an end point. Activity library is a set of standard brick actions. Its function is to create workflow and ensure that workflow can constantly modify its own activities.

2.2 *Urban rail transit construction data association management design*

Based on the workflow of construction data management, in order to facilitate the multi-faceted cooperation between construction data, a construction data collaborative scheduling management based on BIM is proposed. Looking for data relevance in construction refers to the cooperation of construction data. During construction, with the deepening of progress, the amount of urban rail construction data information begins to increase, and the types are diverse. In the construction of urban rail transit, the construction period is long, and uncertain construction change factors will also occur. In order to realize the cooperation between construction data, BIM Technology is used to realize the cooperation of construction progress, which can help manage the efficient utilization of construction information. BIM Technology is used to manage construction data in the study, and its associated management framework is shown in Figure 3.

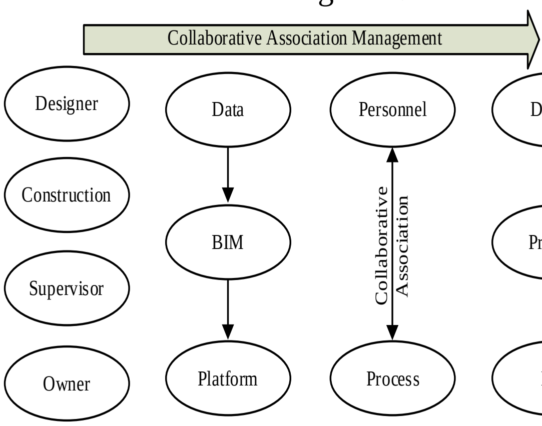

Figure 3. BIM based association management framework

As shown in Figure 3, the collaborative association management of construction data includes four parts: participants, collaborative Association platform, collaborative object and collaborative process. Participants refer to the designer, the builder, the supervisor and the owner in the construction of urban rail transit. Participants are the participants in the design stage in the whole construction process, including the design BIM model, construction scheme, etc. The main application period of the collaborative platform is the construction stage. In the construction stage, the construction data is used as the basis and input of the platform, and the BIM Technology is used to build the construction data association management platform. Collaboration object is the application object in data management. In data collaboration, construction workers will collaborate on the construction process according to different data association relationships, that is, analyze the association of construction projects, and adopt collaborative management to improve work efficiency. The important content of collaborative management is the process of collaborative association management. In the process, participants in different stages are required to discuss the construction progress, conduct comprehensive association analysis on the construction data, and judge the feasibility of association management.

After the collaborative management framework is determined, a professional coordination process for urban rail transit project construction needs to be established based on BIM Technology. BIM platform has powerful information collection ability, can accurately process a large amount of data, and can help the construction realize data simulation. In rail transit construction, BIM Technology is used to realize the association management of construction data. The main purpose is to monitor the construction progress and manage the feasibility of construction progress. The progress management under BIM platform can be designed as shown in Figure 4.

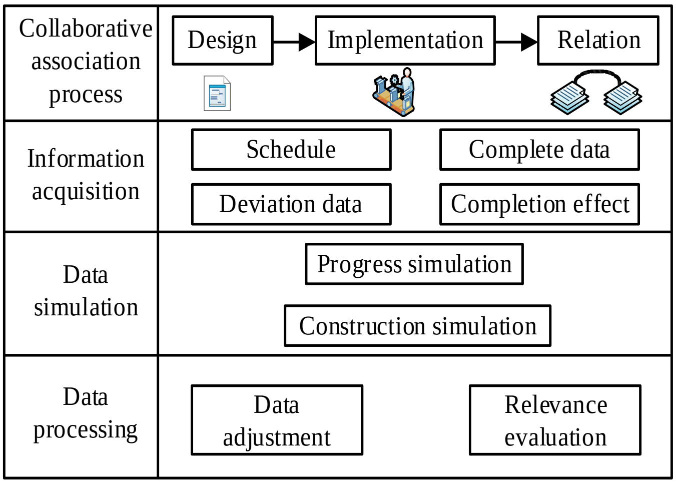

Figure 4. Progress management under BIM platform

Figure 4 shows that a relatively perfect construction data collaboration process can be formulated through collaborative scheduling management. During construction, the real-time data of construction will be collected in real time through BIM Technology. In the information collection stage, for the relevance of construction data, the BIM platform is used to obtain real-time construction data, including construction schedule data, current completion data, construction progress deviation data and construction completion effect data. In the BIM platform, the data simulation technology of the platform is used to simulate the collected construction data, evaluate the correlation between data through simulation, and use simulation to realize the correlation management between construction data. After the data simulation, the data in the simulation is processed. The main purpose is to adjust the data with deviation, ensure the normal development of construction progress, evaluate the correlation degree between the data, and formulate a more reasonable design scheme for subsequent construction.

3 TEST AND ANALYSIS OF DATA ASSOCIATION MANAGEMENT SYSTEM

3.1 *System basic performance evaluation*

After the design of collaborative association management system, its basic performance is evaluated to analyze the feasibility of the system. The simulation analysis of urban rail transit construction data association management is carried out. Firstly, the BIM model of rail transit data management is established, and the BIM model is imported into the simulation software to build a simulation environment based on the construction of a city's rail transit. Firstly, the collaborative processing capability is analyzed in detail. The processing capability of the system is the response capability of the system in data processing. The response time can be analyzed by analyzing the processing time of the model, including calculating the time from input to output and the time from output to feedback of the model in processing traffic data. In the research, the response capability is evaluated by analyzing the response time of the system, as shown in Figure 5.

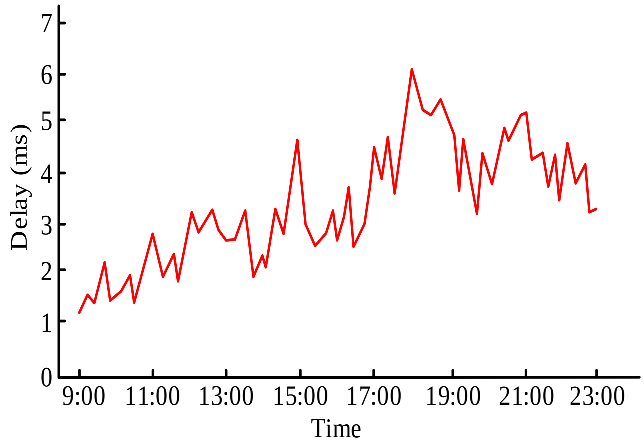

Figure 5. Response time analysis of data association management system

As can be seen from Figure 5, in the construction simulation, the data processing starts at 9 a.m. and ends at 11 p.m. during this period, the response time of the system continues to change. As shown in Figure 5, the response time of the system is only 1.2ms at 9 a.m. because there is less data at this time point and the system needs to process less data, so the system can achieve faster response. The longest response time of the system occurs at 6 pm, and the response time at this time is 6.1ms. The reason is that the system needs to process the construction data of a whole day and carry out association management. However, it can also be seen that at the time point with more data, the response time of the system is only 6.1ms, indicating that the system as a whole has a fast response speed. Secondly, the ability of association management system in data acquisition is analyzed, as shown in Figure 6.

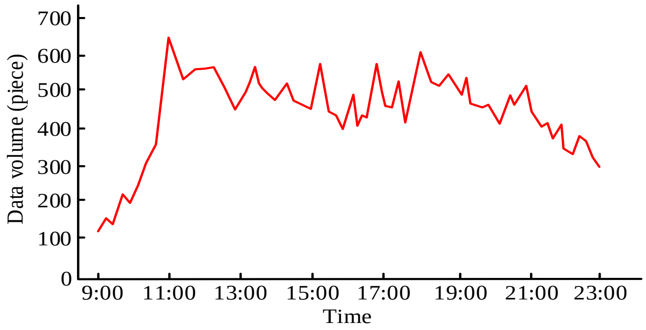

Figure 6. Analysis of data collection ability of data association management system

As can be seen from Figure 6, the data association management system based on BIM Technology can maintain the all-weather data collection state. From the data acquisition effect of the system, the amount of data acquisition of the system in the simulated environment gradually increases from 9 a.m. to 11 a.m. From 11 a.m., in the simulation environment, the data acquisition of the system continues to maintain a high amount of data, and after 20 a.m., the data acquisition amount gradually decreases. The above results show that in the face of the construction simulation environment, the data association management system can be in the state of high data collection for a long time. At the same time, combined with the response time of the system, it can be known that the file analysis ability of the data association system is good, and the huge amount of data can be analyzed quickly, which is convenient for the management of data association. Secondly, analyze the sensitivity and specificity of the system in the application process to evaluate the system's ability to process data, as shown in Figure 7.

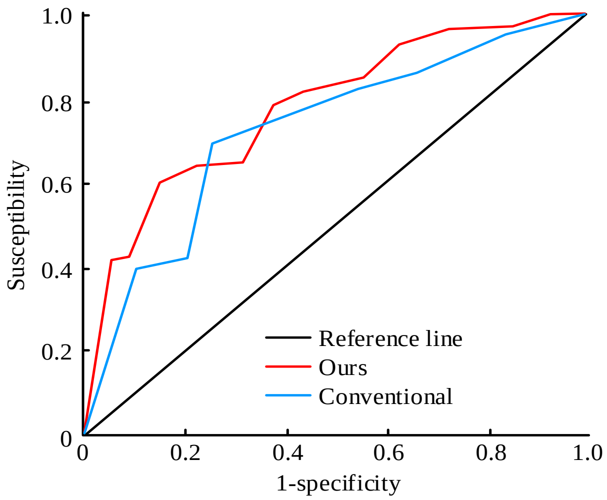

Figure 7. Sensitivity and specificity test

It can be seen from Fig. 7 that the system proposed in the study has a larger area under the curve than the traditional management system, and the system proposed in the surface study has higher sensitivity and specificity than the traditional data management system.

3.2 *System visualization*

The visualization of data association management system mainly includes construction data visualization and construction process visualization. Similarly, the performance test is carried out in the simulated construction environment set in the simulation environment. Taking the first day of simulation as an example, the construction data visualization of the system is shown in Figure 7.

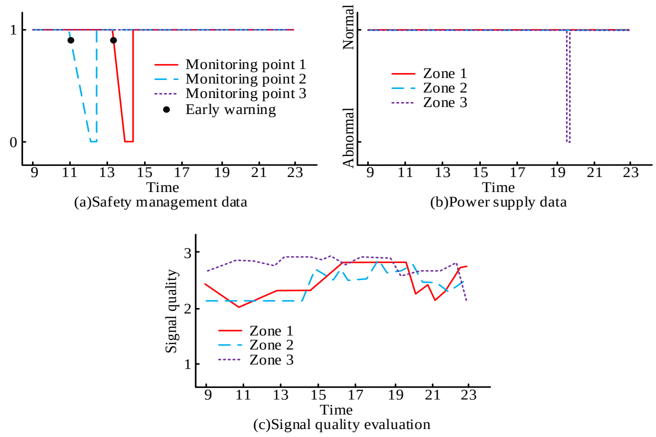

Figure 7. Visualization effect display of construction data

As can be seen from Figure 7, in the visualization after construction data collection, the associated system can fully display the four main construction data in the rail transit construction data: safety management data, power supply data and communication data. For safety management data, the association management system analyzes the potential safety hazards in construction by collecting the data changes of monitoring points during construction, and can analyze the data association relationship between monitoring points with the help of the correlation between data. The associated management system can analyze the safety of safety management data in real time, with 1 representing safety and 0 representing danger, and can give early warning when the data tends to 0 to remind construction managers to pay attention to the safety status of monitoring points. In the visualization of association management, the power supply status of different areas is displayed, which can clearly show the normal or abnormal power supply status of different areas. In the visual display of communication data, the display system can clearly display the signal quality of different construction areas. 1 indicates that the signal is poor and 3 indicates that the signal is good. The signal quality in different areas can be visualized in the system. Secondly, the visualization effect of construction process is analyzed, as shown in Figure 8.

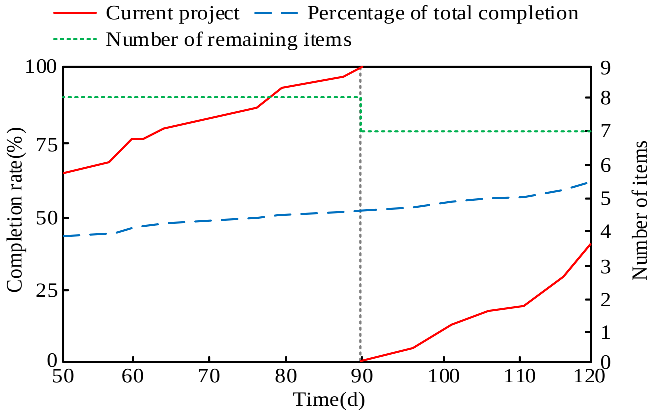

Figure 8. Visualization effect display of construction process data

It can be seen from figure 8 that in the visual display of the construction process of the system, the construction completion percentage, the current project completion percentage and the number of uncompleted projects are mainly displayed. As can be seen from the visualization results of the construction process, when the completion rate of the current project reaches 100%, the system will start to display the completion percentage of the next project, and will calculate from 0, and the number of uncompleted projects will be reduced by 1 accordingly. The above results show that the data association system can carry out collaborative management of data between different regions and different monitoring points, analyze the relevance of data, and carry out more effective association management for construction process data.

3.3 *System application effect*

After the performance test of the construction data association management system, it is confirmed that the system has relatively high response ability, can carry out data collection and association analysis for a long time, and can carry out association management on multiple data in the visual display of the system, and display the data in a visual way to help the construction managers improve the management efficiency. On this basis, the system is applied to the rail transit under construction in a city. The test time is 3 months to analyze the effectiveness of the system in construction management. First, analyze the data collection capability of the data association management system in use, as shown in Figure 9.

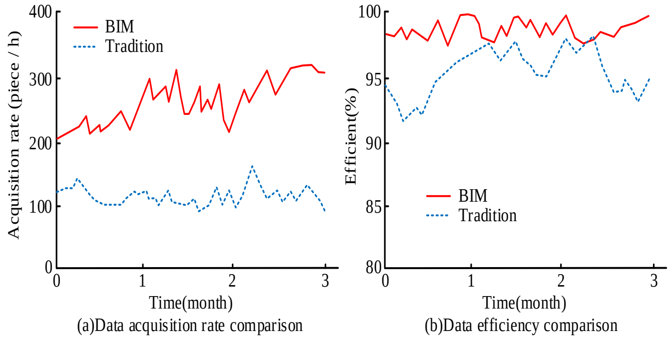

Figure 9. Comparison results of data acquisition capability

As can be seen from Figure 9, the data acquisition capability of the system is analyzed by comparing and analyzing the data acquisition rate and efficiency. Figure 9 (a) shows the comparative analysis results of the data acquisition rate of the association management system based on BIM Technology and the data acquisition rate of the traditional system. The results show that the data acquisition rate of the association management system based on BIM Technology has better effect at different time stages, and is significantly higher than the data acquisition rate of the traditional system. Figure 9 (b) shows the efficiency comparison of the construction data collected by the system during construction. It can be seen that in the three-month construction process, the efficiency of the construction data collected by the associated management system based on BIM Technology can reach 99.7% at the highest and 97.4% at the lowest point, which is significantly higher than the traditional data management system. Finally, evaluate the data relevance and the change of construction cost in the construction data association management, and analyze the correlation between them, as shown in Figure 10.

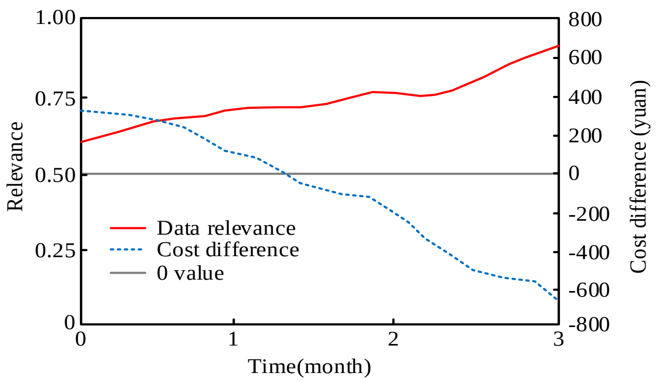

Figure 10. Data association and cost change

As can be seen from Figure 10, in the association management analysis, with the development of construction, the correlation analysis between data is deepened, showing that the stronger the data correlation is. It can be seen that with the progress of construction, the difference between the cost and expected cost in the construction project presents a negative value, indicating that the cost is reduced with the support of the associated management system based on BIM Technology. At the same time, from the changes of data association management and construction cost, it can be found that the deeper the data association analysis, the stronger the data association, and the more obvious the reduction of construction cost.

4 CONCLUSION

With the accelerated pace of urban construction, urban ground transportation problems become more and more obvious. Therefore, accelerating the construction of urban rail transit is of great significance to resolve the pressure of urban traffic. Based on BIM Technology, the research carries out construction management by analyzing the data correlation in rail transit construction. In order to improve the execution ability of data acquisition and processing, the workflow model is introduced to process the construction process. Finally, the scientificity of the system is analyzed through simulation experiment and the feasibility of the system is analyzed through application demonstration. The results show that the system can process a large amount of data, and the response time is short, with strong file parsing ability. In addition, in the visual display of the system, the display effect of construction data and construction process data is good, which can intuitively display all data in the construction clearly and improve the work efficiency of managers. In the application, the efficiency of data collection in the construction of the data association management system is significantly higher than that of the traditional data collection system, with the highest efficiency of 99.7%, and the construction cost under the association management has been reduced to a certain extent. The above results show that the association management system based on BIM Technology can realize construction data management and show the correlation between data. In urban rail transit construction, it can improve the synergy between construction projects and improve construction efficiency.

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