Some aspects of intelligent decision support systems in construction

Victor Evstratov

Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
E-mail: evstratovvs@mgsu.ru

Abstract. The article provides a brief overview of the historical development of decision support systems (DSS). Their application in construction is substantiated. The universal architecture for a decision support system in construction with an example of a checklist for its verification is proposed. The model of the system for IDSS on the resumption of monolithic construction is proposed.

1. Introduction

Progress in the field of management in construction does not stand still, the organization of construction in the process of transition to "intelligent construction" using various information systems [1,2,4 - 11].

It should be noted that the amount of information on which the modern organization of the construction process is based is constantly growing. To analyze all the necessary data and make an effective and timely management decision, human resources alone are no longer enough.

To assist in making certain decisions made various support systems that help structure the volume of information and analyze Big data.

2. Overview

In the scientific literature, there are several definitions of intelligent decision support systems (IDSS). For example, one of the definitions of IDMS is a computer system that, by collecting and analyzing a large amount of information, can influence the decision-making process of an organizational plan [3].

In general terms, a modern IDSS can be represented as a system that helps decision makers (DM) in making decisions using data mining, machine learning, modeling and visualization toolkits, which has a friendly interface, stable data quality, interactive and flexible software settings.

The first DSS grew out of SPT (Transaction Processing Systems) in the mid 60s - early 70s. At that time, these systems did not have interactivity, being, in fact, superstructures over a DBMS, with some functionality of numerical modeling. One of the first such systems can be called DYNAMO, developed at MIT and was a process simulation system based on historical transactions.
Since the early 80s, we can already talk about the formation of subclasses of DSS, such as MIS (Management Information System), EIS (Executive Information System), GDSS (Group Decision Support Systems), ODSS (Organization Decision Support Systems).

In fact, these systems were frameworks capable of working with data at various levels of the hierarchy (from individual to corporate), and any logic could be introduced into the system for use. An example is the Gate Assignment Display System (GADS) developed by Texas Instruments for United Airlines.

In the late 1980s, the ADP (Advanced) appeared, which allowed for what-if analysis and used more advanced modeling tools.

Finally, since the mid-90s, IDMSs began to appear, based on tools of statistics and machine learning, game theory, information modeling, etc.

At the moment, there are several ways to classify DSS, the most popular are presented in table 1.

Table 1. The classification of DSS

| By application areas | By data / model ratio (Stephen Alter method) | By type of toolkit used |
|----------------------|---------------------------------------------|------------------------|
| • Business and management (pricing, labor, products, strategy) | • FDS - File Drawer Systems | • Model Driven |
| • Engineering (product design, quality control) | • DAS - Data Analysis Systems | • Data Driven |
| • Finance (lending and loans) | • AIS - Analysis Information Systems | • Communication Driven |
| • Medicine (medicines, treatments, diagnostics) | • AFM(s) - Accounting & Financial models (systems) | • Document Driven |
| | • RM(s) - Representation models (systems) | • Knowledge Driven |
| | • OM(s) - Optimization models (systems) | | |
| | • SM(s) - Suggestion models (systems) | | |

The need for IDSS in construction industry can be confirmed by at least 4 requirements presented in figure 1.
Figure 1. Necessity IDSS in construction industry

Based on these requirements, it is possible to simulate a certain unified architecture consisting of 4 layers at the top level. Presented on figure 2.

Figure 2. Unified IDSS architecture
Further, in these layers, you can add the tools necessary for the system, shown in table 2.

### Table 2. IDSS toolkit

| Layer               | Functional                        | Tools                                      |
|---------------------|-----------------------------------|--------------------------------------------|
| Interface           | Interactivity                     | Mobile app, desktop app, web-portal        |
|                     | Visualization                     | Flask, Power BI, Tableau, QlickView        |
| Modeling            | Statistical models and machine learning | Python, R, Jupyter, Matlab, Spark, SPSS, SAS, STATISTICA |
|                     | Numerical models                  |                                            |
|                     | Game Theory Models                |                                            |
| Data mining         | Organization of data flow         | Spark, MongoDB, Oracle, SAP, SAS, MySQL, Redis, Alteryx |
|                     | Working with DataBases            |                                            |
|                     | Expert opinions                   |                                            |
| Data collection     | Web-crawling                      | Python, IBM Watson, Azure Data Lake, Amazon Web Services S3, Hadoop |
|                     | Sensors                           |                                            |
|                     | API                               |                                            |

IDSS can be assessed using a multi-criteria checklist, which can be anything and depend on a specific task. Table 3 is shown as an example.

### Table 3. The example of a multi-criteria checklist.

|   |   |   |
|---|---|---|
|1. System |   |   |
| a) Response time | ms | <1000 |
| b) Data handling | Tb | Good |
| c) Quality output | - | Good |
| d) Human-machine interface quality | - | Good |
| e) Resource efficiency | % | 50% |

|   |   |   |
|---|---|---|
|2. Task |   |   |
| a) Time to make decisions | hours | 1 hour |
| b) Completeness of alternatives in analysis | % | 90% |
| c) Errors of the first and second kind | pts | 0 errors |

|   |   |   |
|---|---|---|
|3. Evolution |   |   |
| a) Flexibility | Yes or No | Yes |
| b) Scalability | Yes or No | Yes |
| c) Possibility of quick changes | Yes or No | Yes |

|   |   |   |
|---|---|---|
|4. Business model |   |   |
| a) Development cost | ₽ | 10000 ₽ |
| b) Monetary effect | % value | 10% |
| c) Non-monetary effect | % value | 20% |
| d) Alternative cost | ₽ | 100000 ₽ |

When designing IDSS, it is necessary to adhere to the following steps (fig. 3).
3. System for making a decision to resume monolithic construction process

To make a decision to resume monolithic construction, it is necessary to analyze many factors affecting the cost of work, such as the territorial location of the object; technological complexity of the facility; the level of construction mechanization; level of elaboration of documentation; the level of use of labor resources; share of completed work; technical condition of the structure.

The cost of performing monolithic works can be taken as the main criterion of efficiency in choosing a rational decision, as a generalizing indicator that includes all the most influencing factors.
In this case, the multivariate regression model can look like this:

\[ S_0 = S_1 - x_1*A + x_2*N + x_3*C + x_4*I + x_5*W - x_6*M + x_7*E + x_8*P - x_9*B - x_{10}*T + x_{11}*F, \]

where \( S_0 \) is the cost of work, taking into account the most significant factors, and \( S_1 \) is the cost works on the planned estimate; \( x_1 \ldots x_{11} \) - indicators of the most significant factors; 

\( A \) - share of completed work, 
\( N \) - number of floors in a structure, 
\( C \) - special design solutions, 
\( I \) - degree of construction site constraint, 
\( W \) - influence of weather conditions, 
\( M \) - level of mechanization of construction processes, 
\( E \) - labor supply, 
\( P \) - degree of specialization of construction processes, 
\( B \) - availability of design documentation, including BIM-models, 
\( T \) - technical condition of the structure, 
\( F \) - complete set of formwork systems.

If \( S_0 \) as a result has a negative value, then it is not economically feasible to resume construction.

Thus, a specially prepared IDSS should have the following functional:

- Support for statistical models and machine learning.
- Organization of data flow.
- Visual representation.

Based on the required functionality, IDSS can be divided into 3 layers:

1. Interface, visualization - Power BI.
2. Statistical models and machine learning - Python.
3. Data collection and analysis, data flow organization - Hadoop.

4. Conclusion

- To ensure the necessary degree of reliability of the calculated results is necessary to make data collection and analysis activities of building contractors in the developing of objects of monolithic construction.
- Comparison of the cost of resuming work of an unfinished monolithic object, taking into account its technical condition with the cost of building a new object, allows accept a rational decision.

Reference

[1] Chelyshkov, P.D. Distributed Modeling of Building Systems through Cyber-Physical Integration. Promyshlennoe i grazhdanskoie stroitel'stvo [Industrial and Civil Engineering], 2019, no. 9, pp. 12-17. (In Russian).

[2] Khripko, T.V. Effectiveness of Life Cycle Management of Projects Using Information Modeling. Promyshlennoe i grazhdanskoie stroitel'stvo [Industrial and Civil Engineering], 2019, no. 9, pp. 24-29. (In Russian).

[3] Dvoeglazova, A.V., Timoshenko, A.V. Decision support systems. Algorithms and variants of the DSS architecture. // Innovative information technologies. - 2013. - Volume: 4. - No. 2. - pp. 69-76. (In Russian).

[4] Rymarov, A.G. Synthesis and Analysis of Design Solutions for Formation and Microclimate Control in Building Information Modeling Systems. Promyshlennoe i grazhdanskoie stroitel'stvo [Industrial and Civil Engineering], 2018, no. 9, pp. 28-34. (In Russian).

[5] Knyazeva, N.V. Integration of Information Centers of Maintenance Services with Information Model of a Building. Promyshlennoe i grazhdanskoie stroitel'stvo [Industrial and Civil Engineering], 2018, no. 9, pp. 68-72. (In Russian).
Abdel-Basset, M., Gamal, A., Chakrabortty, R.K., Ryan, M. A new hybrid multi-criteria decision-making approach for location selection of sustainable offshore wind energy stations: A case study (2021) Journal of Cleaner Production, 280, № 124462.

Saba, D., Sahli, Y., Hadidi, A. The role of artificial intelligence in company’s decision making (2021) Studies in Computational Intelligence, 911, pp. 287-314.

Naumova, O.A., Tyugin, M.A. Information and Analytical Support for Enterprise Business Management (2021) Lecture Notes in Networks and Systems, 133, pp. 295-303.

Zakirova, A., Klychova, G., Mukhamedzyanov, K., Zakirov, Z., Nigmatzyanov, A., Yusupova, A. Information and analytical system of strategic management of activities of enterprises (2021) Advances in Intelligent Systems and Computing, 1258 AISC, pp. 687-707.

Sharokhina, S.V., Shevchenko, T.A. System Approach to the Control Organization of Management Decisions (2021) Lecture Notes in Networks and Systems, 133, pp. 763-770.

Karakozova I.V., Malykha G.G., Pavlov A.S., Panin A.S., Tesler N.D. Study of preparatory activities on using BIM-technologies in the medical enterprise design. Vestnik MGSU [Monthly Journal on Construction and Architecture]. 2020; 15(1):100-111.