A REVIEW OF BIM AND FACILITY MANAGEMENT SYSTEMS

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Abstract
The article presents the Building Information Modelling (BIM) and their data collection capabilities. We introduce what parameters can be measured. We compare the control card, remote I/O, PLC, DCS and SCADA control and process control systems to see which is worth using in a building information system. The research examines the measurement system's ability to pre-process data that will help relieve the burden on the expert system. Currently available BIM systems can be optimized and developed using various mathematical models. The use of process control systems can perform not only measurement and data processing, but also logging and alarm management processes.

Keywords: *BIM, facility management, operating parameters, maintenance*

1. Introduction

Technical drawings were first used in the construction of buildings in the late 18th century. You could have several questions and problems when trying to use technical drawings. The edits were not accurate, the cost estimate was inadequate, and the data records were not of adequate quality. Due to the problems mentioned above, various developments have been applied in the construction industry. Larger facilities have emerged that are difficult or impossible to solve at all. In parallel with the development of computer science, in the construction industry also appeared various design softwares that were able to provide answers to the problems. However, more and more demands have emerged in the operation of buildings, so a model has been developed that provides an answer to the problems and a solution to the needs shown in Fig. 1.

This is how BIM (Building Information Modeling) was introduced to the millennium in the late 20th century, which was brought to the public consciousness by Autodesk in 2002. The BIM model is used to manage, administer, analyze, maintain, and optimize facilities. BIM is a facility management system that is a comprehensive digital design and optimization model already used in the design phase of a facility. It helps to analyze our building and understand how it works, and it also comes with a 3D document that is fitted to the model in real-time using camera footage. It is important to mention that such a model is used not only for new facilities but also for previously built buildings (Ma, 2022).

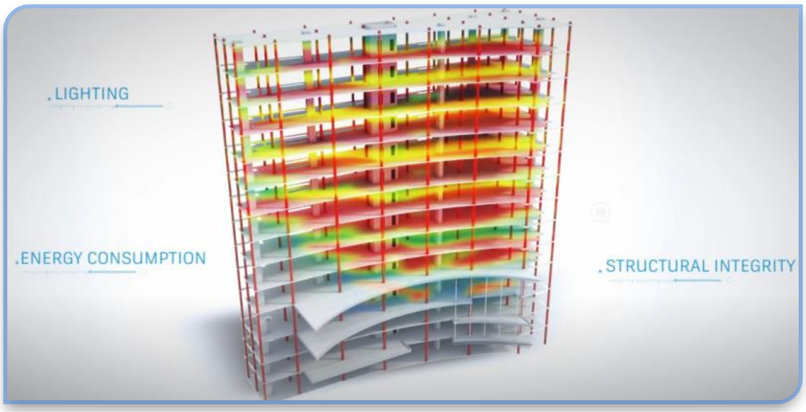

Figure 1. *BIM*

Figure 2. *The benefits of BIM*

Fig. 2. shows the benefits of a generic BIM model. The improvements outlined in the article will have an impact on these benefits. The figure shows better, greater cost predictability of 72%. This appears as well as when planning the operation of the building and the investment. The model improves the schedule by up to 85%. Less chances of error due to quality data storage. It optimizes the design by more than 90%, which is a significant result. And finally, we can understand almost 100% how our facility works (Ma, 2022).

The model may include FM (Facility Management), which plays an important role in the operation of the building. It helps to map the services needed for the building, such as IT systems, human resources and maintenance. FM helps determine signals from the control system during operation and identify its physical location (Iushkin et al., 2022).

BIM systems are used in many areas around the world. Most common: in stadiums, skyscrapers, hospitals, military facilities, and larger industrial facilities. The article presents development opportunities that are used in other fields of science and their use helps to optimize maintenance, assign new features to the model, and provide a solution to the challenges of the 21st century (Zhang and Hu, 2011).

2. Instrumentation in Facility Management

BIM instrumentation begins during the construction phase. Measurements of two different measurement groups are also required. The imaging and space IT techniques create a 3D model of the facility. This helps in quality record keeping of data and efficient cost estimation of investments.

Instrumentation helps to understand the behavior of the building, reveals its weak points and helps to optimize maintenance and energy use (operational, regulatory). The signals can be divided into two different groups: output and input signals. Within this, we can also distinguish between digital and analog signals. Physical quantities can be temperature, pressure, level, flow (mass flow, volume flow), vibration, operating time (planned, actual), two - state signals, water analysis and energy consumption (for operation or for control).

It is important to mention that instrumentation is important not only for operational purposes but also for fault prediction. We can also instrument various devices, such as: air conditioning, ventilation system, heating system and energy consumption. Predicting the failure of a device is important for operation so that we can determine in advance how likely it is that the equipment will fail soon. This avoids unexpected maintenance, a chain of failures and reduced energy consumption.

However, to predict a failure, we need not only measurements, but also the construction of the measurement system. In an intelligent measurement system, we can also run algorithms that can predict failure with high accuracy using different mathematical models. Examples of such mathematical models are finite-state automat and fuzzy logic.

3. Testing for control systems

It conducts research on control systems that can be used in the operation of a facility. Since hundreds of measurements are used in such a system, we have extended our study to more complex devices and systems. The devices examined in this article are PLC (Programmable Logic Controller), SCADA (Supervisory Control and Data Acquisition), remote I / O, card controllers, and DCS (Distributed Control System) systems. Programmability is an important aspect, so automated processes can be integrated into the operation (Ajtonyi and Gyuricza, 2002). A good measurement system can preprocess the measured data and convert it into appropriate data, even for an expert system. The test criteria are listed in the first column of Table I. We chose these test aspects because these properties are necessary for the further development of the BIM and within the FM model. Therefore, the control system must have these properties to be able to see the specific tasks.

In Table I., we can see that remote I / O does not meet many of the test criteria. Remote I / O is used to collect the most remote signals to reduce cabling costs. It does not satisfy the test criteria on its own, but by integrating it into the PLC, SCADA and DCS system, it can significantly reduce installation costs. The PLC is suitable for all aspects, except for the monitoring option, but we can also integrate the PLC system into SCADA and DCS systems. This will also enable the monitoring and data verification function. SCADA is a software that runs on a computer. It cannot function as a system on its own and does not know the properties mentioned above. It can perform these functions by fitting a PLC. One of the best options for scalability is that it can work with multiple PLCs. DCS systems meet all aspects although they are primarily used in the process industry. The operation of the DCS system requires a great deal of professional knowledge. The DCS system is the most expensive in terms of both hardware and software. In many ways, card controllers are only partially suitable and not as reliable as PLCs. From a communication point of view, it requires a lot of expansion hardware, and each new function is provided by a new software component, so its application is time-consuming and even more expensive after a certain number of expansions.

Table I. *Comparison of control systems*

Criteria for comparison	Remote I/O	PLC	SCADA	DCS	Card Controller
Programmability	-	+	+	+	+
Standardized operation	+	+	+	+	partially
Supervisory control	-	-	+	+	-
Expandability	+	+	+	+	partially
Suitable for control	-	+	+	+	+
Suitable for regulation	-	+	+	+	+
Analog signal management	+	+	+	+	+
Digital signal management	+	+	+	+	+

A proper control system has not only control properties but also the properties of a measurement system. These include processing data, converting it to the appropriate format, running algorithms, and communicating with the expert system. Pre-processing and processing of measurements are important for the proper display of data, however, using algorithms using different mathematical models also provides an additional opportunity. Data processing helps to relieve the expert system so that an optimized operation can be achieved. The measured signals can be analog and digital. The analog signals can be: 0-20mA, 4-20mA, 0-10V. Converting these signals to a suitable format, as well as processing data from different bus systems, will also help relieve the expert system. Control systems can be used not only for control but also for regulation. It can also be controlled, for example, with the PID. Intelligent control systems may suggest PID tuning. This can reduce significant operating and control energy. An important feature of the control is the quality and the speed of the control, which eliminates the effect of the disturbance signal on the control circuit as soon as possible.

The structure of the control circuit is shown in Fig. 3. The function of the items shown in the figure is as follows (Piller and Kovács, 2019; Ajtonyi and Gyuricza, 2002; D'Amico et al., 2022):

- The X_a setpoint is a signal that represents the setpoint and is clearly suitable for difference formation, the target value of the control.
- X_r is the error signal set by the difference generator.
- The task of the "PID Control" is to generate the intervention signal X_b from the error signal X_r using a control algorithm (P, PI, PID,…).
- "Actuators" generate the modified characteristic X_m for an actuator (valve, radiator, motor,…) from the actuator signal X_b
- "Process" is the process to be controlled, the controlled parameters of which, the value of X_{sz}, is controlled by X_m according to the value of X_a.
- The "Sensor" continuously measures the X_{sz} regulated parameters.
- X_z is a disturbing signal for the section.

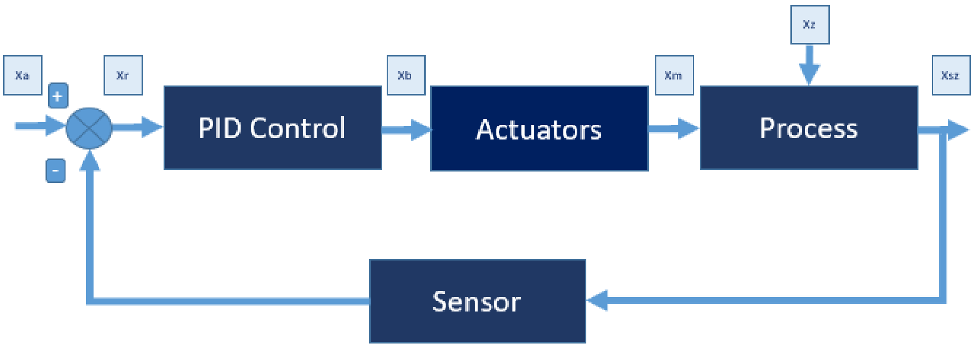

Figure 3. *Block diagram of a control*

4. Mathematical Models and Applications

Mathematical applications are useful not only in data preprocessing but also in control. A failure prediction can also be achieved with different mathematical models. Such models include fuzzy logic and finite automat.

Fig. 4 shows a state graph of a finite automat. The graph describes the states of a unit participating in an operation, as well as the state that the unit may be in. To use a finite automat, we need measurements and logging processes. The mathematical model helps to track the life of the unit and optimize maintenance processes. The model can be further developed with different mathematical models to help predict the state of the unit, such as fuzzy logic.

Digital signals make decisions difficult, and it is not clear what state the unit will be in, as the set of values for digital signals is zero and one. Therefore, fuzzy logic helps to handle values between 0 and 1, such as 0.2. Fuzzy logic is also used in situations where the processes cannot be described without great mathematical effort or at all. If you have a description of the task in an ordinary language, the logic of the blurred sets will help. The assignment functions are fuzzy functions. An example of this is the fuzzy function of the fuzzy set describing the human age. It consists of several roof-shaped triangles of different ages. Each triangle covers a few years of human life. A forty-five-year-old would thus have the following characteristics: still young at 0.75, (this is still relatively much), middle-aged 0.25 (a little), and other characteristics at 0, so not at all. In other words, a forty-five-year-old is still quite young and a little middle-aged, but not old at all, not very young at all. From this example, the graph of the finite automat describes the states and what state my given unit can be in. From the statistical data, which can be the data of logging processes, and from the measured data, you can make it probable what state my examined unit will be in. This procedure can also run in an expert system as an algorithm. In this case, the control system provides the parameters of the so-called membership functions with processed data. The task of the expert system, so only the running of the algorithm and the communication of the result, largely reduces the workload. As a result, the expert system has several uses, but the development is optimized because the workload increases slightly. It is worth examining whether such mathematical applications can be seen by the control system as well. Because if so, the usefulness of control systems will play a greater role in the operation of the facility (Takagi and Sugeno, 1993).

Stochastic Markov models and their most common failures consist of probability distribution functions such as Artificial Intelligence algorithms that determine Weibull, exponential, and normal-distribution parameters. The analytical algorithms of the system will estimate parameters such as the probability R (t) of individual machine components and the functionality for the entire facility, the probability of failure F (t), the failure density f (t), the failure rate λ (t), and the life expectancy (Xue and Hou, 2022).

The self-learning artificial intelligence algorithms to be modeled in industrial research are based on observer algorithms that can determine the parameters of the fault distribution function for a given mechanical unit based on real failure and maintenance records and estimate the expected time of the next failure. To create an optimal maintenance schedule, the total cost of the troubleshooting must be considered, i.e., the cost of the faulty equipment and/or the expected cost of rectifying the fault, as well as the monetary amount of the damage caused by the outage. The system will calculate for each piece of equipment the estimated probability of failure up to its scheduled maintenance date and the expected multiplication of troubleshooting costs to provide the complex risk analysis to the operator. With this procedure, the error prediction, i.e., maintenance, can be further optimized. The combined application of several mathematical models and applications results in quality-controlled control (Katsuhiko, 1997).

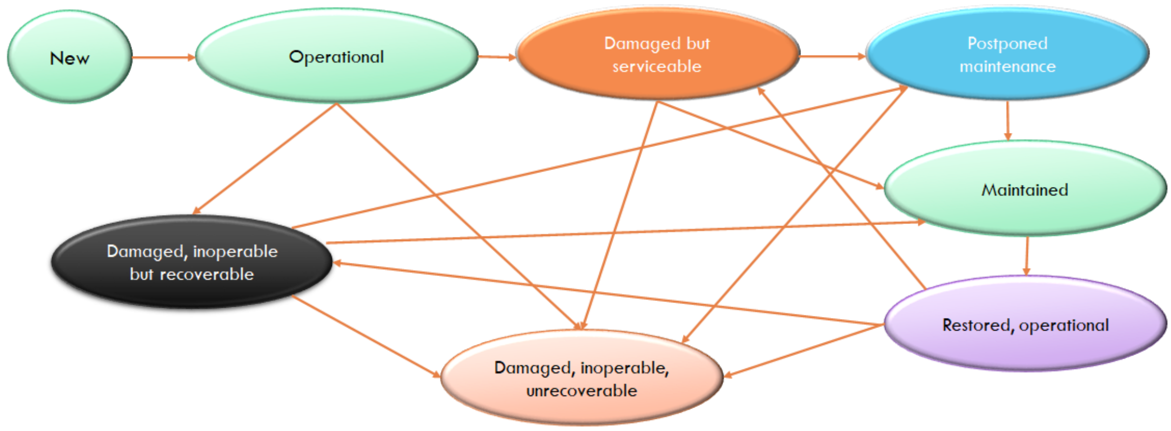

Figure 4. *Finite automat model*

5. Logging and Alarm Management

One of the development options for facility operation could be logging and alarm management for the processes. Processes used in the industry make production automation and the process industry more transparent and secure.

The logging process allows us to sample the measurement channels used in the system and store the data. With this, for example, if the ventilation system fails, it is possible to trace back from the saved data whether the occurrence of the error was visible from the measurements and, if so, what procedure we can take to prevent this in the future. Not only saving measurement data is the primary consideration in logging. So-called user management is also an integral part of logging processes. UM (User Management) allows you to create user accounts and groups, which can grant different user rights and functions. In this way, we can prevent a foreseeable and unforeseeable problem that would be caused by an unskilled user without knowledge. With the right education and training, users can be given more and more power. In addition, managing users allows as to be logged by the control system if you have made changes to the system.

The alarm function is used in many areas of the industry:

- Alarm: An audible and/or visual indication that informs the operator of a malfunction of the controlled equipment, a deviation from the normal operating range of the process, or an abnormal condition that requires operator intervention within a specified time.
- Alert: audible and/or a visible indication to the operator of the status of the equipment or process that requires operator evaluation but not an immediate operator intervention.
- Message: provides information to the operator about the normal operation and does not require operator action.
- Event: Automatic logging of discrete system or process variables.

By using them, we can immediately detect a malfunction and alert staff to the problem. These procedures can be further improved by not only displaying an indication on the display surface, but also automatically sending an email and/or SMS to staff about the error. This can shorten the time it takes for information to flow to people who are not directly in the control room. For optimization and effective troubleshooting, it may be worthwhile to fit a situational awareness system into the process that allows maintenance personnel to know exactly where the faulty unit or system is located. It is also important to record a database that contains the maintenance performed and planned, the parts list. This can also reduce the time it takes to resolve the error. Control systems that have web server support can perform such processes and not only display signals in the control room (Takashi et al., 2017).

6. Conclusion

We explored the application and application areas of BIM and FM. We can measure many physical quantities in the instrumentation, but we can also use measurements that provide useful information for the operation of the building. The result of testing the right controller is that the PLC and SCADA are the most cost-effective and feature-rich systems. Control systems can be used not only for measurements but also for data processing, logging processes, alarm management, user management, control, fault prediction and running algorithms. These features help optimize maintenance, make operations transparent, help optimize investment, optimize human resources, and reduce energy use (operational and regulatory).

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