STRUCTURAL MODELS OF DIGITAL TWINS OF RURAL ELECTRIC NETWORKS

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In the development of modern industries and technologies, digital twins hold great significance, as they are used to create, analyze, and optimize virtual models of systems and processes. Digital twins enable the collection, analysis, and simulation of real-time data. This, in turn, serves to improve efficiency, reduce costs, and ensure safety across numerous fields, including manufacturing, transportation, urban planning, healthcare, and energy.

In the energy sector, digital twins have emerged as a crucial technology to enhance the efficiency and reliability of power supply systems. The use of digital twins in electric networks is highly effective for addressing issues such as energy losses, preventing failures, and ensuring the uninterrupted operation of systems.

Digital twins are virtual models of systems or processes designed to simulate, understand, and predict the characteristics of their physical counterparts in real time. Digital twins are widely applied today in manufacturing (to optimize production lines), urban planning (to simulate urban systems and traffic flows), healthcare (for personalized medicine and equipment monitoring), and automotive (to design vehicles and predict maintenance needs).

Digital twins operate by combining various technologies such as artificial intelligence (AI), machine learning, and data analysis to create dynamic and interactive models of physical assets or systems.

Figure 1. Main Types of Digital Twins

Digital twins are mainly divided into three types: product twins, process twins, and system twins (Figure 1). Product twins represent the digital model of a specific product, reflecting all its characteristics and operational parameters. Process twins are the digital model of a specific process, enabling the monitoring and optimization of every step of that process. System twins, on the other hand, represent the digital model of a complete system that integrates multiple products and processes, allowing for a comprehensive analysis of the entire process.

The development of a digital twin for rural electricity supply systems is a significant step toward improving the efficiency and reliability of these systems. Such twins enable the collection, analysis, and simulation of real-time data, facilitating the continuous monitoring of the condition of power supply systems. This helps prevent failures, optimize maintenance processes, and reduce energy losses. The process involves several key stages and components:

- Data collection;
- Data integration and processing;
- Development of the digital twin;
- Interaction and visualization.

In conclusion, digital twins have great potential to enhance efficiency, reduce risks, and ensure seamless operation in the energy sector. Combined with new technologies, they provide a robust platform to improve production and operational processes.