Brief information about the project

Title	BR24992975 «Development of a digital twin of a food processing enterprise using artificial intelligence and IIoT technologies»
Relevance	This project addresses a strategic challenge for the digital transformation of Kazakhstan's industry. The implementation of a comprehensive digital twin in a food industry enterprise is a practical step towards developing advanced "Industry 4.0" technologies in the country. The project enables a transition from traditional management methods to a modern, data-driven approach, which is a key factor in enhancing the efficiency and competitiveness of domestic enterprises.
Goal	To create a digital twin of a food industry enterprise using artificial intelligence and IIoT technologies, which will facilitate the digital transformation of Kazakhstan's industry, foster the development of "Industry 4.0" technologies, and strengthen the intellectual potential of Kazakhstani science.
Tasks	1. Conduct a comprehensive analysis of the enterprise's current state to identify technological barriers and define key digitalization needs. 2. Develop a comprehensive simulation model of production processes to identify and quantify "bottlenecks" and inefficient operations. 3. Create an infrastructure for real-time data collection and storage using Industrial Internet of Things (IIoT) technologies. 4. Develop and implement artificial intelligence (AI) algorithms for big data analysis, anomaly detection, predictive equipment maintenance, and optimization of production schedules. 5. Create a user-friendly and functional user interface for effective interaction with the digital twin. 6. Conduct pilot operation of the developed system at the enterprise to confirm its effectiveness and prepare for full-scale implementation.
Expected and Achieved Results	**Expected Results:** Creation of a fully functional digital twin for a food industry enterprise—a comprehensive system integrating 3D models, data from Industrial Internet of Things (IIoT) devices, and artificial intelligence algorithms for analysis, forecasting, and optimization of production processes. **Achieved Results:** A comprehensive analysis of the enterprise has been completed, and a refined simulation model has been created, which has allowed for the quantitative identification of production "bottlenecks." A technological foundation for real-time data collection has been established, and a prototype of an artificial intelligence module for analyzing personnel movement has been developed and tested.
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Publications list with links to them	**Scopus:** 1. Amirkhanov, B., Amirkhanova, G., Kunelbayev, M. Adilzhanova, S., & Tokhtassyn, M. (2025). Evaluating HTTP, MQTT over TCP and MQTT over WEBSOCKET for digital twin applications: A comparative analysis on latency, stability, and integration. International Journal of Innovative Research and Scientific Studies, 8(1), 679-694. https://doi.org/10.53894/ijirss.v8i1.4414 2. S. Adilzhanova, M.Kunelbayev, G. Amirkhanova, Ye.Zhussupov, A.Tortay. Development of a data collection and storage system for remote monitoring and detection of security threats in the enterprise / IJIRSS Vol. 8 No. 2 (2025) https://doi.org/10.53894/ijirss.v8i2.5136 3. Amirkhanov, B. ., Nurgazy, T. Amirkhanova, G. Kunelbayev, M.., & Tyulepberdinova, G.. (2025). Creating 3D models of production equipment and infrastructure using Blender International Journal of Innovative Research and Scientific Studies, 8(1), 1572-1588. https://doi.org/10.53894/ijirss.v8i1.4704

	4. Adilzhanova, S., Kunelbayev, M. Amirkanova, G. Tyulepberdinova, G., & Dana, S. (2025). Analysis of the dynamics of cyberattacks and fraud methods using machine learning algorithms for IIoT: Information security of digital twins in Industry 4.0. International Journal of Innovative Research and Scientific Studies, 8(2), 4012-4026. https://doi.org/10.53894/ijirss.v8i2.6201 **KKSON:** 1. S. Adilzhanova, A. Igilmanov, G. Tyulepberdinova, A. Salmanova, G. Amirkhanova. Application of log analysis for detecting DoS attacks and determining user behavior in the process of developing a digital twin of a food industry enterprise // Bulletin of KazATK. Volume 136 No. 1 (2025), pp. 96-107 https://doi.org/10.52167/1609-1817-2025-136-1-96-107 2. G.A. Amirkhanova, M.M. Kunelbayev, G. Tyulepberdinova, M.M. Tokhtassyn, A. Aidynuly, Literature review on current trends and advanced technologies in the field of digital twins in the food industry, "SHKTU KHABARSHYSY", 2025, No 1, pp. 120-130, doi: 10.51885/1561-4212 2025 1 120 **Conference articles:** 1. Amirkhanova, G., Amirkhanov, B., Tyulepberdinova, G., Ishmurzin, T. (2024). Application of Machine Learning Algorithms in Digital Twin Monitoring Systems: An Overview of Approaches, Methods, and Prospects. In 2024 International Conference on Intelligent Computing and Next Generation Networks (ICNGN) (pp. 01-05). 2024 International Conference on Intelligent Computing and Next Generation Networks (ICNGN). IEEE. https://doi.org/10.1109/icngn63705.2024.10871832 https://ieeexplore.ieee.org/document/10871832 2. Kunelbayev, M., Amirkhanov, B., Zauranbek, M., Abdulkhamit, N., Adilzhanova, S., Nurgazy, T. (2024). AI-Enabled Digital Twins: Soft Computing Methods for Industrial Data Mining. In 2024 International Conference on Intelligent Computing and Next Generation Networks (ICNGN) (pp. 01-05). 2024 International Conference on Intelligent Computing and Next Generation Networks (ICNGN). IEEE. https://doi.org/10.1109/icngn63705.2024.10871831 https://ieeexplore.ieee.org/document/10871831 3. Amirkhanov B., Kunelbayev M., Tuylepberdinova G., Mansurova M., Amirkhanova G. Heat pump system of renewable energy sources utilization as a basis for the development of a digital twin // Proc. of the 7th Int. Conf. on Nucl. and Ren. Energy Res. (NURER 2024). Antalya, Türkiye, October 27-30, 2024. Antalya, 2024. P. 166-179. https://nurer2024.org/fs_/files/NURER_2024_Proceedings_v4.pdf 4. Ishmurzin T.R., Amirkhanov B.S., Sakypbekova M.Zh., Tyulepberdinova G.A. Comparative analysis of data visualization and monitoring solutions for digital twin development using IoT technologies // Proceedings of the IX International Scientific and Practical Conference "Informatics and Applied Mathematics". Almaty, Kazakhstan, October 31 - November 1, 2024. Almaty, 2024. P. 137-141. https://conf.iict.kz/wp-content/uploads/2025/01/collection_CSAM_IX_2024.pdf 5. Nurgazy T.N., Amirkhanova G.A., Karymsakova D.T. Creating 3D models of industrial equipment infrastructure with

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Patent information	**Patent:** Patent: 1. KZ 10232 G01F 2025 Utility Model Patent System for determining levels of petroleum products and water in tanks https://gosreestr.kazpatent.kz/Utilitymodel/Details?docNumber=415575 2. No. 56765 dated "15" April 2025 Software implementation of a system for monitoring production processes using Grafana and Prometheus **Copyright Certificate:** 1. KZ 54286 dated "6" February 2025 Software implementation of a time series database benchmark TimescaleDB and InfluxDB 2. No. 56765 dated "15" April 2025 Software implementation of a system for monitoring production processes using Grafana and Prometheus