Figure 1: Start page

$$
\begin{gathered}
y_j = F(\sum_i \omega_{ij} - T_j), \\
\gamma_j = y_j - t_j, \\
\gamma_i = \sum_i \gamma_i F'(S_i)\omega_{ji}, \\
\omega_{ji}(t+1) = \omega_{ij}(t) - \alpha\gamma_j F'(S_j) y_i, \\
T_j(t+1) = T_j(t) + \alpha\gamma_j F'(S_j), \\
E = \frac{1}{2}\sum_{k=1}^{L}\sum_j (y_{j^k} - t_{j^k})^2.
\end{gathered}
\quad \mathbf{(2)}
$$

To use the back propagation algorithm, we must select the E function, which must be minimized. It will be the management error e_n at the time $t = nT_0 - getE_n = \frac{1}{2}e_n^2$ To accumulate errors, we store the data we have previously obtained - $E_n - p, ...E_n - 2, E_n - 1, E_n$, where p determines the number of previously saved images used for network learning (2).

V. Examples of system operation with natural language information display

For information to be clear and understandable to the reader, it must be presented in a consistent manner. The recipe authoring system interface allows the structure of domains and ontologies to be expressed in natural language. This process of converting an internal knowledge representation to an external knowledge representation is performed by a graphical interface component. On the main page general information (in 4 languages) is displayed, Fig. 5.

Fig. 6 shows resulting ontologies for standards (ISA-88, SCg).

VI. Integration of third-party solutions with a knowledge base

A standard system built on the basis of OSTIS Technology can be easily integrated with other systems in the workplace. To integrate ISA-88, ISA-95 and ISA5.1 standards system with other systems running on JSC "Savushkin Product", a web-oriented approach is used—

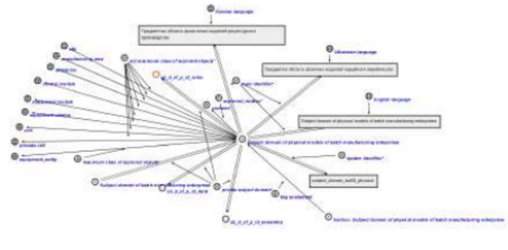

Figure 2: Ontologies for standard ISA-88

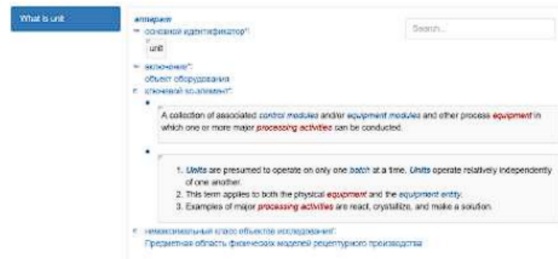

Figure 3: Unit

the ostis-system server is accessed with the use of the following queries:

`http://industry.ostis.net?sys_id=unit`

where "sys_id=unit" defines a term (the name of an entity) whose value we want to find out (in this example, in fact, the answer to the question "What is a "unit"?). This approach makes it relatively easy to add support of the knowledge base for current control systems projects, for this it is enough to indicate the names corresponding to the entities in the knowledge base within the control system. The answer is shown on Fig. 7.

Thus, an interactive intelligent help system for control systems projects is implemented, allowing employees to simultaneously work with the control system and ask questions to the system directly during the work.

Another example is the integrated help subsystem within corporate Add-In **EasyEPLANner** [17] for CAD EPLAN. It helps to describe technological objects (Tank, Boiler, etc.), operations, etc. according to the ISA-88 standard. Fig. 8 shows UML-model of EasyEPLANner objects to be described in OSTIS. The **PID controller** is at the lower level — the control module (highlighted by the green). It can be replaced by the development **neuro-PID controller**.

VII. Use in control systems

It is very important to correct and fast react on different events during process control, especially on critical accidents. But when we have complex distributed system it is rather complicated and in normal way require help of the human operator. It may leads to variety of

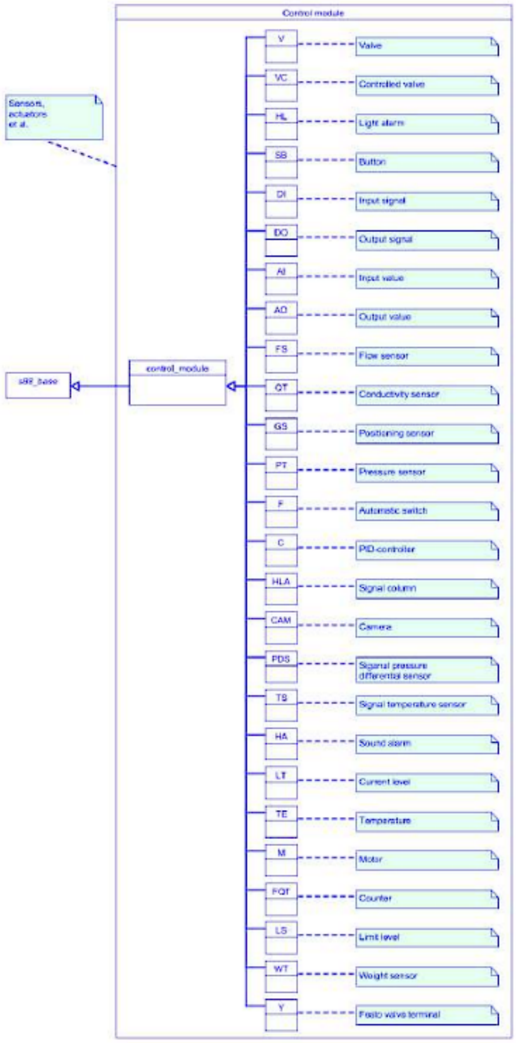

Figure 4: **EasyEPLANner** objects

problems. So usage OSTIS-based system can helps to solve as described on Fig. 4. Project #2 has a valve failure but the project does not know what to do. Then it makes a request to the OSTIS server, which already knows which projects also use this line (with this valve). The OSTIS server polls the rest of the projects (projects #1 and #2). Each project has information about which operations are currently active and gives an answer on what to do — pause the operation, do nothing, etc. After that OSTIS server sends back to project #2 answer with result actions to be used. These are going in automatic way — no need of human operator.

VIII. Future development

Current project issues can be found on GitHub ([18], [19] and [20]). Main problems to be solved are:

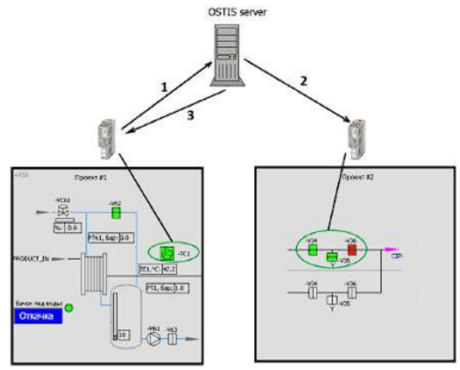

Figure 5: OSTIS in control systems

- Improving system performance and especially accelerating system response time to user requests. It is connect with productivity and overall user satisfaction.
- Continuous updating and refactoring ontological models (further formalization of missing concepts, fix typos and etc.);
- Enhancing PFC-visualization - not only displaying, but also editing diagrams. Adding rich navigating between PFC-diagram and according text representation;
- Further formulation of questions (typical) to the system from the user and their formalization at the level of the existing knowledge base;
- Adding more description of parts of real control projects based on the existing knowledge base.

The implementation of answers to complex questions is necessary to make easier the work of not only process operators, but also maintenance personnel — instrumentation engineers, mechanics, electricians, etc. Therefore, it is planned to implement the system's answer to the question of the following type — in what operations of which objects this actuator is used (for example, valve **"T1V1"**). This question is very important when a device failure occurs and it is necessary to determine the criticality of this situation. For analysis, it is necessary to compare the time of the accident and the history of operations. Since, for example, an accident of the mixproof valve during the line washing operation and the active product dosing along the other line, should lead to a stop of these operations and stop the preparation of the batch in the corresponding unit. The operator must report this to the appropriate maintenance specialist to fix it. After the fault has been eliminated, the operator continues to perform operations. This is the correct events order, which is very important to avoid mixing of detergent and product. If the device malfunction occurred within the line, which is now inactive, then this situation has a low priority, does not lead to a stop in operations and can be eliminated later if the service personnel have free time.

IX. Conclusion

The paper considers an technique to automating the process of creating, developing and making use of standards primarily based on OSTIS Technology. Using the instance of the ISA-88, ISA-95 and ISA-5.1 standards used on the Savushkin Product enterprise, the structure of the knowledge base, the features of the problem solver and the user interface of the support system for these processes are considered. It is proven that the developed system can be easily integrated with other enterprise systems, being the basis for building an information service system for employees in the context of Industry 4.0. The approach proposed in the work allows us to provide not only the ability to automate the processes of creation, agreeing and development of standards, but also allows us to significantly increase the efficiency of the processes of applying the standard, both in manual and automatic way.

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References

[1] N. Lutska, O. Pupena, A. Shyshak, V. Taberko, D. Ivaniuk, M. O. Nikita Zotov, and L. Vlasenko, “Ontological model of digital twin in manufacturing,” in Open semantic technologies for intelligent systems, ser. 5, V. Golenkov, Ed. BSUIR, Minsk, 2022, p. 310–335.

[2] V. V. Taberko, D. S. Ivaniuk, D. V. Shunkevich, and O. N. Pupena, “Principles for enhancing the development and use of standards within Industry 4.0,” in Open semantic technologies for intelligent systems, ser. 4, V. Golenkov, Ed. BSUIR, Minsk, 2020, pp. 167– 174.

[3] V. A. Golovko, A. A. Kroshchanka, V. V. Golenkov, V. P. Ivashenko, M. V. Kovalev, V. V. Taberko, and D. S. Ivaniuk, “Integration of artificial neural networks and knowledge bases,” 2018.

[4] S. Gil, G. D. Zapata-Madrigal, and G. L. Giraldo-Gómez, “An ontological model to integrate and assist virtualization of automation systems for industry 4.0,” Smart and Sustainable Manufacturing Systems, vol. 5, p. 10, 09 2021.

[5] V. R. Sampath Kumar, A. Khamis, S. Fiorini, J. L. Carbonera, A. Olivares Alarcos, M. Habib, P. Goncalves, H. Li, and J. I. Olszewska, “Ontologies for industry 4.0,” The Knowledge Engineering Review, vol. 34, p. e17, 2019.

[6] V. Golenkov, N. Gulyakina, I. Davydenko, and D. Shunkevich, “Semanticheskie tekhnologii proektirovaniya intellektual’nyh sistem i semanticheskie associativnye komp’yutery [Semantic technologies of intelligent systems design and semantic associative computers],” Open semantic technologies for intelligent systems, pp. 42– 50, 2019.

[7] “Digital Twins for Industrial Applications, an Industrial Internet Consortium White Paper,” https://www.iiconsortium.org/pdf/IIC_Digital_Twins_Industrial_Apps_White_Paper_2020-02-18.pdf, 2018.

[8] M. Sverko, T. G. Grbac, and M. Mikuc, “Scada systems with focus on continuous manufacturing and steel industry: A survey on architectures, standards, challenges and industry 5.0,”IEEE Access, vol. 10, pp. 109 395–109 430, 2022.

[9] P. Serenkov, V. Solomaho, V. Nifagin, and A. Minova, “Koncepcija infrastruktury standartizacii kak bazy znanij na osnove ontologij [the concept of a standardization infrastructure as an ontology-based knowledge base],” Novosti. Standartizacija i sertifikacija. [News. Standardization and certification.], vol. 1, no. 5, pp. 25–29, 2004.

[10] V. Uglev, “Aktualizacija soderzhanija standartov proektirovanija slozhnyh tehnicheskih ob’ektov: ontologicheskij podhod [updating the content of design standards for complex technical objects: ontologic approach],” Ontologija proektirovanija. [Ontology of designing], vol. 1, no. 1, pp. 80–86, 2012.

[11] C. Dombayci, J. Farreres, H. Rodríguez, A. Espuña, and M. Graells, “Improving automation standards via semantic modelling: Application to ISA88,” ISA Transactions, vol. 67, 01 2017.

[12] M. Vegetti and G. Henning, “Isa-88 formalization. a step towards its integration with the isa-95 standard,” in 6th Workshop on Formal Ontologies meet Industry, vol. 1333, 02 2015.

[13] “ISA-88 standard,” https://www.isa.org/standards-andpublications/isa-standards/isa-standards-committees/isa88/, (accessed 2022, October).

[14] “ISA-95 standard,” https://www.isa.org/standards-andpublications/isa-standards/isa-standards-committees/isa95/, (accessed 2022, October).

[15] A. A. Uskov and A. V. Kuz’min, Intellektual’nye tekhnologii upravleniya. Iskusstvennye nejronnye seti i nechetkaya logika. Goryachaya liniya - Telekom, 2004.

[16] D. S. Ivaniuk, “Neuro-pid controller for a pasteurizer,” in XV International PhD Workshop OWD, 2013.

[17] “EasyEPLANner project on GitHub,” Available at: https://github.com/savushkin-r-d/EasyEPLANner/, (accessed 2022, Jun).

[18] “EasyServer-4.0 project on GitHub,” Available at: https://github.com/savushkin-r-d/EasyServer-4.0, (accessed 2024, Feb).

[19] “s88-ostis project on GitHub,” Available at: https://github.com/savushkin-r-d/s88-ostis, (accessed 2024, Feb).

[20] “isa-5.1-ostis project on GitHub,” Available at: https://github.com/savushkin-r-d/isa-5.1-ostis, (accessed 2024, Feb).

НЕЙРО-СЕМАНТИЧЕСКОЕ УПРАВЛЕНИЕ В ПРОМЫШЛЕННОСТИ

Иванюк Д. С.

В работе рассмотрен онтологический подход к пониманию, интеграции и развитию современных подходов к управлению (нейроуправление, семантические технологии, современные международные стандарты) с использованием Технологии OSTIS. Уточнены формальные трактовки основных понятий, используемых в стандартах, что позволяет упростить описание реальных задач. Также описаны варианты интеграции базы знаний в используемые программные средства разработки и сценарии её использования непосредственно в системах управления.

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