# Intelligent information systems

UDC 004.891.3 **doi: 10.20998/2522-9052.2020.4.16**

S. Chalyi, V. Leshchynskyi, I. Leshchynska

Kharkiv National University of Radio Electronics, Kharkiv, Ukraine

## A DYNAMIC EXPLANATION MODEL FOR HUMAN-COMPUTER INTERFACE

**Abstract.** The **subject** matter of the article is the processes of automated construction of explanations on the operation of an intelligent system for use in the human-computer interface. The **goal** is to develop a dynamic model of explanation for the human-computer interface using temporal knowledge about the process of functioning of the intelligent system. Temporal knowledge makes it possible to set possible sequences of decision-making actions in an intelligent system based on the known temporal order for pairs of such actions. **Tasks**: to develop an approach to constructing explanations for the operation of an intelligent system based on the use of temporal knowledge; development of a three-aspect model of explanations using temporal knowledge. **The approaches used** are: approaches to the construction of knowledge representation based on temporal dependencies, approaches to the construction of chatbot answers using rules, as well as with their automatic generation. The following **results** are obtained. The structuring of aspects of explanation taking into account the possibilities of their description with the help of temporal knowledge is performed; a temporal approach to constructing an explanation is proposed; a dynamic explanation model using temporal rules has been developed. **Conclusions**. The scientific novelty of the results is as follows. A temporal approach to constructing explanations for the operation of an intelligent system is proposed. The approach describes explanation as a process consisting of a temporally ordered sequence of facts. The order of time for pairs of facts is determined by temporal rules. Such rules may define the explanation process with varying degrees of detail over time, depending on the request for clarification. Detailed explanations reflect the subject area model and include the basic and alternative sequences of actions performed by the intelligent system. The explanation of the basic patterns of the intelligent system makes it possible to interpret the limitations that affect the obtained solution. The explanation of the system as a whole provides an implicit reflection of the key causal relationships, which allows you to get a simplified interpretation of the results of the intelligent system. A dynamic model of describing explanations based on temporal knowledge for use in the human-computer interface is proposed. The model takes into account the description of actions in the subject area, the patterns of these actions, as well as generalized causal relationships between such patterns. The model provides an opportunity to present the dynamics of the process of functioning of the intelligent system with the required level of detail, as well as change the level of detail to clarify the explanation at the request of the user.

**Keywords**: intelligent human-computer interface; intelligent system; explanation; knowledge; knowledge representation; temporal rules.

### Introduction

In recent years, intelligent programs to support the human-computer interface - chatbots have become widespread in many applications [1]. They are widely used to organize interaction with customers in e-commerce systems, payment systems, marketing, education, health care, social media, etc. [2-4]. The key task that such intelligent assistants solve is to provide "smart" answers that satisfy the user's requests.

Such a program extracts the essence of the request in the form of text or voice and provides a response to the user [5]. Historically, chatbots have been designed to pass the Turing test [6, 7]. With the development of artificial intelligence methods, such programs have found practical application for automated support of interaction with users of various information systems.

Intelligent support for the human-computer interface has a number of key benefits that are the reason for the rapid development of such programs. They can work 24 hours a day, simplify navigation on the site of the information system, provide answers to FAQs, automate the collection of data from users based on a dialogue similar to a dialogue with a person [8, 9]. The chatbot program is perceived by a person as a friendly information assistant [10].

However, despite the development of such programs, today the problem of building chatbots that would offer useful information (i.e., that details, clarifies the user's request) requires further research. One of the key ways to increase the efficiency of the intelligent human-computer interface is to build explanations in an automated mode. The explanations should interpret to the user the sequence of operation of the intelligent system and the reasons for the results obtained, which the user requests.

Today, two basic approaches to building chatbots are used. The first approach uses frames and rules developed by experts. These frames specify the script of the dialogue with the user [11]. This scenario depends on a priori knowledge of the subject area. For example, in e-commerce systems, the user usually asks about the properties and benefits of recommended items. When booking seats in the restaurant, you must specify the time, contact phone number, etc.

The second approach involves the automatic generation of knowledge that meets consumer demand. Chatbot then uses this knowledge to form answers. Such answers are either selected by the program from the knowledge base [12], or generated using words from the user's query [13].

In the first case at construction the a priori set of knowledge is formed. Therefore, the chatbot generates the correct answers. But the possibilities of this approach are limited: the chatbot uses only the dependencies that have been included in the rule base.

In the second case, the chatbot generates new answers that were not given a priori. The disadvantage of the second approach is that the generated responses do not always contain useful information for the user.

In general, the existing approaches give a static description of the results of the intelligent system, in particular chatbot.

To overcome such shortcomings in the construction of chatbot explanations, it is advisable to take into account not only the statics but also the dynamics of the intelligent system. Taking into account the dynamics involves the transition from declarative to procedural description of the process of functioning of the intelligent system.

Automation of the procedural description of the process of functioning of the intelligent system is provided on the basis of the use of temporal knowledge. Temporal knowledge in the form of rules sets the order in time for pairs of actions in the information system [14]. The set of rules allows to present linear sequences of actions or corresponding states of the intellectual system in the form of a sequence of facts [15]. This sequence of facts reflects the sequence of formation of the result in the intellectual system and therefore acts as an explanation. The method of inference on temporal rules, which can be used to form a sequence of facts of explanation, is proposed in [16].

However, existing approaches to the construction and use of temporal knowledge are focused mainly on decision support in intelligent systems, in particular in e-commerce systems [17-19]. Not enough attention is paid to the application of temporal knowledge to construct and explain the answers of chatbots. This indicates the relevance of the topic of this work.

**The aim of the article** is to develop a dynamic model of explanation for the human-computer interface, which uses the representation of temporal knowledge to build explanations of the process of functioning of the intelligent system. To achieve this goal, the following tasks are solved:

– development of the approach to construction of explanations concerning work of intellectual system on the basis of use of temporal knowledge;

– development of a three-aspect model of explanations using temporal knowledge.

## Temporal approach to the construction of explanations

The explanation simplifies the interaction with the user, explaining to him the mechanism of operation of the intelligent system. The key idea in the formation of chatbot explanations based on temporal knowledge is to build an automated description of the sequence of functioning of the intelligent system.

Such a description consists of a set of temporally ordered temporal rules. The set of rules describes possible alternative processes of the intelligent system. The current process determines the current state of the intelligent system or the result of its operation as a whole. In the first case, the explanation should reflect the sequence of actions that led to the current state of the intelligent system. This sequence reflects the many causal relationships between the input data, as well as changes in the state of the system over time. In the second case, the generalized sequence of actions reflects the reasons for obtaining the result for a given input data, ie the causal relationships of the upper level.

Thus, the proposed approach to the construction of explanations of the chatbot on the basis of temporal rules provides a procedural description of the sequence of actions that reveal the process of the intelligent system. In fact, the temporal approach makes it possible to abstract from the explicit representation of causal relationships between input data, the mechanism of the intelligent system and the result of its work. Such causal connections are subject-specific. Explicit representation of causality requires the development of appropriate subject area models, or the construction by experts of a scenario based on frames and rules. This approach is quite time consuming because it requires the knowledge of experts in the subject area.

The description of the order of actions in the intellectual system on the basis of temporal rules implicitly reflects the causal links between the input information and the result. This description of time-ordered actions is unified, using the same models of knowledge representation for different subject areas. Together with the user's contextual knowledge, such ordering reveals an explanation of the algorithm of the intelligent system.

Therefore, the explanation in the form of an ordered set of temporal dependences should be considered as a simplified representation of the causal connections between the actions of the intellectual system. This explanation makes it possible to summarize the reasons and conditions for obtaining both the final and intermediate result of the intelligent system.

The explanation based on temporal knowledge has the following key aspects that are essential for the organization of the chatbot in the mode of dialogue, similar to the dialogue with the operator (Fig. 1):

– interpretation of the reasons for the decision made by the intelligent system;

– detailing of key patterns, steps and rules used by the algorithm of the intelligent system;

– disclosure of the model of the intelligent system (for example, the model of response formation).

The explanation in the first aspect sets a "superficial" causal link between the user's request and the response or solution of the intelligent system. In this aspect, the deep mechanisms of such a system are not disclosed. Instead, generalized links are formed, which should promptly satisfy the user's request. Generalized temporal connections regulate the actions of the main subsystems of the intelligent system or key objects in the subject area.

The explanation in the second aspect reveals the key schemes of decision-making and the formation of responses to consumer demand. Such key sequences of actions must be performed in all processes of forming the result of the intelligent system and therefore they play the role of temporal constraints. Disclosure of the patterns on which the information system operates should increase the confidence of the qualified user.

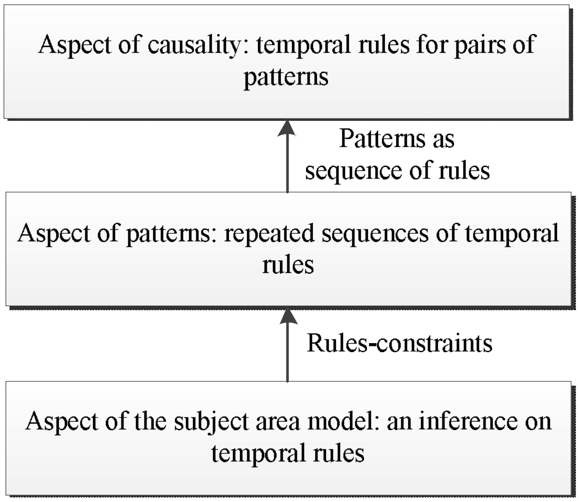


**Fig. 1.** Hierarchy of aspects of explanations on temporal rules

The explanation in the third aspect is intended to substantiate the correctness of important answers for critical users who want to get a detailed explanation of the result proposed by the intelligent system. Therefore, this explanation is based on the use of the model of the subject area as a whole, or models of individual objects in the subject area.

## A dynamic model of explanation

The proposed approach to the formation of chatbot answers according to the given three-aspect presentation of explanations is based on the use of probabilistic inference on temporal rules.

The following rules set the order in time for a pair of states of the intelligent system, or a pair of facts about its functioning:

$$r_{i,j} : f_i \Rightarrow f_j, (\forall i \forall j) t_j > t_i, \tag{1}$$

where $f_i$, $f_j$ – the facts that reflect the decisions made by the intelligent system or characterize the state of the intelligent system; $t_i$, $t_j$ – moments of time when the facts $f_i$, $f_j$ become true.

Each of the facts $f_i$ captures the state of the intelligent system or the action that was performed during its operation.

According to (1), the temporal rule not only establishes a connection between the facts of the process of functioning of the intellectual system, but also sets their order in time. The facts reflect the actions that were performed in the intelligent system.

A complete description of the sequence of actions for the formation of recommendations reflects an aspect of the model of the recommendation system. This sequence is a time-ordered sequence of facts, as well as the rules that link these facts:

$$Q = \left\{ \left\langle f_1,...,f_i,...,f_j,...,f_I \right\rangle, \left\{ r_{i,j} \right\} \right\}. \tag{2}$$

The sequence of facts in expression (2) reflects the decision-making process in the intelligent system. The rule organizes a couple of facts and therefore shows that after the fact $f_i$ must be (or should be with some probability) a true fact $f_j$.

If the second fact is necessarily true after the first, then such a rule is considered a constraint. The following rules use the temporal quantifier A:

$$C = \left\{ Ar_{i,j} : (\forall Q) \exists r_{i,j} \right\}, \tag{3}$$

where $Ar_{i,j}$ – the restriction rule.

That is, the ordering in time for pairs of actions of the intelligent system, given by constraints, is always fulfilled.

The probability of the truth of the fact $f_j$ after the truth of the fact $f_i$ is determined on the basis of the weight of the rule: the greater the weight, the greater the probability of realization of the temporal rule.

The pattern is represented by a conjunction of constraint rules:

$$p_i = \bigwedge_{i=1}^{I} Ar_{i,j} \left| (\forall i) \exists r_{i,j} \right. . \tag{4}$$

According to the definition of pattern (4), the latter consists of temporal rules that specify the temporal order for all facts in the sequence:

$$p_i = \left\langle f_1,...,f_n,...,...,f_N : \forall f_n \exists r_{n,j} : j > n \right\rangle. \tag{5}$$

Thus, each transition from one fact to another is explained by the corresponding temporal rule. That is, the pattern defines a continuous process on a subset of facts about the state of the subject area.

This formalization of the pattern makes it possible to present as one fact in terms of causality.

The fact of the truth of a pattern is given through the conjunction of temporal constraints, which make up this pattern:

$$p_i = \begin{cases} true, if\ Ar_{i,1} \wedge ... \wedge Ar_{i,m} \wedge ... \wedge Ar_{i,M}; \\ false, otherwise, \end{cases} \tag{6}$$

де $Ar_{i,m}$ – темпоральні обмеження.

Thus, the "superficial" explanation in terms of causality is revealed through a set of constraint rules in terms of patterns. In turn, the constraint pattern is supplemented by probabilistic rules in terms of the subject area model.

Such rules reflect differences in the decision-making process in different subject area conditions or for different sets of input data.

The temporal rule in the aspect of causality organizes in time a pair of patterns and has the form:

$$s_{l,m} : p_l \Rightarrow p_m. \tag{7}$$

Thus, in the aspect of causality, each fact reflects the result of the mandatory sequence of actions in the process of forming the decision of the intelligent system. Such facts, built on the basis of patterns, reflect the results of the subsystems of the intelligent system.

Temporal rules in all three aspects form a dynamic model of explanations:

$$K = \{Q, P, S\}, \quad (8)$$

where $P = \{p_i\}$ – a set of temporal patterns; $S = \{s_{i,m}\}$ – a set of temporal rules in the aspect of causality.

The transition between aspects is performed using constraints or artifacts.

The relationship between the aspects is as follows. First, each pattern uses constraints from the subject area model aspect.

Therefore, when constructing patterns, the condition must be met:

$$\forall p_i \in P \; \exists A r_{i,j} \in C. \quad (9)$$

Secondly, each fact in the aspect of causality is formed on the basis of patterns. Therefore, when constructing rules in this aspect, the condition of relevance of patterns should be checked:

$$\forall s_{i,j} \in S \; \exists p_i \in P. \quad (10)$$

Consider examples of facts and rules for explanation in recommendation systems in terms of causality.

Thus, when performing collaborative filtering in recommendation systems, the fact of filtering completion may look like "Recommended for user similarity".

In that case, if the recommendation system uses a hybrid method of forming a recommended list of goods or services, the temporal rule may look like this:

$$r_{1,2} : \begin{matrix} "Recommendation \\ of\ items \\ on\ similar\ users" \end{matrix} \Rightarrow \begin{matrix} "Recommendation \\ for\ similar\ properties \\ of\ items" \end{matrix}. \quad (11)$$

The first and second facts of rule (11) are ordered in time. Therefore, this explanation reflects a simplified causal relationship of the form: "When constructing the recommended list of goods and services, the recommendation system first selected items for similarity of users, and then clarified the recommendation for similar characteristics of goods." Each of the facts of this rule combines a number of patterns of functioning of the recommendation system.

For example, the truth of the first fact indicates the completion of the matrix factorization algorithm, which detects latent factors that characterize the similarity of users. Therefore, this rule reflects the aspect of causality in accordance with the presented in Fig. 1 scheme.

Detailing both facts in the form of a typical sequence of temporal rules describing collaborative and content filtering forms an aspect of the key patterns of explanation. In describing this aspect, the user receives an interpretation of collaborative filtering in the form of a typical sequence of actions to break the matrix of input data and identify latent factors that reflect the interests of users.

The human-computer interface that uses the proposed model has the following features.

Based on known user requests, a temporal database of explanations is formed. As facts in the aspect of the model of the subject area are the words from the query, as well as keywords that characterize the process of functioning of the intelligent system. The rules reflect the sequence of word pairs in the query as well as in the explanation.

The pattern aspect reflects the required sequences of actions to obtain the result. Such sequences are represented by chains of phrases.

In the aspect of causality, temporal rules set permissible (i.e. known from experience) sequences of pairs of phrases that generally describe the sequence of actions.

Replenishment of temporal knowledge is performed on the basis of comparison of known requests and available information about the work of the intelligent system.

## Conclusions

A temporal approach to constructing explanations for the operation of an intelligent system is proposed. According to this approach, explanation is a process that has a procedural description and can be considered with varying degrees of detail over time. The use of temporal dependencies with maximum detail makes it possible to form an explanation in accordance with the process of functioning of the intelligent system.

The degree of detail of the explanations depends on the aspect in which the process of functioning of the intelligent system is considered. The explanation in the aspect of the subject area model contains detailed basic and alternative sequences of actions performed by the intelligent system. The explanation in terms of temporal patterns makes it possible to interpret the limitations used by the intelligent system. The explanation in the aspect of causality provides an implicit reflection of the key causal relationships according to their implementation over time, which allows to obtain a simplified interpretation of the results of the intelligent system.

A dynamic model of explanation presentation for human-computer interface based on temporal knowledge is proposed. The model takes into account aspects of the description of the subject area, patterns of mandatory sequences of actions, as well as the aspect of generalized causal relationships.

The model makes it possible to display the dynamics of the process of functioning of the intelligent system with the required level of detail, as well as to change the level of detail of the answers depending on the clarifying user requests.

## References

1. Bansal, H. and Khan, R. (2018), "A review paper on human computer interaction", *International Journals of Advanced Research in Computer Science and Software Engineering*, Vol. 8, pp. 53-56, DOI: https://doi.org/10.23956/ijarcsse.v8i4.630.

2. Jain, M, Kota, R., Kumar, P. and Patel, S. (2018), "Convey: Exploring the use of a context view for chatbots", *Proc. of the 2018 CHI Conference on Human Factors in Computing Systems*, pp. CHI '18, pp. 1-6, DOI: https://doi.org/10.1145/3173574.3174042.
3. Hu, T., Xu, A., Liu, Z., You, O., Guo, Y., Sinha, V., Luo, J. and Akkiraju, R. (2018), "Touch your heart: A tone-aware chatbot for customer care on social media", *Proc. of the 2018 CHI Confe. on Human Factors in Computing Systems,* pp. 1-12.
4. Cranshaw, J., Elwany, E., Newman, T., Kocielnik, R., Yu, B., Soni, S., Teevan, J. and Monroy-Hernández, A. (2017), "Calendar.help: Designing a workflow-based scheduling agent with humans in the loop", *Proc. of the 2017 CHI Conference on Human Factors in Computing Systems*, pp. 2382–2393, DOI: https://doi.org/10.1145/3025453.3025780.
5. Liao, Q., Mas-ud Hussain, M., Chandar, P., Davis, M., Khazaeni, Y., Crasso, M.P., Wang, D., Muller, M., Shami, S.N. and Geyer, W. (2018), "All work and no play?", *Proc. of the 2018 CHI Conference on Human Factors in Computing Systems*, CHI '18, pp. 1–3.
6. Turing, A.M. (1950), "Computing machinery and intelligence", *Mind*, Vol. LIX, Is. 236 pp. 433-460. DOI: https://doi.org/10.1093/mind/LIX.236.433.
7. Hingston, P. (2009), "A Turing test for computer game bots", *IEEE Transactions on Computational Intelligence and AI in Games*, Vol. 1, no. 3, pp. 169-186, DOI: https://doi.org/10.1109/TCIAIG.2009.2032534.
8. Ranoliya, B.R., Raghuwanshi, N. and Singh, S. (2017), "Chatbot for university related FAQs", *International Conference on Advances in Computing, Communications and Informatics (ICACCI)*, UDUPI, pp. 1525–1530. DOI: https://doi.org/10.1109/ICACCI.2017.8126057.
9. Higashinaka, R., Imamura, K., Meguro, T., Miyazaki, C., Kobayashi, N., Sugiyama, H., Hirano, T., Makino, T. and Matsuo, Y. (2014), "Towards an open domain conversational system fully based on natural language processing", *Proceedings of COLING 2014, the 25th International Conference on Computational Linguistics: Technical Papers*, pp. 928–939.
10. Da Costa, P.C.F. (2018), "Conversing with personal digital assistants: on gender and artificial intelligence", *Journal of Science and Technology of the Arts*, Vol. 10(3), pp. 59-72, DOI: https://doi.org/10.7559/citarj.v10i3.563
11. Mesnil, G., Dauphin, Y., Yao, K., Bengio, Y., Deng, L., Hakkani-Tur, D., He, X., Heck, L., Tur, G., Yu, D. and Zweig, G. (2015), "Using recurrent neural networks for slot filling in spoken language understanding", *IEEE/ACM Transactions on Audio, Speech, and Language Processing*, 23(3), pp. 530-539.
12. Song, Y., Li, C., Nie, J., Zhang, M., Zhao, D., and Yan, R. (2018), "An ensemble of retrieval-based and generation-based human-computer conversation systems", *Proc. of the Twenty-Seventh International Joint Conference on Artificial Intelligence*, pp. 4382-4388.
13. Serban, I. V., Sordoni, A., Bengio, Y., Courville, A. and Pineau, J. (2016), "Building end-to-end dialogue systems using generative hierarchical neural network models", *Proc. of the Thirtieth AAAI Conference on Artificial Intelligence*, AAAI'16, pp. 3776-3783.
14. Chala, O. (2018), "Logical-probabilistic representation of casual dependencies between events in business-process management", *Advanced information systems*, Vol. 2, No. 2, pp. 40-44, DOI: https://doi.org/10.20998/2522-9052.2018.2.07
15. Levykin, V. and Chala, O. (2018), "Method of automated construction and expansion of the knowledge base of the business process management system", *EUREKA: Physics and Engineering*, Vol. 4(17), pp. 29-35, DOI: http://dx.doi.org/10.21303/2461-4262. 2018.00676.
16. Levykin, V and Chala, O. (2018), "Development of a method of probabilistic inference of sequences of business process activities to support business process management", *Eastern-European Journal of Enterprise Technologies*, Vol. 5/3(95), pp. 16-24, DOI: https://doi.org/10.15587/1729-4061.2018.142664.
17. Chalyi, S. and Leshchynskyi, V. (2020), "Method of constructing explanations for recommender systems based on the temporal dynamics of user preferences", *EUREKA: Physics and Engineering*. Vol. 3, pp. 43-50.
18. Chalyi, S., Leshchynskyi, V. and Leshchynska, I. (2019), "Method of forming recommendations using temporal constraints in a situation of cyclic cold start of the recommender system", *EUREKA: Physics and Engineering*, Vol. 4, pp. 34-40.
19. Chalyi, S., Leshchynskyi, V. and Leshchynska, I. (2019), "Designing explanations in the recommender systems based on the principle of a black box", *Advanced Information Systems*, Vol. 3, No. 2, pp. 47-51, DOI: https://doi.org/10.20998/2522-9052.2019.2.08.

Надійшла (received) 25.09.2020
Прийнята до друку (accepted for publication) 11.11.2020

ВІДОМОСТІ ПРО АВТОРІВ / ABOUT THE AUTHORS

**Чалий Сергій Федорович** – доктор технічних наук, професор, професор кафедри інформаційних управляючих систем, Харківський національний університет радіоелектроніки, Харків, Україна;
**Serhii Chalyi** – Doctor of Technical Sciences, Professor, Professor of Professor of Information Control Systems Department, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine;
e-mail: serhii.chalyi@nure.ua; ORCID ID: http://orcid.org/0000-0002-9982-9091.

**Лещинський Володимир Олександрович** – кандидат технічних наук, доцент, доцент кафедри програмної інженерії, Харківський національний університет радіоелектроніки, Харків, Україна;
**Volodymyr Leshchynskyi** – Candidate of Technical Sciences, Associate Professor, Associate Professor of Software Engineering Department, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine;
e-mail: volodymyr.leshchynskyi@nure.ua; ORCID ID: http://orcid.org/0000-0002-8690-5702.

**Лещинська Ірина Олександрівна** – кандидат технічних наук, доцент, доцент кафедри програмної інженерії, Харківський національний університет радіоелектроніки, Харків, Україна;

**Iryna Leshchynska** – Candidate of Technical Sciences, Associate Professor, Associate Professor of Software Engineering Department, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine;
e-mail iryna.leshchynska@nure.ua; ORCID ID: http://orcid.org/0000-0002-8737-4595.

**Динамічна модель представлення пояснень для людино-машинного інтерфейсу**

С. Ф. Чалий, В. О. Лещинський, І. О. Лещинська

**Анотація**. **Предметом** вивчення в статті є процеси автоматизованої побудови пояснень щодо роботи інтелектуальної системи для використання у людино-машинному інтерфейсі. **Метою** є розробка динамічної моделі пояснення для людино-машинного інтерфейсу з використанням темпоральних знань щодо процесу функціонування інтелектуальної системи. Темпоральні знання дають можливість задати можливі послідовності дій з прийняття рішення в інтелектуальній системі на основі відомої темпоральної упорядкованості для пар таких дій. **Завдання**: розробка підходу до побудови пояснень щодо роботи інтелектуальної системи на основі використання темпоральниих знань; розробка трьохаспектної моделі пояснень з використанням темпоральних знань. Використовуваними **підходами** є: підходи до побудови представлення знань на основі темпоральних залежностей, підходи до побудови відповідей чатбота з використанням правил, а також із їх автоматичною генерацією. Отримані наступні **результати**. Виконано структуризацію аспектів пояснення з урахуванням можливостей їх опису за допомогою темпоральних знань; запропоновано темпоральний підхід до побудови пояснення; розроблено динамічну модель пояснення, що використовує темпоральні правила. **Висновки**. Наукова новизна отриманих результатів полягає в наступному. Запропоновано темпоральний підхід до побудови пояснень щодо роботи інтелектуальної системи. Підхід описує пояснення як процес, що складається із темпорально упорядкованої послідовності фактів. Порядок у часі для пар фактів задається темпоральними правилами. Такі правила можуть визначати процес пояснення із різним ступенем деталізації у часі, в залежності від запиту на пояснення. Детальні пояснення відображають модель предметної області і містять у собі базові та альтернативні послідовності дій, що виконує інтелектуальна система. Пояснення базових патернів роботи інтелектуальної системи дає можливість інтерпретувати обмеження, які впливають на отримане рішення. Пояснення роботи системи в цілому забезпечує неявне відображення ключових причинно-наслідкових залежностей, що дозволяє отримати спрощену інтерпретацію результатів роботи інтелектуальної системи. Запропоновано динамічну модель опису пояснень на основі темпоральних знань для використання у людино-машинному інтерфейсі. Модель враховує опис дій у предметної області, патерни цих дій, а також узагальнені причинно-наслідкових зв'язки між такими патернами. Модель забезпечує можливість представлення динаміки процесу функціонування інтелектуальної системи із необхідним ступенем деталізації, а також зміну рівня деталізації для уточнення пояснення за запитом користувача.

**Ключові слова:** інтелектуальний людино-машинний інтерфейс; інтелектуальна система; пояснення; знання, представлення знань; темпоральні правила.

**Динамическая модель представления объяснений для человеко-машинного интерфейса**

С. Ф. Чалый, В. А. Лещинский, И. А. Лещинская

**Аннотация. Предметом** изучения в статье являются процессы автоматизированного построения объяснений относительно функционирования интеллектуальной системы для использования в человеко-машинном интерфейсе. **Целью** является разработка динамической модели объяснения для человеко-машинного с использованием темпоральных знаний о процессе функционирования интеллектуальной системы. Темпоральные знания дают возможность задать возможные последовательности действий по принятию решения в интеллектуальной системе на основе известной темпоральной упорядоченности для пар таких действий. **Задачи**: разработка подхода к построению объяснений относительно работы интеллектуальной системы на основе использования темпоральниих знаний; разработка трехаспектной модели объяснений с использованием темпоральных знаний. Используемыми **подходами** являются: подходы к построению представления знаний на основе темпоральных зависимостей, подходы к построению ответов чатбота с использованием правил, а также с их автоматической генерацией. Получены следующие **результаты**. Выполнена структуризация аспектов объяснения с учетом возможностей их описания с помощью темпоральных знаний; предложен темпоральный подход к построению объяснения; разработана динамическая модель объяснения, которая использует темпоральные правила. **Выводы**. Научная новизна полученных результатов заключается в следующем. Предложен темпоральный подход к построению объяснений относительно функционирования интеллектуальной системы. Подход описывает объяснение как процесс, состоящий из темпорально упорядоченной последовательности фактов. Порядок во времени для пар фактов задается темпоральными правилам. Такие правила могут определять процесс объяснения с разной степенью детализации во времени, в зависимости от запроса на объяснения. Подробные объяснения отражают модель предметной области и включают в себя базовые и альтернативные последовательности действий, которые выполняет интеллектуальная система. Разъяснение базовых паттернов работы интеллектуальной системы дает возможность интерпретировать ограничения, которые влияют на полученное решение. Разъяснение работы системы в целом обеспечивает неявное отображение ключевых причинно-следственных зависимостей, позволяет получить упрощенную интерпретацию результатов работы интеллектуальной системы. Предложена динамическая модель описания объяснений на основе темпоральных знаний для использования в человеко-машинном интерефейсе. Модель учитывает описание действий в предметной области, паттерны этих действий, а также обобщенные причинно-следственных связи между такими паттернами. Модель обеспечивает возможность представления динамики процесса функционирования интеллектуальной системы с необходимой степенью детализации, а также изменение уровня детализации для уточнения объяснения по запросу пользователя.

**Ключевые слова:** интеллектуальный человеко-машинный интерфейс; интеллектуальная система; объяснения; знания; представления знаний; темпоральные правила.