УДК 004.[6+8+94]
OLEKSIY SHUSHURA,
State University of Telecommunications, Kyiv

INFOLOGICAL MODELING OF INFORMATION SYSTEMS SUBJECT INDUSTRIES IN SOLVING OF FUZZY CONTROL TASKS

The development of information technologies for solving problems of fuzzy control requires the use of tools for infological modelling. Existing approaches for describing the tasks of fuzzy control based on the fact that the control unit, as a rule, is represented by a rectangle, and to the left and to the right of it there are arrows indicating the incoming and outgoing information. Existing methodologies for infological modelling, which include IDEF, UML, DFD, ER, Fuzzy IFO and others, are focused primarily on the description of processes, data structures and classes and do not take into account the specifics of fuzzy control problems. In this paper, approaches for the creation of a graphical conceptual model for the problem of fuzzy control, models of linguistic variables and the structure of knowledge base rules in the form of fuzzy products are proposed. In the conceptual model of the fuzzy control problem, a list of input and output variables of the control unit, corresponding linguistic variables and the connections between them are given. In addition, the model specifies the restrictions of the control task. The model of a linguistic variable contains detailed information about it in accordance with the classical definition. The rule structure model of the data-base of fuzzy inference clearly reflects the links between antecedents and consequents. The using of these models makes it possible to provide information on the formulation of the fuzzy control problem in terms of the subject area, which provides an increase in the effectiveness of its consideration. The results of the work can be used to describe the subject areas in the development of information technology for automating the management tasks of complex systems.

Keywords: information technology; infological modelling; fuzzy control.

Problem statement

Modern approaches to the development of infocommunication technologies require the use of infological modelling at the stage of task setting and design, which greatly enhances the effectiveness of communication between the customer and the project implementation team. When solving the problems of information technology development for the automation of the tasks of complex systems control, the use of fuzzy control methodology was widely used [1]. The development of infological models of subject fields in solving fuzzy control tasks requires special approaches that allow formalizing the connection between ordinary and linguistic variables of control devices, displaying constraints on management, presenting the structure of linguistic changes.

Analysis of recent research and publications

Among the methodologies of infological modelling of subject areas, IDEF, DFD, ER and UML were most widely used [4; 7; 8]. The IDEF methodology is primarily intended to describe the functioning of a particular system and does not take into account the characteristics of fuzzy control. The DFD models form a conceptual description of the system's information flows, but do not reflect fuzzy data. The ER methodology was proposed for infological data modelling, but it is more oriented towards building databases than for the description of management tasks. UML models allow you to describe the work of the system in terms of object-oriented analysis, but without taking into account the need for fuzzy control in the form of a description of linguistic variables and production rules. Frames and semantic networks [5] are used to describe product rules, but they are not adapted to simulate fuzzy characteristics.

Fuzzy ER Model, Fuzzy EER Model, Fuzzy IFO Model and Fuzzy UML Data are proposed to account for fuzzy and imperfect information [2; 3]. The above methodologies are also intended mainly for fuzzy data modelling and do not allow to describe the task of management.

Existing approaches to the description of fuzzy control tasks are that the control unit is usually represented by a rectangle, and arrows showing the input and output information are shown to the left and to the right of it [6]. Such models are too simple and do not allow to display the necessary information about the structure of the relationship between variables for the tasks of managing complex systems.

Thus, the task of constructing the principles of infological modelling of the subject areas of information systems in solving the problems of fuzzy control is relevant.

Main part

The goal of the work is to develop approaches to the informal modelling of the informative systems' domains in the solution of fuzzy simulation tasks, which will provide representation in the graphic form of the main components of the problem and the connections between them.

To achieve the goal, it is suggested to use the diagrams:

- a conceptual model of the task of fuzzy control;
- a model of linguistic variables;
- model of fuzzy output rules structure.

The conceptual model of the fuzzy control problem is presented in the form of a diagram that contains a graphical representation of the usual input and output variables of the fuzzy control block, the corresponding linguistic input and output variables, as well as the description of the limitations of the task. An example of a diagram of a conceptual model of a fuzzy control task is shown in fig. 1.

As we see in fig. 1, the region of the model is divided into three parts: the input of the control block (Input), the output of the control block (Output), the limitations (Restrictions). In the input and output sections, the names of the usual input and output variables are given respectively. The rectangles contain the names of the linguistic variables and the arrows indicate the relationship between the usual and the corresponding linguistic variables. Dashed lines depict the generalized influence of input linguistic variables on the formation of the values of output linguistic variables, which will need to be taken into account when a fuzzy output of the fuzzy output knowledge base is formed. In the part of the diagram, which corresponds to the limitations of the problem, in the form of rectangles with rounded corners there are restrictions.

For each restriction, a name that reflects its physical meaning is indicated, and the usual variables that are part of the restriction are listed. In the future, for each linguistic variable, it is necessary to detail its structure.

A detailed description of the structure and characteristics of each linguistic variable occurs in its graphical model. The general form of a model of a linguistic variable in accordance with its classical definition [1] is shown in fig. 2.

As shown in fig. 2, the linguistic variable is represented as a frame. The first field specifies the name of the linguistic variable and then indicates whether it is an input or output variable. The following are

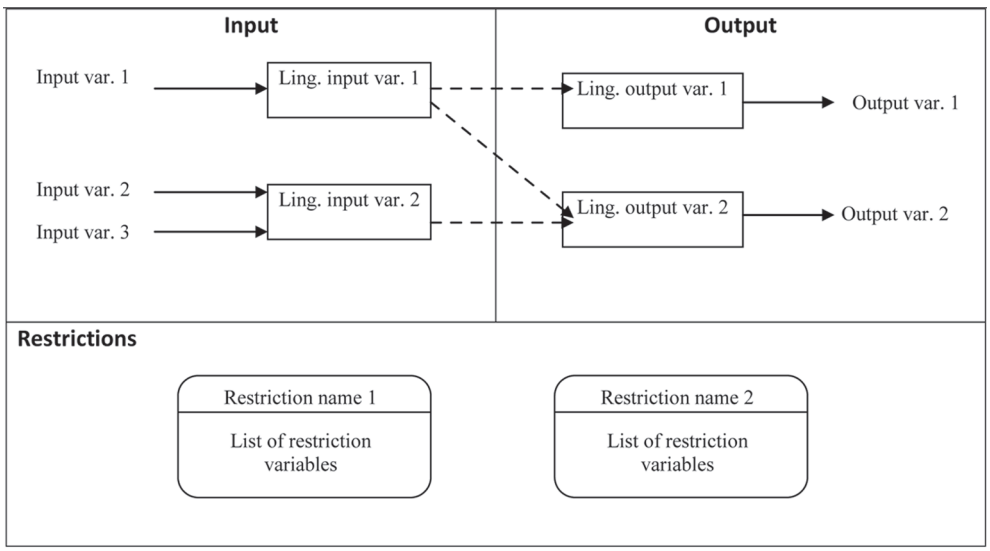

Fig. 1. An example of a conceptual model of the task of fuzzy control

Linguistic variable name	
Type	Input/ Output
Block of variables	
Name of usual variable	A set of valid values
Block of terms	
Term name	Characteristic of affiliation function
Description of new terms forming procedure	
Description of term affiliation forming procedure	

Fig. 2. A generalized model of a linguistic variable model

the names of ordinary variables, which correspond to this linguistic variable, as well as their domain of admissible values, thus defining a universal set of linguistic variables. The next block of the model is the set of terms of the linguistic variable. The names of the terms and a characteristic of their membership functions are given. If applicable, additionally defined a description of the procedure for the formation of new terms of the variable and the procedure for determining their affiliation functions.

Based on the relationships between the linguistic variables presented in the conceptual model of the problem of fuzzy control and the models of linguistic variables, the rules of the knowledge base of fuzzy output in the form of fuzzy products are formed, for presentation of the structure of which a model is proposed, an example of which can be seen in fig. 3.

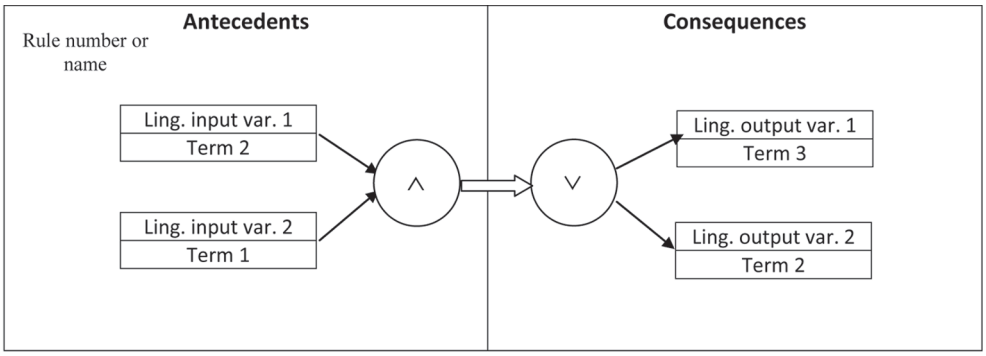

Fig. 3. An example of structure model for a fuzzy rule inference

From fig. 3 it is clear that the model structure of the rule is divided into two parts: antecedents and consequences. In the part of the antecedents, the linguistic variables and their meanings (terms) are indicated as rectangles. Antecedents are combined into complex structures by means of logic operations of conjunction and disjunction, which are presented in the form of circles with an appropriate mark of the operation. The logical structure of antecedents can be complex, formed as a result of several logical operations with different levels of embedding. A wide arrow indicates the end of the conditional part of the rule and the transition to the output.

The structure of the conclusion of the rule is based on principles analogous to the conditional part but mirrored. Initially, a logical operation is performed, which will be performed by the last of the consequences, and then the consequences themselves. The structure of the final part of the rule can also be complicated. However, in most models of fuzzy output, it is assumed that only a logical operation of the conjunction is used to combine antecedents or consequences.

Conclusions

Thus, the paper proposes models for a formal description of the problem of fuzzy control in the form of graphic schemes. The models include a conceptual model of the control task, a model of linguistic variables, and a model of the structure of fuzzy output rules. The use of these models allows us to provide information about the fuzzy control task in terms of the subject area, that provides an increase in the effectiveness of its consideration as a customer and implementer. Application of results is possible during the development of information technology for tasks automation for managing complex systems based on fuzzy logic.

Refrences

*1. **Zadeh L. A.** Fuzzy sets // Information and Control. 1965. Vol. 8. P. 338–353.*

*2. **Ma Z. M., Li Yan.** A Literature Overview of Fuzzy Conceptual Data Modeling // Journal of information science and engineering. 2010. № 26. C. 427–441.*

*3. **Peter Pin-Shan Chen.** The Entity-Relationship Model – Toward a Unified View of Data // ACM Transactions on Database Systems (TODS). 1976. Vol. 1. P. 9–36.*

*4. **Буч Г., Рамбо Д., Якобсон И.** Краткая история UML // Язык UML. Руководство пользователя = The Unified Modeling Language Usere Guide. 2006. С. 14. 496 с.*

*5. **Дубовик С. Е., Сошников Д. В.** Использование семантических сетей, расширенных деревьями И/ИЛИ для представления структурно-динамических знаний в интеллектуальных системах // Электронный журнал Труды МАИ. 2003. № 13.*

*6. **Леоненков А. В.** Нечеткое моделирование в среде MATLAB и fuzzyTECH. 2005. 736 с.*

*7. **Лямец В. И.** Основы общей теории систем и системный анализ. 2015. 304 с.*

*8. **Маклаков С. В.** Создание информационных систем с AllFusion Modelling Suite. 2003. 432 с.*

*9. **Шушура О. М., Тарасова І. О.** Метод нечіткого управління на основі змінних з многомірними функціями приналежності // Штучний інтелект. 2010. № 1. С. 122–128.*

*10. **Шушура А. Н., Тарасова И. А.** Синтез структуры и алгоритмов системы нечеткого управления с использованием функций принадлежности нескольких аргументов // Universum: техн. науки: электрон. науч. журн. 2014. № 4(5). URL:*

http://7universum.com/ru/tech/archive/item/1259

Рецензент: доктор техн. наук, професор **М. І. Сидоренко**, Інститут радіофізики та електроніки НАН України, Харків.

О. М. Шушура

ІНФОЛОГІЧНЕ МОДЕЛЮВАННЯ ПРЕДМЕТНИХ ГАЛУЗЕЙ ІНФОРМАЦІЙНИХ СИСТЕМ ПРИ РОЗВ'ЯЗКУ ЗАДАЧ НЕЧІТКОГО УПРАВЛІННЯ

Розробка інформаційних технологій для розв'язку задач нечіткого управління потребує використання засобів інфологічного моделювання. Існуючі методології інфологічного моделювання, до яких можна віднести IDEF, UML, DFD, ER, Fuzzy IFO та ін., орієнтовані передусім на опис процесів, структур даних та класів і не враховують специфіку задач нечіткого управління. У статті запропоновано підходи до створення графічної концептуальної моделі задачі нечіткого управління, моделей лінгвістичних змінних та структури правил бази знань у вигляді нечітких продукцій. Результати роботи можуть бути використані при розробці інформаційних технологій для автоматизації завдань керування складними системами.

Ключові слова: інформаційна технологія; інфологічне моделювання; нечітке управління.

А. Н. Шушура

ИНФОЛОГИЧЕСКОЕ МОДЕЛИРОВАНИЕ ПРЕДМЕТНЫХ ОБЛАСТЕЙ ИНФОРМАЦИОННЫХ СИСТЕМ ПРИ РЕШЕНИИ ЗАДАЧ НЕЧЕТКОГО УПРАВЛЕНИЯ

Разработка информационных технологий для решения задач нечеткого управления требует использования средств инфологического моделирования. Существующие методологии инфологического моделирования, к которым можно отнести IDEF, UML, DFD, ER, Fuzzy IFO и др., ориентированы в первую очередь на описание процессов, структур данных и классов и не учитывают специфику задач нечеткого управления. В статье предложены подходы к созданию графической концептуальной модели задачи нечеткого управления, моделей лингвистических переменных и структуры правил базы знаний в виде нечетких продукций. Результаты работы могут быть использованы при разработке информационных технологий для автоматизации задач управления сложными системами.

Ключевые слова: информационная технология; инфологическое моделирование; нечеткое управление.

ЗВ'ЯЗОК

Наукове видання

Редакційна обробка та коректура
О. П. Бондаренко, Т. В. Ількевич

Комп'ютерна верстка та дизайн
Г. С. Тимченко

Відповідальний за випуск
І. І. Тищенко

Формат 60×84/8. Папір друкарський.
Гарнітура SchoolBookC, EuropeCond. Зам. 639
Наклад 300 прим.

Державний університет телекомунікацій
03110, м. Київ, вул. Солом'янська, 7
Тел. (044) 249-25-75
E-mail: *zviaz-ok@ukr.net*