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ON ONE APPROACH TO THE FORMATION OF THE USER INTERFACE WITH THE EXPERT SYSTEM

ПРО ОДИН ПІДХІД ФОРМУВАННЯ ІНТЕРФЕЙСУ КОРИСТУВАЧА З ЕКСПЕРТНОЮ СИСТЕМОЮ

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Abstract. *The paper presents the results of integrating the chatbot @ribs karkas bot and the chatbot @es economy karkas bot with an expert system for organizing online consultation. A description of the architecture and implementation of the chatbot messenger Telegram in an expert system based on the system "KARKAS" – a tool for building models of knowledge bases. The structure of the interaction of chatbot and agents of the expert system in the online mode is considered. An analysis of the possibilities of creating chatbots in the TELEGRAM messenger, their integration with system experts in the field of economics.*

Key words: *chatbots, agents, messages, knowledge base, expert system.*

Introduction.

In the business environment, the free Telegram messenger has become the corporate communication standard. This is due to the following reasons: a high degree of data encryption in it, stability of work, the ability to transfer large amounts of information, openness of the protocol, cross-platform.

On the other hand, what is very important for integrating the Telegram messenger with other applications is that the developers provide an API-based library for working with chatbots.

A bot (chatbot, interlocutor) is a program that simulates human communication based on elements of artificial intelligence. Today bots can communicate with each other to achieve their goals in other words, they can be used as agents in multi-agent systems [1].

One of the first programs implementing the concept of a chatbot was the "ELIZA" program, which mimicked the behavior of a psychotherapist during the initial interview of a patient [1]. The idea of implementing this program was to find in the text of the communication of keywords or messages in order to ask a question to maintain a dialogue with the interlocutor. If the keyword is found in the database, then the question to the interlocutor was asked in accordance with a pre-prepared template question or the statement of the interlocutor turned into a question. If the word combination is not found, then the program asked the interlocutor general questions, such as "Why do you think so?".

There are several strategies for implementing such a dialogue:

1. The interlocutor's question is selected from the list of questions related to the keyword, according to the higher frequency of use of the question in the subject area.

2. The bot collects questions and phrases used by interlocutors, thus learning and increasing their subject area content.

3. Syntactic approach based on grammatical analysis of the interlocutor's phrase and provided with rules of the form "if".

Naturally, the disadvantage of such communication was not quite a logical dialogue between the bot and the interlocutor. The interlocutor had the illusion that the bot understood him, although in reality this was not the case. In other words, the chat bot lacks the implementation of interaction with the output machine, as is widely used in expert and expert training systems [1].

In recent decades, with the advent of the smartphone, the concept of artificial intelligence has become increasingly popular with regard to messaging applications. The global chatbot market will grow in the coming years. One of the main advantages of chatbots in customer service is that the interlocutors are free to ask questions that they would not ask a support representative or company manager. In addition, the bot is able to answer questions instantly.

Chatbots are usually integrated into dialog systems, such as virtual assistants, giving them the ability to communicate naturally or engage in casual conversations unrelated to areas of their core expert systems.

In most cases, chatbots use messaging programs to communicate with customers. The person can type or ask a question, and the chatbot will answer the correct information. Depending on the situation, many chatbots can learn from what the client says to personalize the interaction and build a preliminary interaction.

The chat bot can be considered as a question-and-answer system (QA-system) with elements of machine learning, namely with functions of parsing of natural language, the machine of a logical conclusion and the module of communication with external applications. An important problem for chatbots of QA-systems is the creation of a logic output machine that determines the relevance of knowledge in a given question.

This paper [2] presents experience in implementing a chatbot for expert recommendation tasks. The chatbot was developed as an expert recommendation a system to help developers find the right person to contact in open source projects. Chatbot targets the Pharo software ecosystem and developer community and is integrated with the chat service Discord, which the Pharo community uses as one of its main communication channels.

The article [3] discusses the need to design interactions in networks of people and intelligent machines.

The article [4] discusses the issues of integrating bots into chat platforms for developers.

This article [5] explores the concept of a "repair bot" and introduces Repairnator. The Repairnator bot is a standalone agent that continuously monitors test failures, reproduces bugs, and runs program repair tools for every bug that is reproduced. If a patch is found, the Repairnator bot informs the developers about it.

Main text.

The paradigm of integrating chatbots to work with expert systems is now becoming increasingly important [2].

Using the API Telegram library, the bot @ribs_karkas_bot was created for online user consultation with a tool for creating knowledge bases with the "KARKAS" system [6 – 9].

Telegram messenger chat bots, as interlocutors, when working with the "KARKAS" system give more opportunities to consult with the expert system via a smartphone, which, for example, is important for effective decisions in various subject areas such as medicine, ecology, business. In other words, you can now send a text message to the bot @ ribs_karkas_bot (a bot to determine the risk of coronary heart disease) and get the necessary information immediately, that is, to conduct a consultation in real time. The content of the chatbot /help command is shown in (Figure 1).

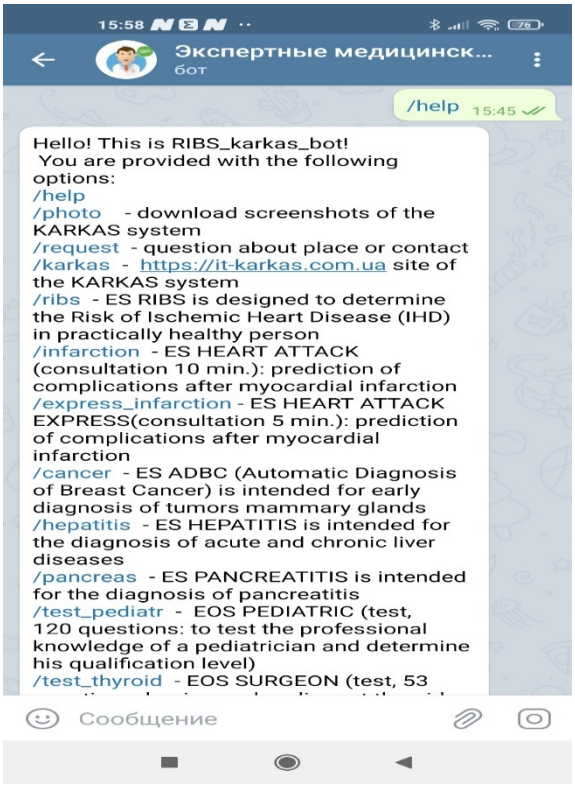

Figure 1 - Type of command /help @ribs_karkas_bot

Authoring

The @ribs_karkas_bot bot allows for online consultation with the following prototypes of expert systems:

- the "RIBS" system [3 – 6] is designed to determine the risk of coronary heart disease (RCHD) in a practically healthy person. The relevance of the development of the system lies in the fact that at present in medicine there is a clearly expressed process of transition to the concept of RCHD prevention, then there are concepts of risk factors associated with the lifestyle of a particular patient. The purpose of the system is to recognize the presence of risk factors for coronary heart disease with an emphasis on the patient's individual lifestyle, using the knowledge of experts. behavior, the degree of social and psychological support, the level of physical activity, the degree of adequacy of rest;

- "HEART ATTACK" system [3 – 6] helps doctors diagnose heart attack

patients, assess their condition and predict the development of the following complications in myocardial infarction, fibrillation, acute left ventricular failure, chronic heart failure, arrhythmias, thromboembolism, myocardial rupture, re-infarction. inference implements Bayesian decision making Consultation with the "INFARKT" expert system in case of 28 symptoms takes 10 minutes, and the option of express consultation (7 symptoms) takes 3 minutes;

- "HEPATITIS" system [3 – 6] is intended for diagnostics of acute and chronic liver diseases. The system allows: to recognize the cause of liver disease and, if possible, by eliminating it, to obtain a therapeutic effect, to purposefully include medications for the treatment of liver diseases, to conduct a statistical assessment of therapeutic measures in patients;

- system "ADBC" [3 – 6] (automatic diagnosis of breast cancer) is designed for early diagnosis of breast tumors. Diagnostics is based on the knowledge of an expert oncologist, which are grouped into the following sections: thermography, anamnesis, physical examinations, echotomography. to classify such tumors: lipoma, fibroadenoma, fibrocystic mastopathy diffuse; fibrocystic mastopathy localized, mastitis.

The bot @es_economy_karkas_bot allows online consultation with the following prototypes of expert systems:

1. The command / fa calls the prototype EC to analyze the financial condition of the enterprise, designed to improve the quality of the result of the assessment of the financial condition of the enterprise.

2. The command / finsost calls the EU prototype to analyze the financial condition of the enterprise (critical, unstable, stable, promising).

3. The team / bank_commercial calls the EU prototype to select a bank for financial services to the company.

4. The command / insurance_company calls the prototype EC to select the insurance company.

5. The command / credit_insurance calls the prototype EC to insure commercial loans.

6. The / creditworthiness command calls the EC prototype to determine the borrower's credit class.

7. The / enterprise_strategy command calls the EC prototype to select the enterprise strategy.

8. The / product_suppliers command calls the EC prototype to select product suppliers.

9. The / product_competitiveness command calls the EC prototype to assess the competitiveness of the product.

When calling the command / bank_commercial, a prototype EC is called to select a bank for financial services to the enterprise.

The purpose of the EC prototype is to advise on the selection of a commercial bank for financial services to the enterprise.

The scope of the EC prototype is a variety of companies that need financial services from banks.

The purpose of the prototype of the EC - the selection of the most optimal option

for the bank's financial services to the company depending on its needs for cash-settlement, credit, deposit and trust operations.

Initial data:

- for the analysis of activity of the enterprise production, sale, purchasing activity, presence or absence of free money is used;
- to determine the bank's solvency, the bank's own funds and assets are used;
- to determine the bank's liquidity, funds on current, current and deposit accounts are used.

Expected results (list of possible values of the purpose of the consultation):

- requirements for financial services of the enterprise - is the urgency of cash payments, forms of cash payments (cash, non-cash), deposit, credit, cash-settlement or trust transactions;
- requirements for banks - solvent or insolvent, liquid or illiquid bank.

Subject area identification. The following economic standards set by the National Bank of Ukraine and determining the reliability of this bank are mandatory for each commercial bank:

- bank solvency;
- balance sheet liquidity indicators;
- the maximum amount of risk per borrower;
- the amount of required reserves placed with the National Bank of Ukraine (Figure 2).

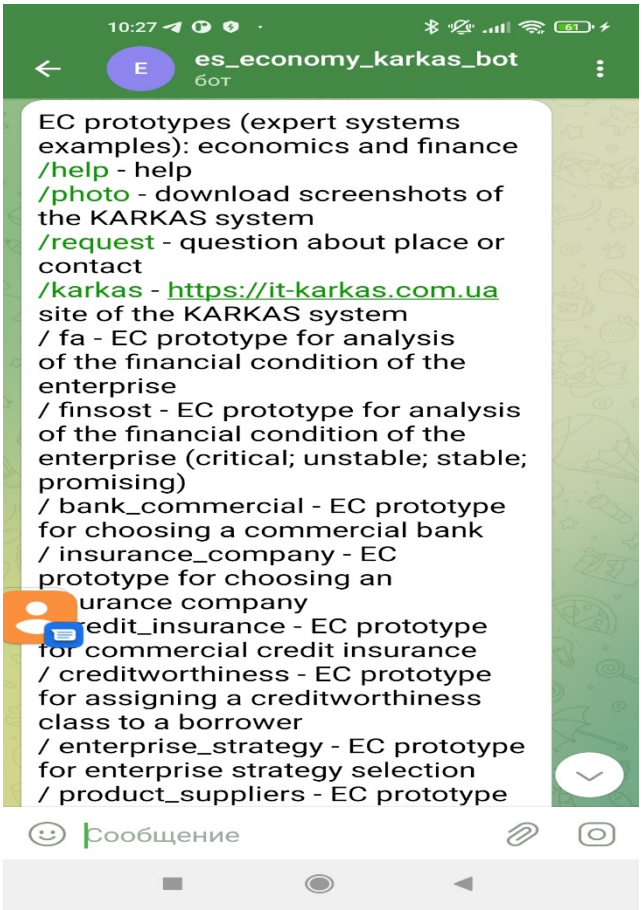

Figure 2 - Type of command / help @es_economy_karkas_bot

Authoring

When choosing a commercial bank, the company usually relies on the following indicators:

- bank reliability;
- which form of payment is suitable for the company: cash or non-cash;
- operations that the company wants to carry out;
- form of payment desired by the enterprise.

The "KARKAS" system is a toolkit for developing prototypes of knowledge bases for expert and expert training systems. Knowledge representation is based on a hierarchical functional system generated by the "KARKAS" system on the basis of production rules and frames. The inference engine uses a hierarchical functional system in consultation with the user. The user can choose different modes of operation of the inference machine: using direct inference, backward inference, indirect inference, Bayes' formula, criteria tables, when the production consequent is a list of parameters.

The online consultation module (interlocutor) allows using the Telegram messenger to exchange messages with the knowledge bases of the "KARKAS" system via the Internet, that is, to carry out a consultation in real time. Note that the formation of the knowledge base and its configuration is carried out on the local computer.

Telegram messenger has millions of active users and is the fastest messaging application. It works on all devices on mobile and desktop platforms.

The "KARKAS" system is a tool for building knowledge base models. The structure of the subject area can be varied, for example, the choice of a solution among a certain set of options, the use of unreliable knowledge. The "KARKAS" system allows both to develop models of knowledge bases and can be used for testing and teaching students over a local network. The "KARKAS" system using chat bots: @es_economy_karkas_bot, @test_karkas_bot allows online consultation with users and testing of students' knowledge from different subject areas: computer graphics, database technologies, web analytics, business intelligence systems.

The "KARKAS" system is built on a modular basis and for this reason it has the ability to connect other additional modules. The following main modules can be distinguished in the system architecture: loader; visual editor for developing knowledge base models; offline and online consulting agent; data clustering module.

The loader launches the system and coordinates the interaction of all modules. The visual editor of knowledge base models allows you to create for expert and expert training systems: questions with answers, products, frames, knowledge base filtering, a hierarchy of knowledge base classes, a hierarchical functional system. It is possible to post the knowledge base on the site https://it-karkas.com.ua.

The consultation agent contains the following components: an inference engine, an explain block, a test analyzer, a notice board, a fact base monitor.

The data clustering module allows for interactive and intelligent data classification. To test the user's knowledge, a test generator is used to control the conduct of tests - the teacher's monitor.

System modules are presented in the form of software passive agents (their interaction is carried out using arrays of parameters and through the common computer memory). The environment of their interaction is the "KARKAS" system.

Functional system is a system formed to achieve a given useful result (objective function) in the process of its functioning. Its system-forming factor is a specific result. In other words, the goal is seen as a given result, and the restriction - as a degree of freedom necessary to achieve the result.

A distinctive feature of functional systems - in their openness, not autonomy, not isolation from the environment. Non-autonomous differential equations serve as a mathematical model describing the evolution of such systems.

For example, a functional system can be thought of as a set of functions with some set of operations applied to those functions. The role of functions is played by the rules of the knowledge base, and the main operations are the comparison of the attribute with the sample and the definition of the conditions of applicability of the rules.

The functional system is characterized by the following properties:

- connectivity (chain of knowledge base bundles),
- complexity (hierarchy of levels of local knowledge bases),
- stability (adaptive behavior of the system) - the structure of the oriented graph of the functional system does not change with vertical perturbations of the rules. In other words, only the values of the antecedents of the rules for the local knowledge bases of the bundle chain are changed, and the bundle base, which is interpreted as the external environment, remains unchanged [4].

Such components as a visual editor of knowledge base models, a hierarchical functional system, an inference engine, an explanation block, a knowledge base filtering block are common to the listed modules and act as tools for the functioning of the modules.

The system has two modes of use:

1) the mode of a cognitologist - a specialist, simulates the ontology of the subject area and constructs a model of the knowledge base;
2) the mode of a problem specialist (the user's qualifications are not high enough, and therefore he needs help and support for his activities from the system).

The system combines various approaches to building knowledge-based systems (Table 1).

Table 1 -The components of the system "KARKAS"

Expert systems	Expert learning systems	Multi-agent systems
The visual knowledge base editor	The learning	The agents help
The hierarchical functional system	The testing, intelligence tests	The chatbots: @ribs_karkas_bot, @test_karkas_bot, @es_economy_karkas_bot
The inference engine, the explanation block	The teacher monitor	

Authoring

The components of the system are interconnected, exchange information and allow to adequately reflect the ontology of the subject area during its operation.

The integration of the chatbot with the consultation module of the "KARKAS"

system consists in the exchange of messages between them, that is in the transmission and reception of requests to work with Telegram servers.

The connectivity of the functional system is expressed in the filtering of the database.

Let it B_i be a local knowledge base, it contains product rules for determining the subgoal G_i, which is at the i-th level in the hierarchy of the functional system. Knowledge base filtering is the ultimate system of local knowledge bases B_i (1)

$$B_0 \prec B_1 \prec ... \prec B_i \quad (1)$$

partially ordered ($\prec$) as follows: the consequent of each rule from B_i is contained in the antecedent of the rule B_{i+1}.

To build a knowledge base filtering it is enough to specify a chain of rules of a hierarchical functional system to achieve the main goal. Then, with the help of a recursive algorithm, other rules for local functional system of knowledge bases are built by generating rules during consultation with an expert.

The expert analyzes the rules provided by the agent of the functional system and can place the created rules in the local knowledge base at the appropriate level of the hierarchy of the functional system, or prohibit its use, or allow its use for some time. Thus, with the help of the knowledge base filtering algorithm, both the replenishment of local knowledge bases and their adaptation to the subject area are carried out. The number of local knowledge bases corresponds to the levels of the hierarchical functional system.

Thus, the knowledge base of the subject area is considered as a hierarchical functional system, in which the result has an organizing effect on all stages of ontology formation. Classes and connections between them can be considered as a logical construction of a hierarchical functional system. The hierarchical structure of the database allows the inference machine to achieve a local goal at each level of the hierarchy and, accordingly, a global goal.

The physical model of the knowledge base stores instances of classes, objects, values of attributes of objects and logical connections between classes, objects.

The concept of ontology in artificial intelligence is identical to the concept of knowledge base and is based on classes, instances of classes, the relationship between them. An important problem of ontology is the modeling of the logical conclusion.

The inference engine of the "KARKAS" system uses a hierarchical functional system during the consultation with the user. The user can choose different modes of operation of the inference machine: the use of direct inference, inverse inference, indirect inference, Bayesian formula, table of criteria, when the consequent product is a list of parameters.

Integration of the chatbot with consultation and dialogue modules of the "KARKAS" system consists in the exchange of information between them without user participation, as well as the transmission and reception of requests to work with TELEGRAM servers using TELEGRAM API and JSON from secure HTTPS protocol (Figure 3).

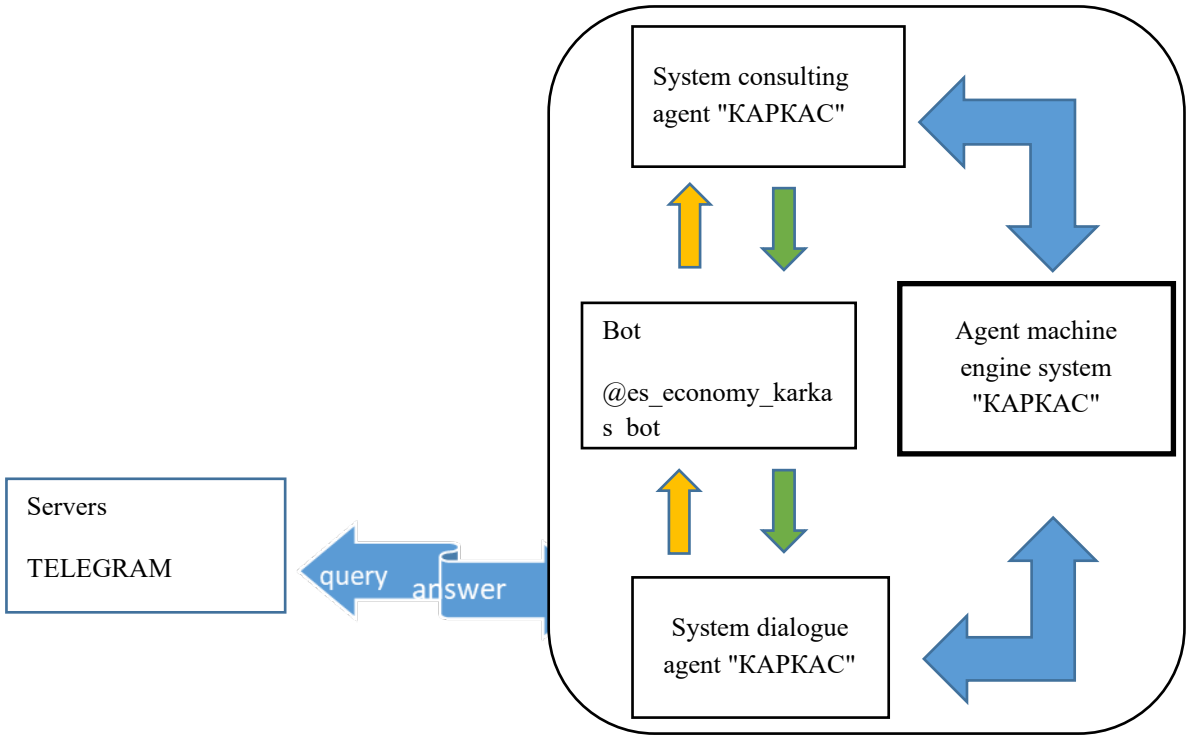

Figure 3 - Chat bot integration architecture with "KARKAS" system

Authoring

The following components are used to work with requests to TELEGRAM servers:

1. The superobject library is used to pars JSON objects.
2. Indy 10 library was used to send http requests and download ftp knowledge bases from https://it-karkas.com.ua.
3. The TelegAPI library is used to work with TELEGRAM servers.

The module of online consultation (interlocutor) of the "KARKAS" system allows to exchange messages with knowledge bases via the Internet by means of the Telegram messenger.

Consultation and dialogue agents exchange messages with each other to perform the following operations:

1. Pressing: buttons, check boxes, radio buttons.
2. Transmission and reception of messages between visual objects on the form.

Thus, the above modules perform the functions of agents and in this sense, the implemented chatbot @ribs_karkas_bot in the system "KARKAS" can be considered as a multi-agent system.

Transmission and reception of consultation agent messages.

1. You can activate the application (ribs_karkas_bot.exe) that launches the bot on a resource that has access to the Internet (hosting, home computer). Then run it in the Telegram messenger: @ribs_karkas_bot. Type commands /help or /start bot and the bot will offer to select commands to run expert systems, tests (Figure 1).
2. For example, when you select the /ribs command, the following operations are performed:

- the ribs.knb knowledge base is downloaded from the website https://it-

karkas.com.ua;

- the consultation module is executed and the inference engine of the conclusion of expert system is started;
- the dialogue module is activated.

3. The result of the consultation of the expert system is transmitted to the bot on a broadcast protocol.

Thus, the algorithm of the chatbot @ribs_karkas_bot consists of the following steps:

Step 1. Activate the chatbot @ribs_karkas_bot in the Telegram messenger.

Step 2. Select the commands: /help or /start, then, the /ribs command calls the expert of system prototype to select the risk of coronary heart disease.

Step 3. The bot launches the consulting agent of the "KARKAS" system.

Step 4. The inference engine of the "KARKAS" system is activated.

Step 5. The hierarchical functional system is formed for dialogue with the user.

Step 6. The dialog agent is activated, which sends the bot a message with the text of the question and answers. The bot receives the message as a JSON object, performs its parsing, displays the message in the chat and waits for the user's response.

Step 7. The user in the chatbot selects or enters the answer. The bot sends the response to inference engine of the expert system's.

Step 8. The expert system consulting agent receives the message and transmits it to the inference engine, which transmits the message to the dialogue agent. The purpose of the consultation is specified, based on a hierarchical functional system, during the dialogue with the user.

Step 9. The iterative consultation process continues until the inference engine receives the result from the expert system. The user can terminate the consultation with the /quit command at any time.

The dialogue diagram of the chat bot and the expert system is shown in (Figure 4).

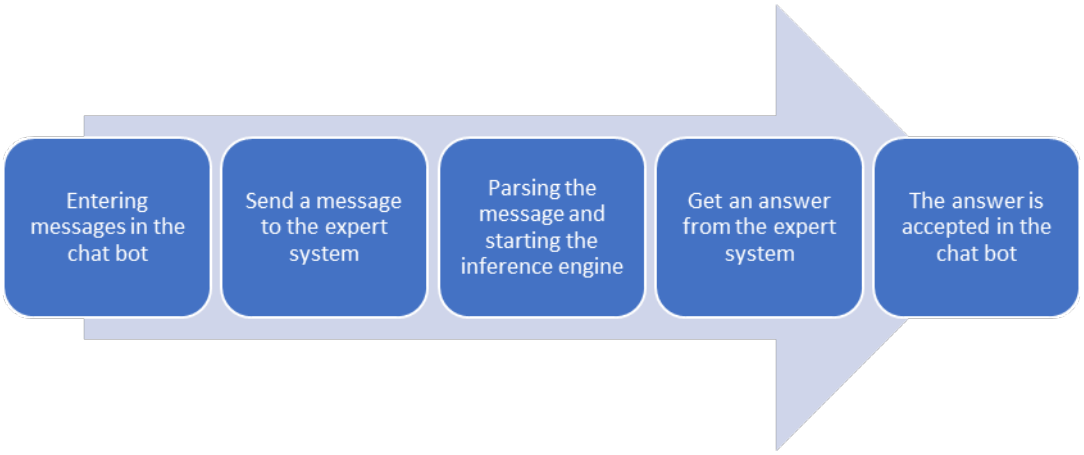

Figure 4 - Interaction of chat @ribs_karkas_bot with expert system

Authoring

One of the current trends in the development of the mobile application market is the development and adaptation of mobile applications that perform the functions of expert systems. Figure 5 shows a view of the user interface for a mobile expert system RFCHD for the Android and IOS platforms.

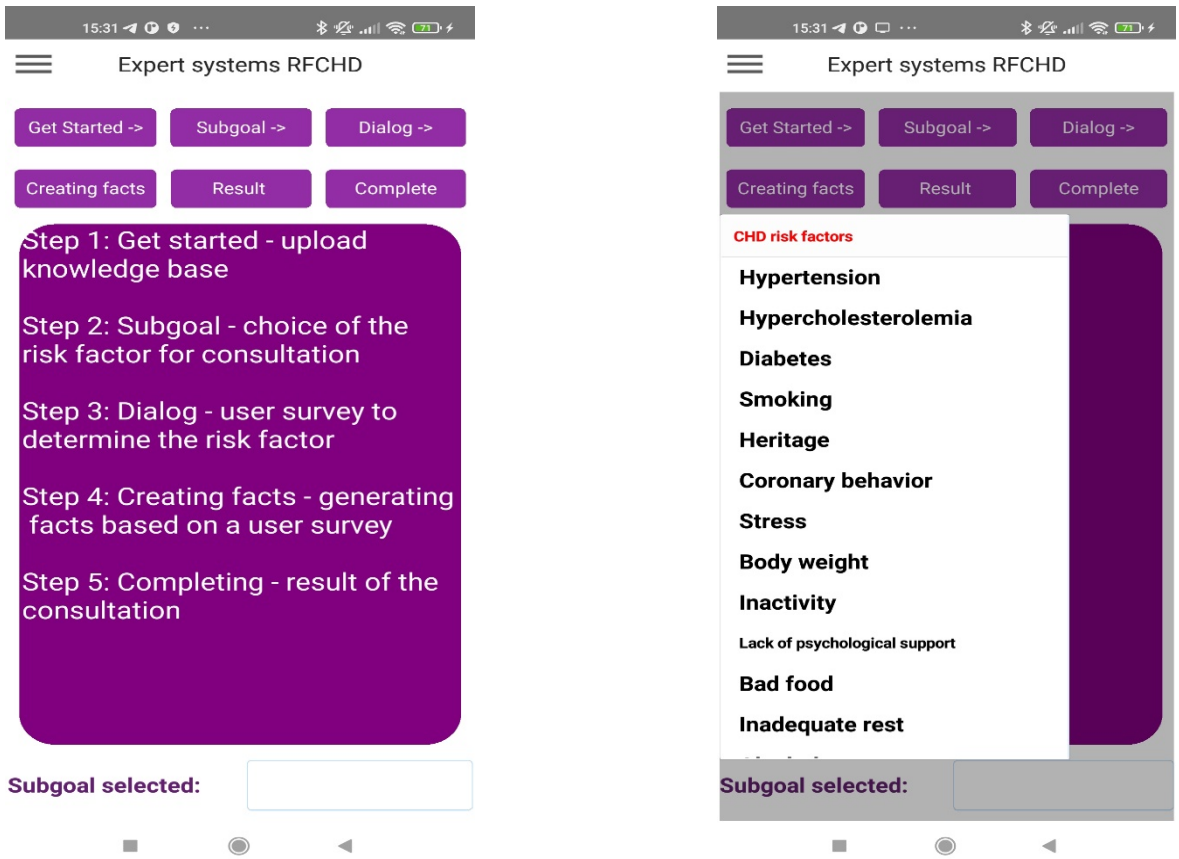

Figure 5 – The mobile expert system RFCHD for the Android and IOS platforms

Authoring

Summary and conclusions.

Have been considered the @ribs_karkas_bot chatbot and @es_economy_karkas _bots is integrated into the "KARKAS" system.

Were received the @ribs_karkas_bot chatbot which allows online consultation with the "RIBS" expert system to determine the risk factor for coronary heart disease.

The paper presents the results of integrating the chatbot @es_economy_karkas _bot with an expert system for organizing online counseling. The algorithm of interaction of chatbot and agents of expert system in the online mode is considered.

As a result, a fully functioning chatbot @es_economy_karkas_bot was created, which is integrated into the "KARKAS" system and allows online consultation with prototypes of expert systems in the economic and financial subject area. After deploying the program, it is planned to significantly expand the functionality of the bot.

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Анотація. *В роботі представлені результати інтегрування чат-бота @ribs karkas bot та @es economy karkas bot з експертною системою для організації консультування в режимі онлайн. Опис архітектури та реалізації месенджера чат-бота Telegram в експертній системі на базі системи «KARKAS» – інструменту для побудови моделей баз знань. Розглянуто структуру взаємодії чат-бота та агентів експертної системи в онлайн-режимі.*

В результаті був створений повністю функціонуючий чат-бот @es economy karkas bot, який інтегрований в систему «КАРКАС» і дозволяє в режимі онлайн проводити консультацію з прототипами експертних систем в економіко-фінансовій предметній області. Після розгортання програми планується значно розширити функціональність бота.

Система «КАРКАС» являє собою інструментарій для розробки прототипів баз знань для експертних і експертно-навчальних систем як в офлайн, так і онлайн режимах на смартфонах. Подання знань ґрунтується на ієрархічній функціональній системі, яка генерується системою «КАРКАС» на базі правил продукцій і фреймів.

За допомогою системи «КАРКАС» розроблений ряд прототипів ЕС в наступних предметних областях: медицина, економіка, мобільний зв'язок і кластерний аналіз багатовимірних даних.

Система «КАРКАС» за допомогою чат-ботів: @Ribs_karkas_bot, @es economy karkas bot, @es info tech karkas bot, @test karkas bot дозволяє проводити онлайн консультацію з користувачами і тестування знань студентів в різних предметних областях: комп'ютерна графіка, технології баз даних, веб-аналітика, системи бізнес-інтелекту.

Ключові слова*: чат-боти, агенти, повідомлення, база знань, експертна система.*

sent: 23.06.2022