Algorithmic support of a personal virtual assistant for automating the processing of client requests

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Abstract—This article describes creating algorithmic support for the functioning of a personal virtual assistant, which allows automating the processing of customer requests. The study aims to reduce errors and processing time for a client request in business systems – text chats or voice channels using a text transcription system. The results of the development of algorithmic support and an assessment of the quality of work on synthetic data presented.

Index Terms—virtual assistant, natural language processing, request processing automation, algorithmic support

I. INTRODUCTION

Personal virtual assistants have gone through a development path of several decades – from text recognition and transcription systems to multifunctional software agents using technological advances in artificial intelligence [1]. In 2022, personal virtual assistants perform tasks for the end user and are used in business services, such as: virtual operators, automatic response systems, smart devices, voice assistants, interactive voice menu [2]. Personal virtual assistants focused on the end user are being introduced into software systems of business systems. Using personal virtual assistants in systems for automated processing of client requests allows businesses to build new user interaction scenarios, improve business metrics based on resource optimization and influence on technological, temporal, economic and behavioral factors [3]. Such possibilities of use served as a rationale for the need for algorithmic support for a personal virtual assistant.

Thus, the technological connection of personal devices, multimedia devices and virtual assistants has opened great opportunities for business: there are integrations with music and video services, Internet sites, mobile applications. Personal virtual assistants gained an image, character, and they tried to bring interaction with them closer to interaction with a person.

The development of personal virtual assistants has made it possible to expand the range of possibilities for using assistants in solving business problems, to ensure communication between business and the end user as if communication were built between two people. The performance of not only routine daily tasks, but also complex business logic, assigned to personal virtual assistants, has created a demand for application in all areas of business.

II. VIRTUAL ASSISTANT IN REQUEST PROCESSING SYSTEMS

Interaction with a virtual assistant can be carried out using various communication channels, such as sending text requests, voice requests, downloading images or a video stream [4]. However, speaking about the processing of requests in an automated request processing system, we abstract from the request, delegating the transformation of information coming from the end user into a textual and indicative form. For what tasks can a virtual assistant be used? The answer to this question appears based on the needs of the business and the vision of the product in which the virtual assistant will be used. An increase in business metrics creates criteria that a personal virtual assistant must meet, what functionality it must have, and what tasks it must provide. Of course, the first requirement for a modern personal virtual assistant is effective interaction with the end user, receiving and processing requests. Such basic functionality can already be adapted to solve typical tasks, and the system itself is scaled to match the loads in terms of the number of requests in an automated system. Thus, a list of basic application possibilities appears:

1) Reception of user requests in the communication channel of the business area.
2) Processing and transformation of a user request into a standardized machine-understandable form.
3) Passing the converted request to the associated software system.
4) Sending a response to the end user in the business area communication channel.

Such basic capabilities of a personal virtual assistant can already be applied to communication with the end user, transferring all interaction into the communication channel required by the business.

Thus, the concept of using a personal virtual assistant in a system for automated processing of client requests implies the interaction of the end user with a certain software agent that performs the functionality of the system’s business logic to effectively perform business tasks in a specific area of activity, while the functionality of a personal virtual assistant is limited only by the vision of the product.
III. APPROACHES TO CLIENT DATA CLASSIFICATION FOR ALGORITHMIC SUPPORT

Linguistic features are an important criterion for classifying customer data. Since the specifics of interaction with a personal virtual assistant implies that the user sends a request in a text or voice channel, it becomes possible at the request processing stage to extract features from the textual representation of the user’s request. Such signs can be lexical, textual, and lexico-grammatical signs. According to such criteria, it becomes possible to classify user data, for example, by assigning a certain query complexity rating based on linguistic features, to analyze the user’s mood based on the words or phrases used in the query’s context, to remove repetitions or insignificant words by textual features for statistical analysis. When developing a personal virtual assistant, one should carefully consider the potential of linguistic feature analysis, as this may require the use of such approaches as those that have become popular today, approaches from the field of artificial intelligence [5].

IV. MODELING THE PROCESS OF OBTAINING AND ANALYZING DATA IN AN AUTOMATED SYSTEM

Let’s simulate obtaining and analyzing data in an automated system. Let’s imagine the model of receiving and analyzing data in an automated system as a chain of processes going from the stage of receiving a request from the user to sending a response to the user. First, the primary source of data from the end user is a user request to the system, transmitted in one channel of communication with a personal virtual assistant, whether it be a voice or text request. If communication takes place in a voice channel, it must present the data for further algorithmic processing in a form understandable for algorithmic support, in some machine representation. Speaking of such a machine representation, we can mean the translation of information in the natural language of the user into a textual or indicative form. Receiving information in this form from the user, it becomes possible to respond to the user’s request – to decide in an automated system that the user wanted to request and provide him with information or provide a service as part of a business service. For example, if a user requested from a personal virtual assistant an action from a business system in natural language, showing a specific action (“turn on”, “say”, “I have a question about ...”), the personal virtual assistant must answer the request or perform an action (turn on a specific service, answer a question, delegate decision making to another business system).

The event chain of processes for processing a user’s request by a personal virtual assistant, which shows the stages of applying algorithmic support to analyze the request, is shown in Fig. 1.

V. FORMATION OF A SET OF VIRTUAL ASSISTANT PROTOTYPE TECHNOLOGIES

A. Selection of software components for algorithmic support

The connecting link of the components that underlie the personal virtual assistant will be the programming language. Depending on the business service, the load and speed of the system play an important role, so most times it is worth considering the presented programming language options. In this article, the choice is made in favor of the Python programming language, since over the past decade it has proven to be effective, accelerating the creation of systems because of its syntax and a common solution for creating algorithmic support in many scientific and applied fields, as well as for creating software, in including for business [6]. An important factor in choosing this language is many of open-source software libraries accepted by the professional community for implementing algorithmic support based on approaches from the field of machine learning [7].

Speaking of open-source software libraries, there are some favorites among the libraries accepted by the professional community for implementing machine learning algorithms. Many large companies use the scikit-learn library to create software that uses machine learning algorithms and is also used in the scientific community for research and experimentation [8]. When working with user requests, it becomes possible to build algorithmic support that uses information about the request, for example, by processing the user’s natural speech in a textual representation. As an open-source library for working with natural language, we will use the fastText library developed by Facebook [9]. In the set of technologies, it is necessary to formalize the format for receiving and transmitting data, as well as the possibility of transferring data to the database. These can be generally accepted and common formats for storing and transmitting JSON or XML data, however, the choice of formats is not limited and may change based on speed or convenience reasons for storing data [10, 11].

Such a set of technologies already makes it possible to create a prototype of a personal virtual assistant that can solve the tasks of processing client requests, being integrated into an automated request processing system. For further development of a prototype of a personal virtual assistant, it is necessary to formalize the interaction of algorithmic support components. The scheme of interaction of the selected components is shown in Fig. 2.

B. Development of software for algorithmic support

After selecting the algorithmic components, software was written in Python to load, process, and classify natural language queries. The software is independent of the hardware platform being run and can be used on both Windows and Linux.

VI. RESULTS

The results of the work described creating algorithmic support for the functioning of a personal virtual assistant. We obtain the results of assessing the quality of the classification of queries on The 20 Newsgroups data set [12]. When running the two machine learning models, the weighted average value of the F1 metric was 82.5%. Fig. 3 show the results of classification in The 20 Newsgroups data set. It also obtained the running time of machine learning models. The running
Fig. 1. The event chain of processes for processing a user’s request by a personal virtual assistant.

time of the logistic regression models of 189 ms and the fastText model of 214 ms. These results show the applicability of the selected models in an industrial environment.

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| class | precision | recall | F1-score | support |
|-------|-----------|--------|----------|---------|
| 0     | 0.752     | 0.734  | 0.743    | 319     |
| 1     | 0.680     | 0.781  | 0.727    | 389     |
| 2     | 0.740     | 0.731  | 0.736    | 394     |
| 3     | 0.716     | 0.735  | 0.725    | 392     |
| 4     | 0.828     | 0.816  | 0.822    | 385     |
| 5     | 0.845     | 0.729  | 0.783    | 395     |
| 6     | 0.764     | 0.897  | 0.825    | 390     |
| 7     | 0.905     | 0.891  | 0.898    | 396     |
| 8     | 0.940     | 0.945  | 0.942    | 398     |
| 9     | 0.881     | 0.932  | 0.906    | 397     |
| 10    | 0.947     | 0.945  | 0.946    | 399     |
| 11    | 0.931     | 0.889  | 0.910    | 396     |
| 12    | 0.764     | 0.784  | 0.774    | 393     |
| 13    | 0.895     | 0.838  | 0.866    | 396     |
| 14    | 0.898     | 0.919  | 0.908    | 394     |
| 15    | 0.788     | 0.925  | 0.851    | 398     |
| 16    | 0.711     | 0.901  | 0.795    | 364     |
| 17    | 0.964     | 0.854  | 0.906    | 376     |
| 18    | 0.780     | 0.594  | 0.674    | 310     |
| 19    | 0.814     | 0.470  | 0.596    | 251     |

accuracy | 0.825 | 0.825 | 0.825 | 0
macro avg | 0.827 | 0.815 | 0.817 | 7532
weighted avg | 0.829 | 0.825 | 0.823 | 7532
Fig. 2. The scheme of interaction of the selected components.

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