ALGORITHMS AND SOFTWARE

METHODS OF INTELLECTUAL ANALYSIS OF PROCESSES IN MEDICAL INFORMATION SYSTEMS

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Methods of data mining and intelligent analysis of are investigated for the development of a mobile intelligent application "Emergency Medical Aid", which effectively solves the problems of information support for medical purposes in a particular emergency situation for the user.

With the help of Data Mining methods, a knowledge base for a personal assistant has been developed, which makes it possible to analyze indicators of a person's condition and draw conclusions regarding the diagnosis in the field of emergency medicine. The knowledge base presented allows us to apply the inference model with the possibility of using fuzzy rules.

To improve the efficiency of determining the diagnosis by the system using the Process Mining methods, models of the business process of the medical information system have been created, built on the basis of an artificially generated event log compiled with the involvement of experts in the subject areas of emergency medicine.

An intelligent application on the iOS platform that plays the role of a personal assistant for decision support is presented.

Keywords: *data mining, process mining, personal assistant, iOS, framework, medical services, emergency, algorithm.*

МЕТОДИ ІНТЕЛЕКТУАЛЬНОГО АНАЛІЗУ ПРОЦЕСІВ У МЕДИЧНИХ ІНФОРМАЦІЙНИХ СИСТЕМАХ

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Досліджено методи інтелектуального аналізу процесів, які протікають у медичних інформаційних системах. Вивчено методи видобутку даних та інтелектуального аналізу процесів для розробки мобільного інтелектуального додатку "Невідкладна медична допомога", який ефективно вирішує проблеми інформаційного забезпечення медичного призначення у конкретній надзвичайній ситуації для кінцевого користувача. Така задача є особливо актуальною через пандемію вірусу SARS-CoV-2.

Використано методи Data Mining, на основі яких розроблено базу знань для персонального асистента, що дає можливість аналізувати показники стану людини та робити висновки щодо діагнозу в галузі екстреної медицини. Розроблена база знань дає можливість застосувати модель умовиводу з можливістю використання нечітких правил.

Для підвищення ефективності визначення діагнозу системою з використанням методів Process Mining створені моделі бізнес-процесу медичної інформаційної системи. Для побудови таких моделей запропоновано використовувати штучно сформований журнал подій, що складений зі залученням експертів з даного предмета за напрямом невідкладної медицини. Під час створення моделей виконані такі етапи: отримання журналу бізнес-процесів, візуалізація графіків на основі результатів кластеризації журналу вихідних даних бізнес-процесів, нова генерація журналу подій на основі отриманого графіку та створення моделі на основі штучного журналу бізнес-процесів.

Представлено інтелектуальний застосунок на платформі iOS, який виконує роль особистого асистента для підтримки прийняття рішень. У програмному застосунку реалізовані такі функції:

– швидка допомога швидкого набору, перегляд карти медичних установ на геолокаційні карті користувача; можливість вимірювання пульсу. Застосунок має мінімалістичний інтерфейс, що дозволяє скоротити час, необхідний для пошуку правильного діагнозу.

Ключові слова: *добування даних, добування процесів, персональний асистент, iOS, фреймворк, медичні сервіси, аварійна ситуація, алгоритм.*

Introduction. Mining data and processes in medicine is one of the tools for analyzing experimental data and clinical observations [1, 2]. The mathematical apparatus is widely used for diagnostic purposes, solving classification problems and searching for new patterns, for formulating new scientific hypotheses. The processing of medical research is based on the principle – what is true for a random sample is true for the population from which the sample is obtained. However, choosing or collecting a truly random sample from a general population is practically very difficult. Therefore, one should strive to ensure that the sample is representative of the studied populations, that is, adequately reflects all possible aspects of the studied state in the population.

On the other hand, the last few years have seen an active increase in the popularity of mobile devices. The increase in power and performance of mobile devices has expanded the range of problems that can be solved with their help. Thanks to the built-in sensors of geolocation, motion, cameras, as well as their compact size, mobile devices have advantages over desktop personal computers, as well as more efficiently solve a wide range of tasks. In the modern world, mobile devices are effective assistants in business, widely used in medicine, taxi and delivery services. Experts draw consumers' attention to the fact that now on the market of mobile platforms, iOS and Android are gaining rapid popularity lately.

The application market is filled with a huge variety of applications ranging from simple games to commercial business applications. In turn, applications can be constructively different in nature: educational, entertainment, auxiliary and others. The number of applications of one nature or another depends directly on the interest of users.

After analyzing the market for existing applications, we can say that there are practically no solutions that would help in emergency situations, in particular emergency medical care. Emergency medicine is one of the few industries in which the human factor plays a major role. Unfortunately, the most used transport for arriving at a patient and for further transportation to a medical facility is an ambulance driven by a human driver. Despite the special traffic rules for them, there is still a chance that the ambulance will arrive too late, and in Ukraine this chance is especially actual. The actual question is what then to do to the patient in this case.

The paper proposes to investigate intelligent methods for analyzing medical information on emergency systems and develop a mobile intelligent application that will be used for medical purposes as a personal intelligent assistant in the provision of emergency medical care. The work is relevant due to the events of the SARS-CoV-2 pandemic in the world, the reform of medicine, as well as the lack of such solutions on the market.

The purpose of the research. The paper examines the study of methods of data mining and processes, the development of an intelligent application "Emergency medical care" on the iOS platform, which effectively solves the problems of information support in medical emergencies for the user [3].

To achieve this goal in the work it is necessary to carry out:

– research of methods of data mining and processes;

– presentation of a knowledge base that allows one to analyze the indicators of a person's condition and draw conclusions regarding the diagnosis in the field of emergency medicine;

– implementation of intelligent analysis of processes;

– creation of a model of the IS business process, built on the basis of an artificially generated event log compiled with the involvement of experts in the subject area of emergency medicine;

– development of an intelligent application on the iOS platform;

– testing of the developed application.

The software application must have two modes of operation: manual and automatic.

In manual mode, the user has determined his diagnosis and is trying to find ways to treat it before the ambulance arrives.

Automatic mode refers to those users who cannot diagnose themselves, in which case the application begins to interact with the user through dialog boxes.

The following functions must be implemented in the software application: speed dial ambulance; viewing a map of medical institutions on the user's geolocation map; the ability to measure the pulse; a minimalistic interface to reduce the time it takes to find the right diagnosis.

Material and methods. Data Mining is an in-depth study of data, and Process Mining, respectively, is the study of processes. Both directions solve the same problem – business analytics, business process analysis [4, 5].

Let's consider the main similarities of Data Mining and Process Mining technologies: used to analyze large amounts of data that cannot be analyzed manually; extract knowledge from data that can be used to make business decisions; use mining technologies (or deep analysis technologies) in which algorithms go through large amounts of data in search of models and relationships.

At the same time, it is necessary to delimit the spheres of technology activity.

Data Mining uses a multidimensional view to identify trends in interactions between objects. Conclusion – Data Mining is aimed at finding patterns.

Process Mining, in turn, builds process models. It analyzes processes and events, detects process performance deviations, bottlenecks and inconsistencies. Event logs, audit logs, as well as data and events in information systems are used as input data.

Process Mining is the link between data mining and traditional BPM (Business Process Management) organization. Data Mining "extracts" valuable information by analyzing data, but, as a rule, does not affect processes. This is where Process Mining is used.

Using the methods of Data Mining technologies, a knowledge base is presented, using which it is possible to apply an inference model with the possibility of using fuzzy rules (Fig. 1).

General description of the Process Mining method. At the first stage, using the Process Mining method, it is necessary to build a model based on the existing event log. Next, a model is used to artificially generate new process instances. This model is flexible enough that the output may result in process instances that were not in the original process log. The presence of such additional behavior should increase the accuracy of the resulting model and improve its overall performance.

For this purpose, it is necessary to take a complete log of the business process of the information system, compiled with the involvement of experts in the subject area.

Next, build a model (or models if the instances of the business process are different and have a complex structure). Generate new process instances based on the corresponding model. Build a new business process model based on the event log using business process recovery algorithms. Based on the existing event log, it is necessary to teach a model that will encapsulate the behavior contained in the log.

The main requirements for the model are:

– simplicity that will not allow you to get a model that is "retrained". Such a model would be useless, since it would be possible to obtain such a log without introducing additional behavior into it;

– storing basic order relations between elements of the event space, which will avoid adding unnecessary "noise" in the process model. Adding "noise" can only worsen the metrics of the process model, and add additional work to filter out deliberately incorrect process instances in the log.

Results. Within the framework of practical results, the implementation of the Data Mining method is presented in the form of a rule base for storing diagnoses (Fig. 1).

The application uses the key to the file with the structure (Fig. 1) and receives a dictionary that stores all the information and diagnosis. The rule base presents information in the form of a diagnosis with its name, a step-by-step guide to first aid and steps that illustrate user actions.

▼ diagnosis	Dictionary	(3 items)
▼ EmergencyHelp	Dictionary	(1 item)
▼ MeanOfProtection	Dictionary	(3 items)
Title	String	Для вашей защиты вам потребуется:
Text	String	перчатки для защиты рук, очки для защиты глаз, индивидуальная маска или респиратор
Image	String	MeanOfProtectionImage.png
▼ DrowningThreatmen	Dictionary	(3 items)
Title	String	Помощь утопающему
Text	String	Проверить признаки жизни, вызвать скорую помощь, очистить пострадавшему ротовую полость, есл
Image	String	drowningThreatment.png
▼ AstmaHit	Dictionary	(3 items)
Title	String	Приступ астмы
Text	String	Постарайтесь успокоить пострадавшего, проверьте пульс и дыхание, вызовите скорую, поместите в
Image	String	AstmaHit.png

Fig. 1. The rules base for the application.

A business process model is used to move from Data Mining methods to Process Mining methods. Using the Process Mining method, we will build a model based on the existing business process log of the information system, compiled with the involvement of experts in the subject areas of emergency medicine:

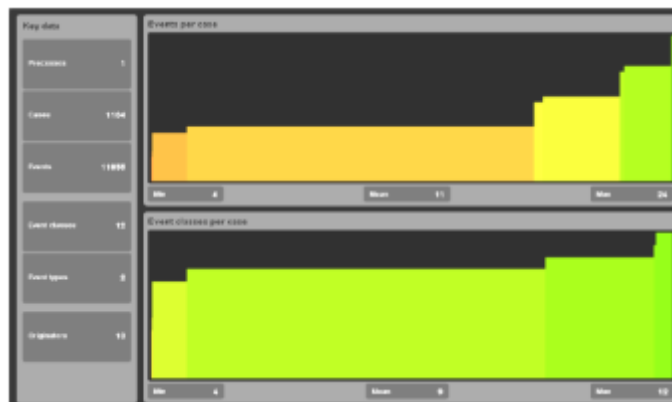Getting a log of business processes (Fig. 2):

Fig. 2. General information about the business process log.

Graph visualization based on the clustering results of the output log of business processes (Fig. 3).

New event log generation based on the resulting graph and model creation based on an artificial log of business processes.

Such a model is quite flexible, at the output we get process instances that were not presented in the original process log, which increases the accuracy of the resulting

model, improves its overall characteristics, allows for a more accurate diagnosis and offers the patient emergency measures.

Fig. 3. New event log.

Figure 4 shows the algorithm of the software application.

Discussion. Analysis of the subject area and analysis of existing solutions show that existing solutions cannot claim to be a personal assistant in the field of emergency medicine. The implementation of such an application will allow us to occupy a niche in the appstore for the iOS platform.

During the implementation of the application, bottlenecks in the application were identified that require improvement, namely: despite the depth of the analysis performed, at this stage the application will not be able to help the user in all critical situations that may arise, and in no way will be able to replace the help of the ambulance team. This is due to the fact that the area of "Emergency medical care" is quite extensive, in which it will be difficult for an ordinary user to separate the main part from the secondary part without losing details. Working closely with a healthcare facility can improve this indicator.

Another factor is the uniqueness of the content within the application, we are not talking about the text load for the user, but about the image illustrating the steps to help the victim, as well as the design of the application. The use of free images from the Internet creates the risk of copyright infringement when using someone else's content, and there is also a possibility that the images will overlap between services, which is unacceptable, otherwise the user of the final product will have a thought about the unreliability and insufficient quality of the software product.

Work on the creation of the paid version will be carried out in several directions.

The disadvantages listed above determine the further vector of application development. Since this version will be distributed free of charge, it is planned to develop a paid version of the application in the future. Compared to the basic version, the paid version will have a number of significant differences.

It is supposed to develop the server side for the application. This is important because the following will be implemented:

– secure login to the application using a username and password;

– creating a personal account for storing the user's personal information;

– added support for third-party devices such as Apple Watch and other fitness trackers.
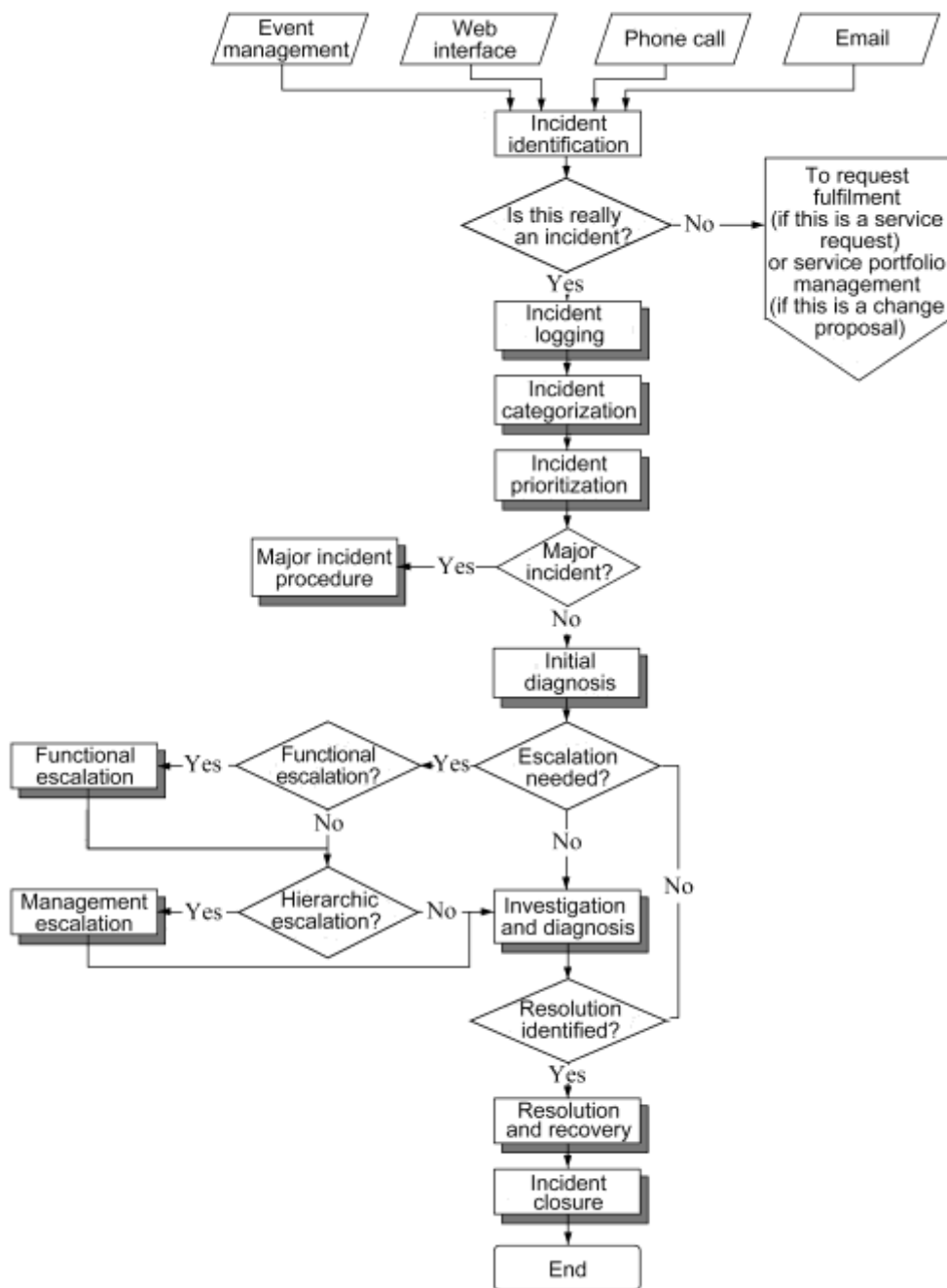

Fig. 4. Algorithm of the software application.

A client part for a doctor will also be developed:

– a patient will be assigned to each doctor, access to the user's personal data will help to simplify medical interaction with the patient;

– implementation of the ability to make voice and video calls within the application;

– using push messages to speed up data exchange between client applications.

Despite the fact that the interaction between the patient and the doctor will take place through the application, it is highly recommended to create a web version of the application. Of course, it will not have the same functionality as the mobile version, but it should fully cope with the task of information support for the user.

CONCLUSIONS

Thus, the studied subject area is quite promising, especially in our country. The space of technologies and the absence of competitors allows one to realize a more responsible approach to the development process of all software product parts, and interaction with medical institutions will be able to bring the product to a qualitatively new level. The best option would be to integrate with a private clinic for reliability and process automation, developing in this direction will help save lives.

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