Developing a training program by the method of interval repetition

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Abstract—Paper is focusing on main mechanisms for memorizing information by a person. Using these mechanisms, we can create a learning algorithm that reduces time required to memorize new information. At the same time, information is remembered by a person for a long time. If we based on training algorithms it is possible to create a program that automates process of preservation new information. In this case it is supposed to collect impersonal data about training process. We expected that these data will be used to further study mechanisms of human memory. In this paper we analyzed existing programs for automating memorization and also we discussed about their weaknesses and strengths. Based on review of solutions requirements for the developed system were created. An algorithm for preservation information by the method of training repetitions is considered. Based on this algorithm, an algorithm for training program has been developed. We developed scenarios of interaction between program and user. Based on the developed user interaction scenarios, the modules from which the program will consist are designed. Before writing the program we were selected suitable programming languages and as well as software platforms that facilitate the creation of programs. Database schema has been developed. Main result is creating a program that automates and facilitates the process of memorizing new information by a person.

Index Terms—distance education, hybrid application, learning automation, memorization, memory mechanism, interval repetition

I. INTRODUCTION

In the modern world due to rapidly development of new technologies, people spends more and more time for learning. Both children and adults are studying, at the same time adults are improving their qualifications or acquiring new professions. In this regard various technologies which reduce training time and facilitate training gain relevance. For many people it is quite difficult to memorize a large amount of information because that cannot be memorized using only logical memory. For memorizing foreign words, as well as for memorizing

various terms, historical dates, rules, definitions mechanical peoples used a mechanical memory. The memorization mechanism when using logical and mechanical memory is quite different. For better memorization (when using mechanical memory) it is necessary to periodically repeat the memorized information at regular intervals. To facilitate and partially automate the memorization and repetition procedure, it is advisable to use a special training program. As a result of using such a program, the learning speed and the reliability of memorizing new information increase. A training program must take into account the mechanisms of the human brain in order to increase the efficiency and quality of memorization. Only by taking into account the way the brain works can the training program make it easier to remember new information.

It is worth noting that mechanisms of human brain, and in particular the mechanism of memorization, haven't been sufficiently studied. Training programs can also be used to collect anonymous data on progress of training procedure. These data can be used to study later the algorithms of human brain and memory mechanism. In the future the research results will lead to the improvement of teaching methods.

Analysis of existing solutions

Quite a number of articles are devoted to the issues of automation of learning and online learning. The article [1] deals with the problem of automatic assessment of students' knowledge based on the answers to test questions. It is advisable to add game elements to educational programs to increase students' interest [2].

The article [3] formulates functional requirements for an automated learning environment and gives an example of developing an automated education system. In [4] the authors analyze the requirements for an intelligent learning automated information system to improve the efficiency of the educational process. The classification of information technologies

used in the educational process to improve its effectiveness is also proposed.

It is advisable to use social networks to increase the involvement and cooperation of students in the learning process. In [5] there is data showing that the use of social networks increases students' interaction skills and the quality of collaboration.

Let us consider programs for memorizing words and expressions using interval repetition. One of oldest programs is Anki [6]. The basic principle of operation is that user selects a set of words to memorize, program shows word and translation. Number of words varies from training to training, the repetition interval increases according to the methodology (1 min, 10 min, 1 day, 4 days, etc.)

Main disadvantages of program are lack of training reminders and inconvenient program interface. When using this program during training, all interface elements remain in place, which adversely affects the work. There is also no API for accessing data about user work in application. Another memory program is Memrise website. Memrise is positioned as a service for learning foreign languages [7]. Site works only online. There is practically no interactive component in it, there is no possibility to create your own cards, and there is no support for working with interval repetition technique. To increase motivation, Memrise uses ranking and comparison of results with achievements of other users. Each of service members can share their progress with other users. However given all the disadvantages, the benefits of this feature are questionable. This service is a typical representative of platforms whose authors themselves decide how to present information to the user. At the same time they do not apply best practices in user interface design and do not go deeper into optimizing training using common teaching methods.

Quite interesting is Mnemosyne program, which uses interval repetition method and it is free. This is research project on nature of long-term memory. Mnemosyne is an easy-to-use program. At the same time experienced users can customize it using plugins and scripts [8].

Mnemosyne uses a sophisticated algorithm to optimize memorization process. At the request of user, anonymous statistics of educational process can be uploaded to central server for analysis. This data is used to study memory behavior over a very long period of time. Results will be used to further improve algorithms and software.

This program is best in terms of the implementation of methodology and research potential. However user interface is not optimized. Also this program is only available on desktop systems. This is a significant drawback, since it is advisable to use every free minute to repeat the material under study. In this case, a computer may not always be at hand. It is important that the training program runs on tablets and smartphones and is always available to the user.

II. METHODS

A. Information Memorization Mechanisms in Humans

If we need to use the peculiarities of human memorization of information when developing a training program, we need necessary to understand how human memory works. Memory is a complex cognitive process, consisting of several private processes related to each other. These processes are called mnemonic. Mnemonic processes include memorization, preservation, reproduction and forgetting. Each of them individually can be optimized using various technologies implemented in training program [9].

Memorization (or fixation) is a mnemonic process that is responsible for imprinting and storing new information in memory, most often through associating new information with that acquired in past. There are two types of memorization according to degree of human activity in the implementation of this process.

Involuntary (or unintentional) memorization is memorization in which there is no predetermined goal and a person does not use any techniques, methods and manifestations of willpower.

Voluntary (or deliberate) memorization is purposeful, conscious memorization by a person of any information [10].

To solve this problem the main attention should be focused on intentional memorization. It is process of purposeful memorization that has been studied most of all, and certain methods have been developed that can serve as a good basis for developing a training program.

Memorization is first process. In many ways modern teaching methodologies are aimed at facilitating memorization process. However without attention to preservation, the results of memorization are likely to disappear, and process loses its meaning [11]. Reservation (or retention) is mnemonic process that is responsible for keeping the recorded information for more or less long time in form that is available for its reproduction [12].

Process of preservation information is quite complex. Preservation is not just a passive storage of information, but a complex dynamic process. This process includes processing, aggregating and sorting of information. It involves participation of various mental operations, such as systematization, generalization and etc. That is process of preservation information entails not only retention of memorized information, but also its mental processing.

Forgetting is mnemonic process that is the opposite of preserving process. It is a loss, clearing without the possibility of restoring in the mind of information that was previously recorded in memory of a person. Forgetting can be partial and complete [13].

The deduced patterns and rules allow us to say that information is forgotten in order of relevance. First that information is forgotten that is not required by a person in the process of his work. The degree of forgetting is higher, the less often there is a need for certain information for human activity. At the same time it depends on importance of information for achieving current goals and solving problems. Forgetting has a huge biological value, because this process regulates a limited space in central nervous system of a person. It clears it up for emergence of new conditioned reflex connections.

The selective nature of memory is one of its most important features [14].

The described processes (preservation and forgetting) cannot be directly influenced by computer technologies and information systems. However, this may affect indirectly. The nature of phenomenon of memorizing precisely necessary information is not clear, but the regularity itself has been repeatedly verified experimentally. In order to preserve information, it is necessary to increase its value from the point of view of human brain. There are two main ways to increase the value of information, one associated with the emotional coloring of the knowledge consumed and the other with repetition of what was learned.

For teaching purposes the repetition method is best suited [15]. The method of repetition of what has been studied in practice has been used for a long time. Even the well-known proverb "Repetition is mother of learning" testifies to this. The question is: how best to use this method? More specifically, we need to answer following questions:

- At what intervals should the repetition procedure be performed?
- How much data do you need to repeat?
- When to stop repeating current piece of information and move on to another?

It should be noted in advance that there are no complete answers to these questions. Implementation of developed program, obtaining data about learning process with help of it and processing this data will make it possible to get closer to the answer.

Repetition of what has been learned is based on the reproduction process. Experiments in this area indicate that most healthy people have the same reproductive ability [2]. Thus a replay-based learning methodology will work the same for most users. Let us consider more detail concept of "reproduction".

Reproduction is mnemonic process, the meaning of which is to update previously recorded information by extracting it from long-term memory and transferring it to operational one. The human memory into 3 types according to the duration of information storage in memory:

1) Short-term (or primary memory) has a low retention time and works in conditions of one-time and short-term perception of information.
2) Long-term (or secondary memory) characterized by a high retention duration and often acts with repeated repetition of information. The storage time of information in long-term memory is theoretically unlimited. Long-term memory "is associated with the implementation of selection, imprinting, preservation and the possibility of arbitrary reproduction in the future of some information that first enters short-term memory, which is, as it were, a stage in the formation of long-term memory. From short-term memory to long-term memory is transferred: information that is realized by a person as important and useful for him: very vivid impressions; impressions on

which the subject's attention is fixed for a long time and continuously; consistently repeating events, phenomena, facts. Long-term memory is stable and inert."
3) Working memory works while working with conscious information and occupies an intermediate position between short-term and long-term, since it contains information extracted from both long-term and short-term memory. Working memory is designed to accompany an activity or other type of activity carried out by a person.

The information obtained during learning process must be placed in long-term memory so that it can be used for a long time. Thus, it is advisable to develop a program for storing information precisely in long-term memory.

By the way of storing information, memory is divided into mechanical and logical. Mechanical memory is realized automatically on the basis of contiguity associations and stereotyped repetition of information; its characteristics are stereotyped and usually accuracy in reproduction. Logical memory is based on preliminary comprehension of memorized material and is more efficient than mechanical memory.

Modern educational methods imply a deep study of material. As a consequence, logical memory is used. A great deal of work has been done in this direction, and the process has been sufficiently optimized [16]. On the other hand, memorization techniques using mechanical memory are not yet effective enough. This area can be improved with a program that helps to memorize information. For memorizing information using mechanical memory, the interval repetition method is the best way. The technique should ensure the preservation of knowledge in long-term memory. The key to technique is systematic reproduction of information. The program should control the repetition intervals and provide convenient access to the material to minimize the time spent by the user on reproducing the recorded knowledge.

B. Requirements to developed system

Based on analysis of subject area, limitations and existing analogues, the following key technical requirements for developed information system were determined.

1) System should consist of several components:
   a) User application.
   b) Web service for collecting, processing and sending data about application usage to storage.
   c) Web service for centralized processing of collected data.
   d) Public web API for providing anonymized data for learning.
2) User application must be mobile-oriented and run on both popular mobile platforms (iOS and Android).
3) Application should provide to user the following features:
   a) Create flashcards with information to remember.
   b) Train cards, that is, repeat the contents of card at regular intervals.
   c) Tracking the degree of memorization cards, start time of next workout, amount of cards studied.

4) Application should automate following stages of learning process.
   a) Creation cards with information.
   b) Storage cards with information.
   c) Choice cards for training.
   d) Planning your next workout.
   e) Tracking progress of studying card.
   f) Reminder to start training.
5) Application need following conditions:
   a) Application will work without an Internet connection.
   b) Save cards and study progress when app is uninstalling and reinstalling.
   c) Provide the same functionality for both platforms (iOS and Android).
6) Web service for collecting data on use of application need the following conditions.
   a) Work flawlessly with incomplete data.
   b) Conduct primary data processing: checking, formatting and depersonalization.

C. Application design

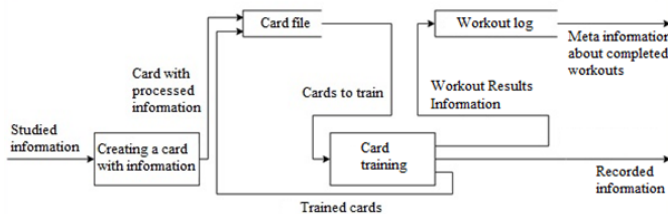The process of storing information by the method of interval repetitions is shown in fig. 1.

Fig. 1. Process of memorizing information algorithm

Training begins with processing of studied information. Cards are created with information containing a question, an answer, time of first training session. These cards are replaced in corresponding box of filing cabinet. Next, there is an expectation of training. When it comes time to train, cards that need to be trained at the given time are selected. Question cards are presented to user. User gives an answer. Correctness of the answer is checked. The training results are recorded in training log. If a question in card was answered correctly a certain amount of times, card is removed from card index and is not used for repetition in future. The rest of the cards are returned to the filing cabinet. The process ends after memorizing all the studied information.

In process of designing a custom application module, the MVC architecture was chosen (fig. 2). This architecture allows us to divide the application into 3 parts: model, view and controller [17].

Model is a part of the architecture that is responsible for application logic, storing and processing data. At the same time model does not interact directly with application user in
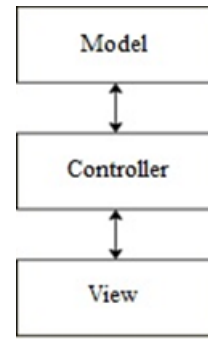

Fig. 2. Scheme of MVC architecture

any way; it can only receive data from the controllers and return it upon request from other parts of application. Its main task is to abstract the rest of the application from structure of data it uses, as well as hide the details of the data change process. Model can consist of many classes or functions that have different responsibilities, whether it is interacting with a data store, validating or transforming data.

View is part of the architecture responsible for providing user with an interface to interact with application, as well as outputting data. In this case the same data can be presented to user in different views.

Controller is piece of architecture that handles user requests. Requests are any user actions that trigger the triggering of handler methods that refer to models. In this case user actions are called events [18].

Models are classified into active and passive, depending on interaction between the model and view. In active model state changes occur in connection with logic of work. These changes are reflected in view. The passive model changes only under the influence of external requests. These changes as a result of the query are also reflected in view. For our purpose active model is more suitable, since training program should change its state over time and encourage user to start repetition process.

MVC is a high-level abstraction of application logic. A deeper architecture is required to implement a specific application. Flux architecture is often used for these purposes. Flux is an extension of the MVC architecture, more specifically the model and controller parts. Flux describes process of storing and processing data. Its main distinguishing feature is the one-way directionality of data transfer between components. Flux sets limits on data flow and defines state change in a single place - the data store [19].

The minimal version of this architecture is shown in fig. 3 and includes following set of components: actions (includes event, dispatcher and handler entities), storage, views.

Action consists of three entities:
1) Event is a notification about an event that has occurred, contains an event identifier;
2) Dispatcher is an event manager that calls appropriate handler for each of them and transfers processing result to storage;
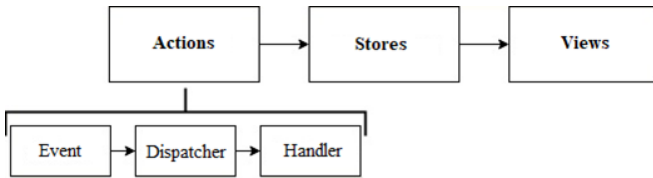
Fig. 3. Diagram of minimal Flux architecture

3) Handler is a component that processes data from storage in accordance with a certain algorithm.

Store is a storage component and it is only data source that provides information about the current state of a model. This data is used to represent state of model.

When designing the application, the following scenarios interaction of program with the user was developed.

1) Opening application.
2) Creation card with information.
3) Card training.

Based on developed scenarios of user interaction, studied architectural solutions and templates for mobile applications, the following system modules we were designed.

1) Card module. Card module consists of a card class, an interface for accessing it. System allows user to create cards, edit them, increase or reset the degree of memorization, delete from database and view general list of cards. System also automatically indicates the time of card creation and assigns the time of her next workout according to the methodology.
2) Training module. Training module deals with training process. Training module consists of a workout class describing its current state, including meta information about amount of cards and the time spent. Within the framework of module, the training process takes place, issuance of questions and answers to user and storage of the training results.
3) Notification module. Notification module schedules and sends notifications to user about need for training. It is consists of a queue of notifications. And this module stores necessary data, such as title and body of notification, as well as event handlers for the transition of the notification to the application.
4) Database model. For this system, a database model was designed. Relational database was chosen because it needs to maintain relationships between various object parameters in database.

III. RESULTS AND DISCUSSIONS

Application development began with selection of tools. Based on described platform and architecture of web service and application, it is possible to describe the preferred technology stack to meet specified requirements. In general JavaScript was chosen for the development of the entire system, since it can be used to develop each of the modules, as well as its extension: TypeScript - it allows use of static typing in development process [20], which ensures greater stability of system modules. It is advisable to implement a web service on the node js software platform using Express. Express is popular web framework based on Connect. It includes all basic functionality, such as serving static files, URL routing, and application configuration [21]. It provides ability to create reusable modules without undue constraints. This solution seems to be optimal from the point of view of ratio of support cost to system performance within framework of problem being solved.

Let us consider implementation features of mobile application. There are two options for developing apps for mobile devices: native and hybrid apps [22]. A native application that targets one platform will not work on another platform. For example you cannot install a native Android app on an iOS device. A separate platform-specific version needs to be released using the appropriate iOS-focused development tools. In contrast a mashup application is a web application developed with HTML, CSS, and JavaScript and wrapped in an application wrapper (or user interface).

The main advantage with respect to native apps is that they are superior in performance and take full advantage of the device's capabilities. They are also more secure. The disadvantage is that the developer must support multiple programs for each platform.

Hybrid apps are interpreted at runtime, so their performance is less than native apps. In addition, hybrid applications do not fully utilize the features of the operating system. A key advantage of hybrid applications is that the developer develops and improves one universal program code.

The application under development is not resource demanding, hence, it is reasonable to choose hybrid application development to get all the advantages of this approach.

When creating an application, it is advisable to use React Native technology. This is a framework for developing cross-platform applications for iOS and Android. This framework does not use WebView and HTML technologies and has managed to establish itself as one of the most popular technologies for developing hybrid mobile applications.

Also for implementation we should choose Expo platform. It is a set of tools that speed up and simplify the development of application prototypes using the React Native framework. Expo platform provides a JavaScript API that allows to access most of capabilities of a mobile device OS without having to write native code. Expo consists of expo-cli - developer tools for deploying a project, viewing application logs, publishing, and many other features [23]. Expo platform also includes a client for mobile devices, which allows testing of the developed and finished application on various devices.

Based on the above requirements and using the selected tools, an interval repetition training program was developed. This program implements only the client part of the developed application. It has full functionality and allows full training. Fig. 4 and fig. 5 shows the interface of the developed application.
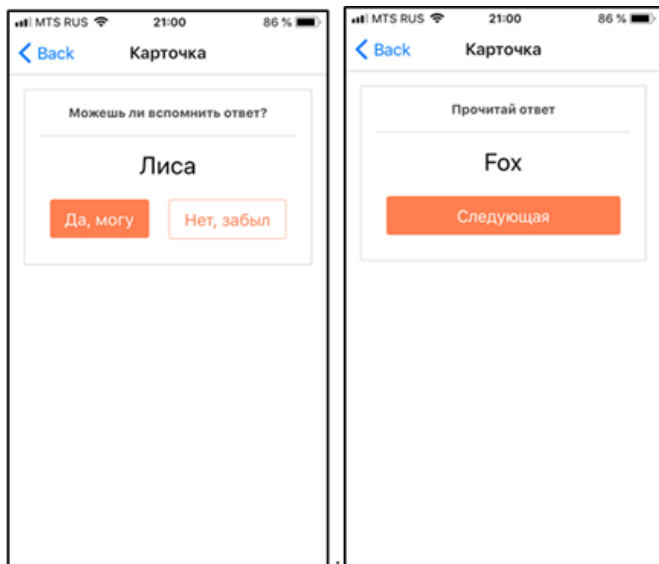
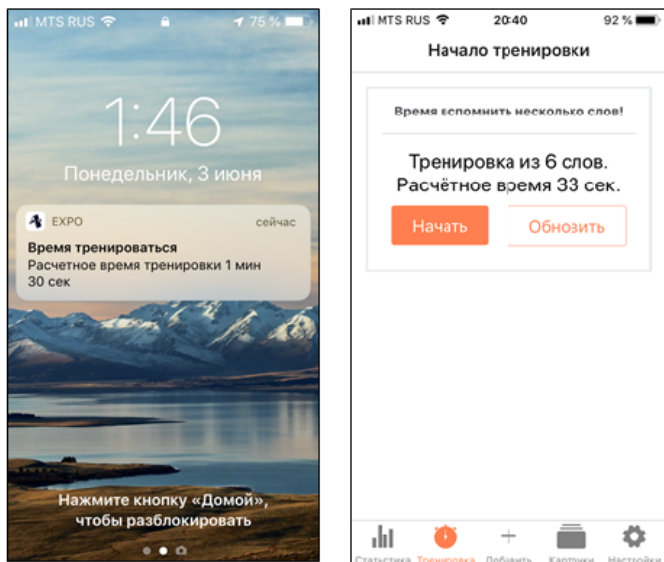Fig. 4. An example of the interface of the developed program

Fig. 5. Start of training

The developed program was tested. Six copies of the program were distributed to people learning a foreign language. The testing showed the effectiveness of the program. The testing also confirmed the effectiveness of the interval repetition method for learning foreign words. According to subjective feelings of the testers the memorization of foreign words became faster.

The developed program made it possible to observe the required repetition intervals, as well as to optimize the memorization process. Words that can be memorized quickly take less time, and words that are harder to memorize are repeated more often.

Implementation and testing of the server part of the application is expected in the future.

IV. Conclusion

In this paper, the mechanisms of human memory of information were considered. For mechanical information memorization it is reasonable to use the method of interval repetition. The possibilities to automate the learning process by the method of interval repetition, including the control of training time and duration, were investigated. When designing the program the Flux architecture was chosen. Based on the chosen architecture, a program was designed to automate the learning process.

Mechanism has been developed for collecting impersonal data on learning processes. This data can be used in future to study information storing mechanisms in human's brain. Module of web service that collects data about learning process was designed. Database has been designed to store cards with information and collected data on learning process. User interaction model has been developed that implements an automated learning process.

An application development toolkit was chosen. TypeScript was used as the programming language. Express framework was chosen as the web service platform. React Native framework was chosen for the mobile application.

Prototype of application was developed and tested based on design of application module, user experience scheme, we chosen architecture and database model. Testing has confirmed the performance of the application and the effectiveness of the interval repetition method for remembering new information.

In the future it is planned to implement the server part, which will collect impersonal data on the results of training. The collected information can be used in the future to further study the mechanism of human memory.

V. Acknowledgment

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