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WEB-ORIENTED APPLICATION FOR KEEPING A DENTAL CHRONICLE FOR RECORDING AND ANALYSING THE STATE OF THE ORAL CAVITY

Abstract. A web-based application for keeping dental records is proposed for effective monitoring of the patient's oral cavity. The application provides the opportunity for the patient to keep his own dental history in order to increase the level of responsibility, interest and awareness of the state of his own health, which can be a good motivation. It also increases the level of diagnosis and further treatment by providing access to the entire clinical history of the patient. The client-server architecture model, MVC design template, JavaScript programming language, HTML, SCSS preprocessor, MERN programming stack, which included such modules as MySQL, Express(.js), Node.js, React, were used to implement the application.
Keywords: web-oriented application, JavaScript, SCSS, MERN, MySQL, Express(.js), Node.js, React, MVC, BEM methodology, oral cavity.

Formulation of the problem. Today information technologies simplify people's lives in various spheres, issues and industries. Medicine does not stand aside. While constantly developing it requires the introduction of modern technologies and developments in order to optimize and improve existing processes such as diagnosis, treatment, organization of appointment schedules, communication between doctors and patients, work of clinics, disease histories management, conducting surveys for scientific analysis, control of medication intake, monitoring of one's own body parameters, etc. Dentistry is no exception. It`s a field that is an important component of medicine and has a significant impact on human life.

Despite all available developments and technologies, there are still a large number of issues that require improvements and the implementation of universal solutions. They are the problem of complicated diagnoses due to untimely seeking help, the increase in the number of diagnoses due to the careless attitude of patients to the care of the oral cavity and postponement of periodic visits to the doctor, speeding up diagnosis based on previous treatments and tests that can be viewed in

one application, independence of the treatment process from the change of the doctor, existing cases of neglecting a detailed description of the performed procedures by the doctor.

All these issues can be solved by the approach proposed in this work. It is based on the possibility of keeping of the appointment records by both the doctor and the patient. This makes it possible to not only improve understanding during treatment, contribute to the improvement of its quality and productivity, but to increase the level of responsibility and awareness of the patient about the state of his own health. An important aspect is also the possibility to monitor not only the treatment processes, but also the performed analyses. Especially this applies to the graphical presentation of information such as photographs of the oral cavity.

In addition, there is a need to develop modules for monitoring healthy habits aimed at oral care. The problem of understanding the current state of the oral cavity is solved by means of its graphic 2D model, which displays the main dental procedures and the patient's level of compliance with standard hygiene rules such as the frequency of tooth brushing.

Analysis of the latest research. The presented developments in this field can be classified according to the following categories such as reference books [1], educational as well, those that remind you of brushing your teeth [2], those that teach you to brush your teeth [3-5], questionnaires [6-8], those that aimed at managing the dental journal and planning the work process [9, 10], diet diaries [11]. There is the latest study that use an artificial intelligence to detect dental diseases using the analysis of panoramic images in real time [12].

The analysis of the available existing solutions showed the following: most of the considered applications developed for the dental industry are mobile applications; the considered applications are focused primarily on specialists, not on patients; many of the listed developments do not provide cross-platform functionality; lack of a comprehensive solution to the tasks. Taking into account the above-mentioned features the development of a patient-oriented web application for keeping dental records, forming the habit of responsible care for one's oral cavity and organizing the treatment process on the part of the doctor is relevant.

Web-orientation provides a number of advantages over mobile applications. They are cross-platform, ease of updating, flexible integration options with all services, security, efficiency, a single base. In turn, patient orientation is not only an effective motivational tool for compliance with rules and recommendations, but also a mean to make a person more knowledgeable and healthy.

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The goal of the work. The purpose of this article is the development of a web-based application for maintaining a patient's dental history to ensure the possibility of effective oral cavity monitoring.

Main part. The developed web application is based on a three-level client-server architecture consisting of clients, a central server and a database server. This architecture was chosen due to easy sharing of resources and data between platforms, flexibility, availability, extensibility and scalability.

During application development, the MERN programming stack was taken as a basis due to a number of its advantages such as cost-effectiveness, SEO support, better performance, open source, easy switching between the client and the server. In the classical sense, the components of this stack include the MongoDB database, the Express (.js) web framework, the React (.js) interactive library and the Node (.js) server framework. However, in the developed application the MongoDB database was replaced by the MySQL relational database. The final structure of the applied stack is presented in Figure 1. Additional modules were also used, including nodemon, dotenv, jsonwebtoken, bcrypt.js, cors, cookie-parser, axios, etc.

As the programming pattern MVC (Model-View-Controller) was chosen. The implementation of the MVC template was added at the expense of the MERN stack as follows. The *view* element is the client part developed using React.js; *controller* element represents classes developed on the server side of the application using Node.js; the developed methods, including CRUD operations, are responsible for the *model* element and the connection with the database. Also, the BEM (Block Element Modifier) methodology belongs to the technologies that were used in the development of this application. This is a component approach to web development, based on dividing the interface into independent blocks. Due to this approach, the naming of structural elements and the structure of the interface files were organized.

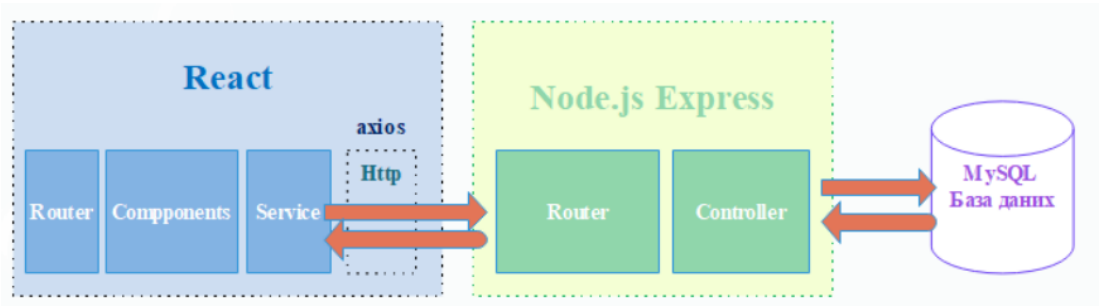

Figure 1 - Structure of the applied programming stack

The application programming language is JavaScript. It was chosen because this language is intended for web-oriented development and is the basis of the

MERN stack. In addition, for the application development, the HTML markup language was used to build the frame of the pages and SCSS preprocessors were used for pages design. The SCSS preprocessor is to speed up the development; it became more productive especially with the use of the BEM methodology.

Purpose and structure of the application. The developed application has the following purposes:

- maintaining a dental chronicle of the patient's oral cavity, followed by graphic visualization of the current state;
- doctor`s management of treatment processes;
- tracking of existing symptoms and complaints about the user's state of health;
- control of the expiration date of toothbrushes replacement and monitoring of the number of teeth cleanings per day.

The developed application is called "Dental Diary" and is based on the following modules:

– the *observer's diary* is an additional part of the "Dental Diary", which is aimed at monitoring the dynamics of the evolution of previously indicated symptoms;

– *tooth brushing diary* is an additional part of the "Dental diary" system, which stores data on brushing teeth, which the user enters through the form;

– the *patient's diary* is a structural part of the "Dental Diary" application, which is intended for keeping a personal dental chronicle of each participant and consists of the elements such as treatment, record and procedure;

– *toothbrush replacement log* is an additional part of the "Tooth Diary" system, which stores data about the time of toothbrush use;

- *patient log* is the main part of the "Dental Diary" system, which is available only to specialists in the dental field, and is intended for keeping the clinical history of each patient who has granted access for this purpose.

In general, there are "doctor" and "patient" types of users in the system. Access to application functions depends on the type of user. The logical structure of the application consists of such web pages as main page, registration page, authorization, personal account, patient log, patient diary, brushing diary, observer diary, treatment, record and procedure. The application file structure consists of client and server parts. The first one is located in the "frontend" directory and has a structure according to the requirements of using the React library, including "node_modules", "public" and "src" folders. "src" directory contains the implementation of the presentation element according to the MVC pattern. The file structure in the "src" directory is based on the BEM methodology using the Flex approach in which each block of the

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interface corresponds to a separate directory. The server part is located in the "backend" directory and includes the main application launch files such as index.js and App.js. Controller files are placed in the "controllers" directory, and navigation files are in the "routers" directory. Database connection is implemented in the "dbconnect" directory. Additionally used Node.js modules are located in the "node_modules" directory. The described file structure is presented in Figure 2-3.

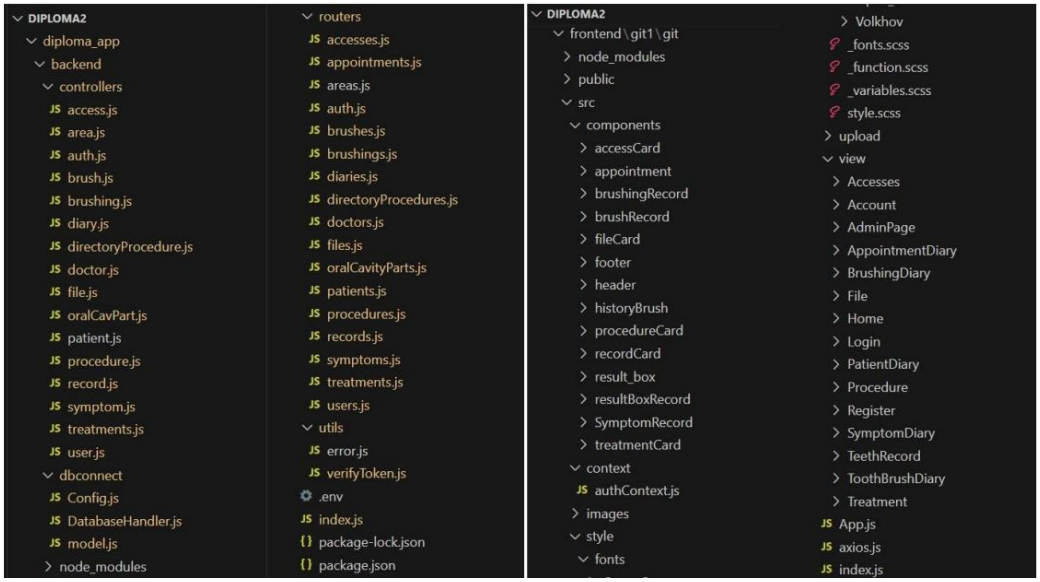

Figure 2 - File structure of the application

Figure 3 - Expanded file structure of the client part

The structure of the database is shown in Figure 4. It consists of 14 entities and 4 views. Entities are 'Access', 'Diary', 'Doctor', 'File', 'Mouth part', 'Procedure', 'Scope', 'System procedure', 'Cleaning record', 'Symptom', 'Record', 'Toothbrush',

'Treatment', 'User'. Representations are 'Diary Data', 'Treatment Data', 'Record Data' and 'Procedure Data'.

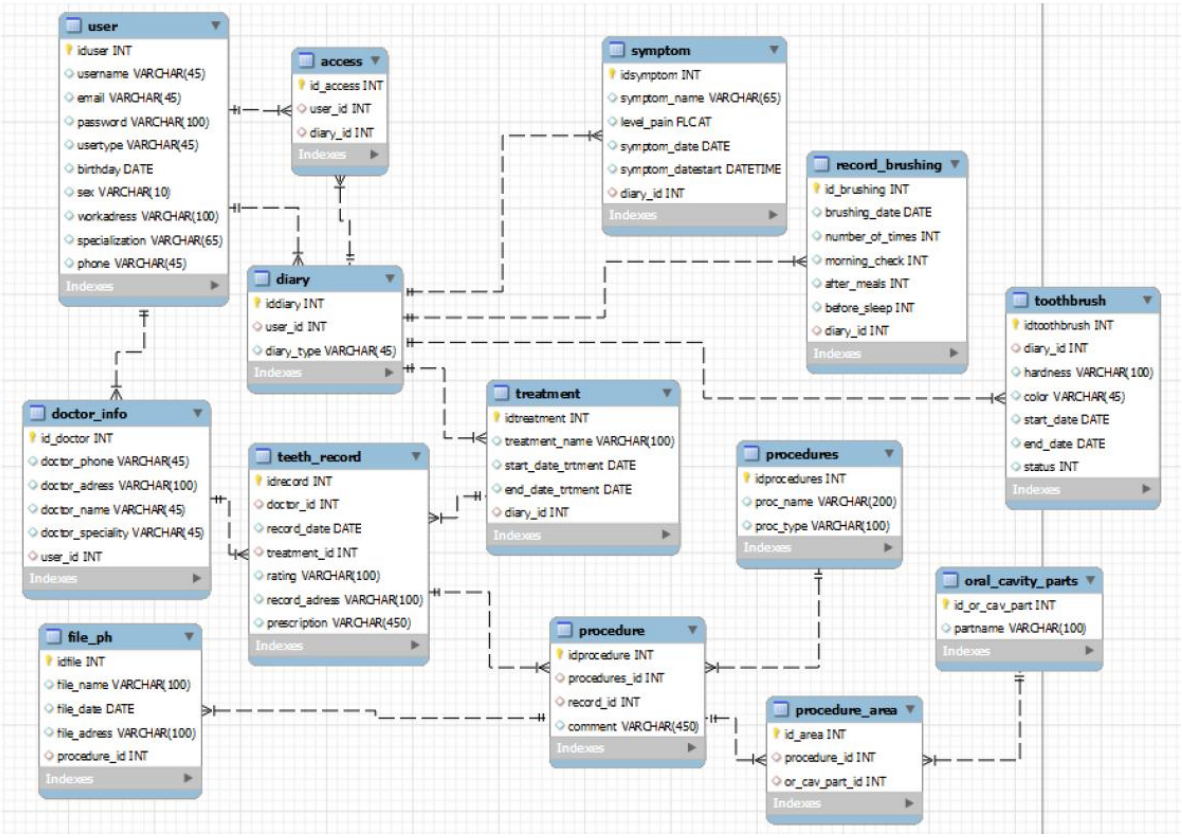

Figure 4 - Physical model of the database

Application interface. According to the logical structure, the client interface of the application was developed. It is shown in Figures 5-7. An important element of the application is a graphic 2D model of the current state of the oral cavity. Depending on the entries made in the "Patient's Diary", the display of the model changes. The appearance of the model can also be enhanced by brushing teeth. Three dental operations are currently available. These are adhesive tooth restoration, tooth extraction and pulp extirpation or root canal surgery.

All data is to be entered using forms. It is possible to add files such as dental images to the procedures. File format should be *jpg* or *png*. In addition to the graphic model of the oral cavity, the output data also has a presentation in the form of cards such as treatment, records and procedures, records of cleaning or replacing toothbrushes.

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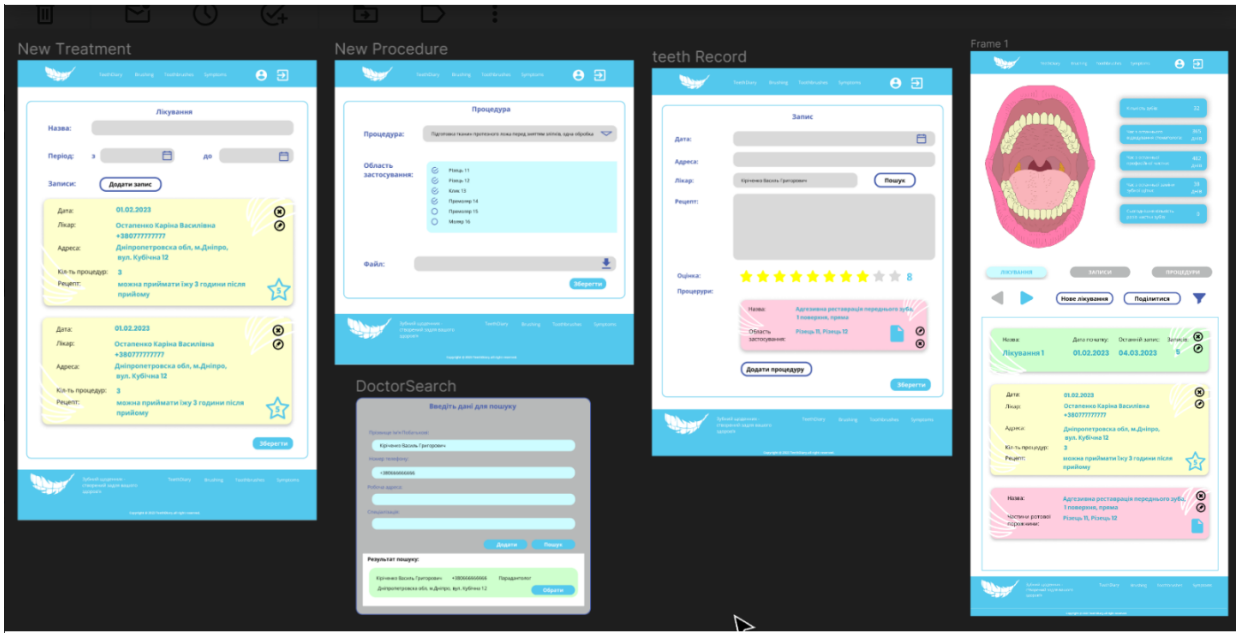

a b c D

Figure 5 - Interface design: a) Treatment page; b) Procedure page and Doctor Search form; c) Record page; d) patient's diary

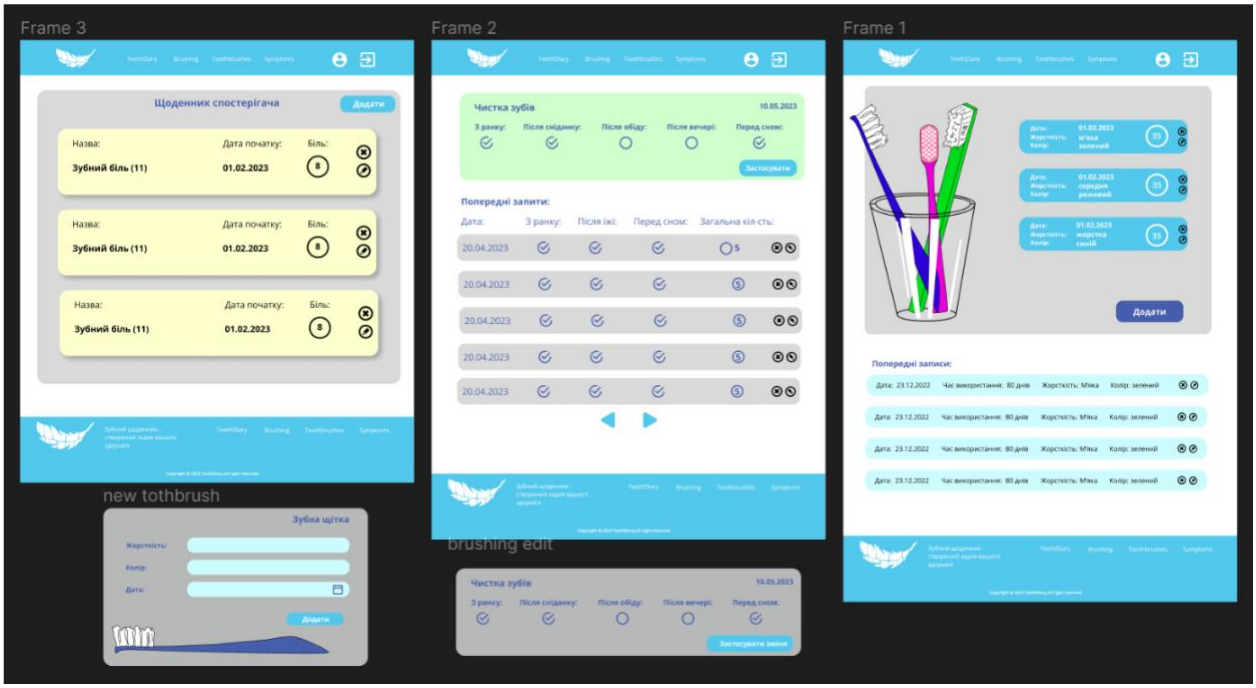

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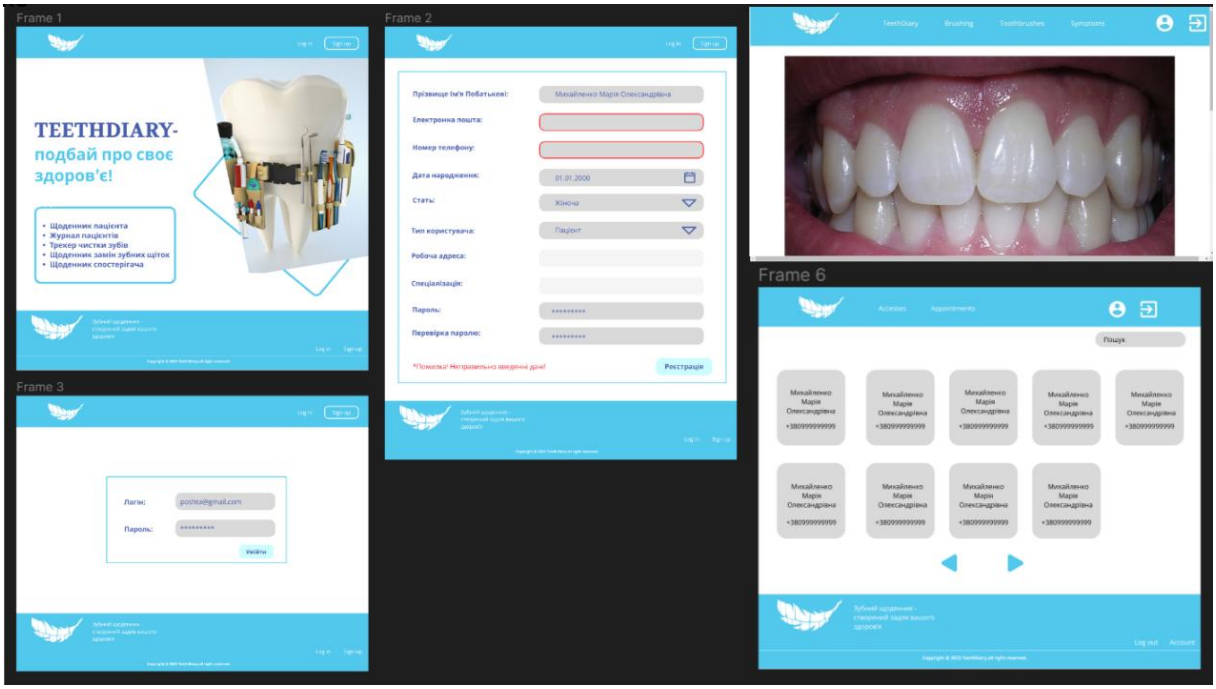
Figure 6 - Interface design: a) observer's diary and toothbrush creation form; b) tooth brushing diary and a form for filling in data on brushing teeth;
c) toothbrush replacement diary



a B C

Figure 7 - Interface design: a) main page and authorization page; b) registration page; c) viewing the procedure file and the patient log

Each entry can be edited or deleted. One of the data views can also be called an information panel, which shows current data on the last visit to the dentist, the last professional cleaning, the last toothbrush change, the number of teeth in the oral cavity and the number of teeth brushing today.

Conclusions. The paper proposes a web-based application for keeping dental records for recording and analyzing the state of the oral cavity. The practical significance of the developed application is to provide users with a convenient motivational tool for oral health care and monitoring. The user of the "patient" type is provided with the following functionality as registration and authorization, keeping records of treatment processes, viewing attached image files, tracking the frequency of brushing teeth and changing toothbrushes, monitoring the appearance of symptoms and health complaints. The user of the "doctor" type is given the opportunity to keep and view the history of treatment of patients who have given their access. Further development of the proposed research has several directions. They are expanding the range of display of performed procedures on a graphic model; creation of the "Calendar of Appointments" module for convenient planning of the doctor's work schedule; implementation of the comparative analysis of certain type images and for a

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certain period of time; implementation of communication between the doctor and the patient with the possibility of making an appointment through the system.

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Веб-орієнтований застосунок ведення дентальної хроніки для запису і аналізу стану ротової порожнини

Запропоновано веб-орієнтований застосунок для ефективного моніторингу та догляду за станом ротової порожнини пацієнта. Розроблений застосунок має наступне призначення: ведення дентальної хроніки стану ротової порожнини пацієнта, з подальшою графічної візуалізацією поточного стану; ведення лікувальних процесів лікарем; відстеження наявних симптомів та скарг на стан здоров'я у користувача; контроль спливання терміну використання замін зубних щіток та моніторинг кількісті чисток зубів на день. Загалом в системі наявно два типи користувачів: лікар і пацієнт. Звичайному користувачу надаються наступні функціональні можливості: реєстрація і авторизація, ведення записів про лікувальні процеси, перегляд доданих файлів знімків, відстеження частоти чистки зубів і зміни зубних щіток, моніторинг появи симптомів та скарг на здоров'я. Користувачу типу лікар, надається можливість вести і переглядати історію лікування пацієнтів, що надали свій доступ. Для реалізації застосунку було використано модель клієнт-серверної архітектури, шаблон проектування MVC, мова програмування реалізації JavaScript, HTML, препроцесор SCSS, стек програмування MERN, який включив наступні модулі: MySQL, Express(.js), Node.js, React.

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