Formation of Virtual Tours with the Use of Augmented Reality Information Technology

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Abstract

The research is aimed at creating a web application for the formation of virtual tours of the buildings and the territory of "Lviv Polytechnic" National University with the use of information technology technology. The urgency of the topic is due to the need to promote the higher education establishment in the socio-communicative environment of Ukraine and the development of technologies that allow to expand the possibilities of marketing in the formation of sightseeing tours of places that are cultural monuments, attractions in the university. Virtual or augmented reality technologies are particularly relevant to ensure a virtual university visit within a pandemic, due to quarantine, which limits people's ability to visit places of interest on their own. The advantages during the development of such a multimedia information product are presented in the article.

Keywords 1

Web Application, Virtual Tours, Information Technology, Virtual Reality, Augmented Reality

1. Introduction

Use of modern information technologies that allow to make virtual trips to different institutions and places, become indispensable in many areas of human activity. The most dynamically developing industry in Ukraine is tourism; during the selection of the trip, each tourist wants to be acquainted with all the conditions and seeks to obtain comprehensive information about the place of visit. The technology of "virtual tour" allows to provide information visualization. This approach helps to present the image of the object from different angles and to get acquainted with the corner of public space that aroused interest. As a convenient visualization tool, the technology of "virtual tour" is effectively used in the field of marketing, which allows to show a potential consumer his product or service, creating a vivid place. This tool allows you to get more complete information about the object under review.

The article offers an analysis of the basic principles of project development of the intellectual system "virtual tour" using of augmented reality technology with possibility of placing an information product on the web. The project envisages the creation of a convenient WEB-system, which will provide the user with complete information about the objects, the opportunity to view the premises and the transitions from location to location within the building.

The purpose of the study is to develop augmented reality information technology for creation of a virtual tour of Lviv Polytechnic National University.

The main objectives of the research are:

- conducting system analysis;
- development of a conceptual model of augmented reality information technology;
- development and display of algorithms of work of components of the augmented reality information technology.

2. The state of research of the problem

Miao Hu, Xianzhuo Luo, Jiawen Chen, Young Choon Lee, Yipeng Zhou, Di Wu provide a detailed and systematic overview of virtual reality technology and its applications on the Internet of Things. They identify the main VR issues in system design, viewing prediction, computing, streaming, and user experience assessment [1].The research [2] focuses on the digital reconstruction of the historic Victoria Theater building in Newcastle. The virtual reality project is called Visualizing Victoria. Researchers focuse in particular on the current design and user experience of using a transmedia approach to virtual environment to preserve the heritage of the place. The study[3] builds a four-tiered research model to explore how a 360° virtual tour can reduce psychological stress in people through two types of presence (sense of presence and telepresence) and affective-motivational states (pleasure and engagement) during this unusual period of a pandemic. Ting Yang, Ivan Ka Wai Lai, Zhao Bin Fan, Qing Min Mo show that telepresence has a greater influence on the formation of affective-motivational states than the sense of presence. Among the factors, the greatest influence on the satisfaction of the 360° virtual tour and the reduction of stress is the pleasure; participation reduces the impact of telepresence on satisfaction with a 360° virtual tour. This also contributes to the study of virtual reality by highlighting the concepts of "sense of presence" and "telepresence", as well as demonstrating the mechanisms through which virtual reality technology affects the psychological well-being of people.

A natural in-air gesture-based user interface has been developed with a user-centered approach for navigating virtual tours of cultural heritage exhibitions. In detail, the proposed interface was designed to "visit" Murcia, a karst zone located in Puglia. It has been demonstrated to incorporate an "immersive" gesture-based interface to enhance the user experience, giving it the feeling of seamlessly exploring the places of Murdjia[4].

However, the topical and least developed issue is the creation of virtual tours or interactive navigation systems for a virtual tour of higher education institutions in Ukraine, so analysis, cost forecasting and effectivedevelopment is a very important and relevant object of research.

3. System analysis

3.1. Building a tree of problems

Taking in the account the rapid development of solutions, working on the basis of augmented reality technology, it is necessary to constantly analyze the basic principles in order to provide the end user with a high-quality information product, presented in the form of a network. The results of the analysis of the available tools allow to build the most optimal virtual tour of the buildings of the higher educational institution with the imposition of augmented reality on it and to make a convenient, understandable for the end user interface.

In order to successfully complete the task, implement the following steps:

• formation of requirements for software;
• conducting a system analysis of modern tools for creating information technology for augmented reality systems;
• construction of a conceptual model of the information system;
• software architecture design;
• development of basic system modules;

• conducting experiments on the work of the required protocols;
• software product testing [5-22].

A tree of problems is a graph that facilitates the process of finding ways to solve problems and form the necessary tasks. The tree of problems is one of the key tools in systems analysis. Its use allows to determine the whole range of interrelated causes and consequences of the problem, almost completely eliminating the influence of external subjective factors. In Figure 1 the tree of problems for the developed application is shown. To build a tree of problems, certain problems are additionally classified according to their affiliation to the functional areas of activity.

To build the tree of problems, certain problems are additionally classified according to their affiliation to the functional areas of activity. The top contains a generalized initial problem and then, from top to bottom, problems-causes, and then problems-consequences.
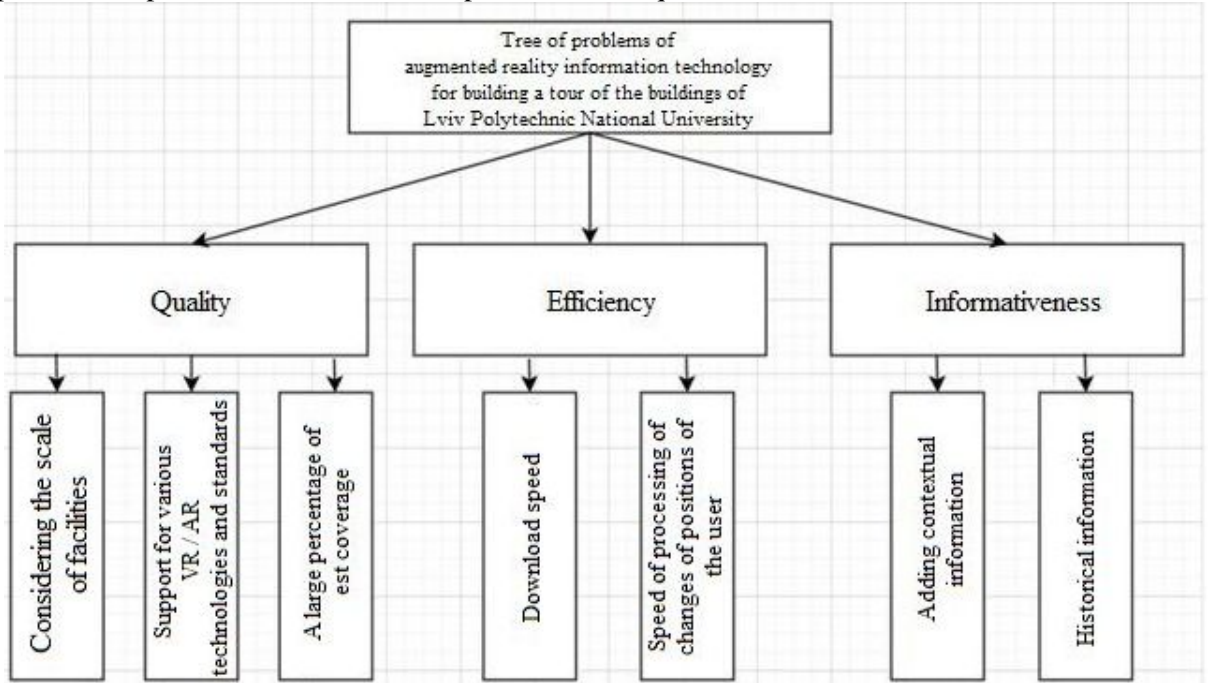

Figure 1: Tree of problems of augmented reality information technology for building a tour of the buildings of Lviv Polytechnic National University

The tree of problems is a means of analyzing the solution of problems. Obviously, the solution of all problems must be determined in time, that is, they must be structured into problems of the first, second and next turn. Moreover, having a general strategic plan for their joint solution, it is necessary to develop at each stage a plan of specific actions to solve the problems of this queue with the adjustment of the strategic plan based on the results.

3.2.   Tree of Problems Construction

The tree of goals is a visual graphical representation of the relationship and subordination of aims, that presents the division of the general aim in sub-goals, objectives and specific actions. In Figure 2 the tree of the purposes for the given project is resulted. The main goal is to develop software for the virtual tour of Lviv Polytechnic National University. Then the decomposition of main goal on sub-goal will be carried out.

At the first level of the tree is the goal of "Development of augmented reality information technology for the construction of a virtual tour of Lviv Polytechnic National University, which is its infancy:
- increase of information in digital form on the Internet about Lviv Polytechnic National University;
- providing a convenient way to view the virtual tour of Lviv Polytechnic National University;
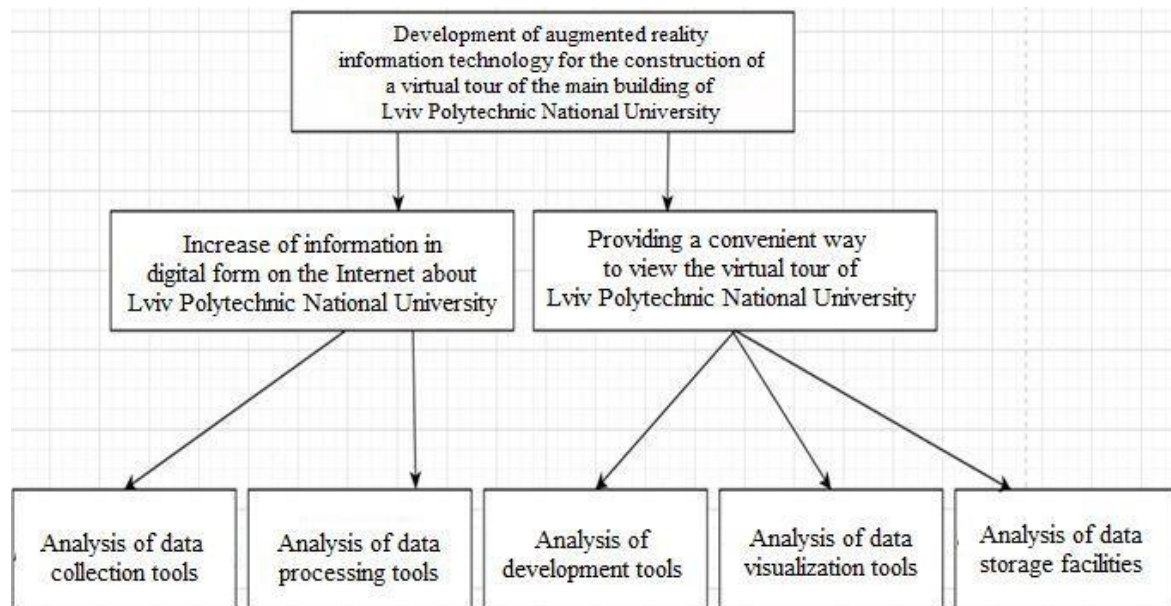
Figure 2: Tree of the whole augmented reality information technology for development of the tour by the buildings of Lviv Polytechnic National University

At the stage of "increasing the information in digital form on the Internet about Lviv Polytechnic National University there is a need to characterize the object of design, to identify the purpose, the main tasks. Also, work on scientific sources on this topic and get acquainted with existing similar implementations, highlight their pros and cons, analyze the tools that will be used to gather information.

The next stage of the second level of the tree of goals is "increase of information in digital form on the Internet about the goal", which provides for the goals of the 3rd level:

- analysis of development tools;
- analysis of data visualization tools;
- analysis of data storage facilities.

In order to effectively achieve the set goals, the goal was precisely and exhaustively formulated, the object and subject of the research were defined, and the tasks that need to be performed to achieve the goal were described. Next, the functional (requirements for system functions) and non-functional requirements (requirements that describe the limitations of functionality) are sequentially formulated.

During the implementation of this stage, a detailed description of the application functionality was provided. This contributes to the transformation of abstract concepts into concrete solutions, which are implemented in the information system, the design of algorithms for data processing, the design of its main modules, the optimization of software.

This stage consists in the development of the software product in a predetermined environment and with the help of previously selected auxiliary tools.

3.3. Analysis of data collection tools

Data collection is the process of collecting and processing information about these variables, systematized to answer current questions and evaluate results. The purpose of data collection is to select high-quality data that, after processing, will give convincing and reliable answers to questions.

The means of data collection in our study are special devices that are needed to digitize the environment in 360-degree space.

Such means are:

Digital SLR camera (Canon EOS 80D Body);

24.2 MP APS-C CMOS sensor and RGB + IR exposure sensor with a resolution of 7560 pixels, which ensures accurate exposure, you can take bright and detailed pictures under any conditions. The wide ISO sensitivity range (100–16,000) and the flicker detection function make it possible to obtain

good results in low light conditions and guarantee stable exposure in rooms with flickering artificial light.

Fisheye lens (Canon EF 8-15mm f / 4.0L USM (US) Refurbished);

Poor-quality images distorted by glare caused by high-light sources cause problems when shooting at such a wide angle. To eliminate them, all lens elements have a Super Spectra coating developed by Canon. The inner surface of the front element is also coated with Canon with a subwavelength structure (SWC), which is less than the wavelength of visible light. This reduces the speed at which light passes to the way it passes through the glass, preventing the risk of glare appearing when light hits the matrix.

The tripod is equipped with a head with smooth panning. (The MeFOTO GlobeTrotter tripod is equipped with a head with a smooth 360-degree pan and a removable platform with a bubble level).

3.4.   Analysis of data storage facilities

To process the data that is the result of digitization of the environment, we use a database server – MySQL, which is a free system for managing relational databases and developed by the company "TX" to increase data. This open source database management system (DBMS) was created as an alternative to commercial systems. MySQL was very similar to mSQL from the very beginning, but over time it has expanded and now MySQL is one of the most common database management systems. In the study, MySQL is used primarily to create dynamic web pages, as it provides support from a variety of programming languages.

MySQL is used in the development of small and medium-sized applications. In the developed intelligent system MySQL used as a server to which local or remote clients have access, however the distribution includes the internal library of the server allowing to include it to autonomous.

The flexibility of the MySQL system is supported by a large number of table types: users can select both MyISAM tables that support full-text search and InnoDB tables that support transaction-level transactions. MySQL contains special types of EXAMPLE tables, which simplifies the process of creating new table types, and thanks to the open architecture and licensing of the GPL, new table types are constantly appearing in it.

3.5.   Analysis of data processing tools

The means of editing the code is Visual Studio Code, which can be used with different programming languages. It allows us to open one or more directories and after that save them in workspaces for reuse.

Visual Studio Code was used as a code editor because, unlike Microsoft Visual Studio, which uses its own .sln solution files and project-related files, it supports a number of programming languages and a set of features that are different for each language. Unwanted files and folders can be removed from the project tree using the settings. Many Visual Studio Code features are not available through the menu or user interface, but can be accessed using the command palette.

We extend this editor with plug-ins accessible through the central repository, and include add-ons to the editor and language support. A handy feature is the ability to create extensions that add support for new languages, themes, perform static code analysis, add code letters, using the language protocol protocol. It also contains several extensions for FTP, which allows you to use the software as free support for web development. We synchronize the code between the editor and the server, without downloading additional software, which allows Windows users to install the code page on which the simulator is stored. This allows you to use the application on any platform, any programming language.

3.6.   Analysis of data visualization tools

There are many visualization technologies, and among them there are very complex, but very simple techniques adapted to the requirements of the developer are enough to transmit many

messages. For example, the age-sex (population, demographic) pyramid, a standard tool for data visualization of population demographic trends and comparison of populations, presented by two histograms placed vertically.

Modern visualization techniques are Euler circles and related Venn diagrams, which are used to illustrate the relations of sets and their intersections, Chernov faces, graphs, and organizational diagrams are used for demonstration. For some visualizations, not polar Cartesian coordinates are used, but polar ones.

The main means of visualization during the development of information technology of augmented reality for the creation of virtual tour by the buildings of the Lviv Polytechnic National University is usually a virtual reality helmet, but due to its high mobility, other devices were also used to present the output data of the information system by means of complementary reality technologies.

3.7. Analysis of development tools

For construction of information system based on augmented reality information technology for construction of a virtual tour of the buildings of Lviv Polytechnic National University the following tools and technologies were used:

HTML, as a markup language, is used by web browsers to interpret and create text, images, and other materials in visual or audio web pages. By default, each HTML markup element used browser-defined characteristics and was modified or extended with the additional use of the web page's CSS designer. The SGML usage technique covers the features of early text formatting languages, and is used by the RUNOFF command, developed in the early 1960s for CTSS (Compatible Time), Sharing System. The SGML concept of generalized markup is based on elements (nested annotated ranges with attributes), and is used to print effects, as well as to separate structure and markup; HTML is gradually moving in this direction with the help of CSS. Berners-Lee considered HTML as an addition to SGML. It was formally defined by the Internet Engineering Working Group (IETF) on the publication of the first proposal for an HTML specification in mid-1993 and contains definitions of the SGL document type. The project expired six months later, but was recognized as recognizing the custom tag of the NCSA Mosaic browser for embedded imagery, reflecting an IETF philosophy based on standards for success. Similarly, Dave Raggett's competing Internet project, "HTML + (hypertext markup format)," proposed in late 1993 to standardize already implemented functions such as tables and forms.

WebGL is a standard based on OpenGL ES 2.0, which allows embedding in web browsers that support HTML5, full 3D graphics without resorting to plug-ins. In the future, the developers plan to refine the WebGL standard to use not only in browsers for personal computers, but also in mobile Internet devices. The WebGL working group includes Khronos Group, representatives of leading developers of Internet browsers, such as Apple Safari, Google Chrome, Mozilla Firefox and Opera, as well as specialists from AMD and Nvidia.

This technology allows the use of hardware-accelerated 3D graphics in a web application without the need to use special web browser plug-ins on any platform that supports OpenGL or OpenGL ES. Technically, this allowed the binding of JavaScript scripts to the functions defined in the OpenGL ES 2.0 libraries, implemented at the browser level. WebGL is a further development of Canvas 3D in Mozilla and is stored in the Mozilla Firefox and WebKit development libraries, as well as in previous releases of Google Chrome 4. In November 2009, Khronos Group announced the first Web specification. Google has announced support for the specification in its Chrome browser since version 9. Mozilla (starting with Firefox 4) and Apple Safari have announced support for WebGL in upcoming versions of the products.

WebGL is widely supported in modern browsers. Although the possibility of its use depends on other factors, namely the GPU. The official WebGL site offers a simple test page to check for compatibility. More detailed information (for example, which render the browser uses or which extensions are available) is provided on third-party websites [23]. WebGL works in various browsers.

4. Conceptual Model

One of the levels of building the architecture of information system is conceptual level, which involves the construction of a conceptual model (or model of subject area) of this information system. The components of the model are objects and their relationships. The conceptual model provides a conceptual representation of data, is used to express, organize, organize and exchange representations. With the help of the conceptual data model, the objects of the subject area and the relationship between them are presented. The main object of the information system "Virtual Tour" of Lviv Polytechnic National University, and the main functions are operations in accordance with the policy of the user's rights. Operations with the environment in the information system "Virtual Tour" provide for the performance of the functions of viewing, searching, storing information.

As the developed information system is rather complex, the role of conceptual modeling at its creation has sharply increased. During the formation of such an extended functional, a conceptual modeling was performed, which allowed to create a prototype of the system with the definition of its main functions. Based on the proposed functionality, numerous methods of conceptual modeling were created. These methods were used to improve the presentation of functions of modeled information system. When creating a conceptual model of the information system, methods and techniques of conceptual modeling were used, which provide for modeling of work processes, modeling of labor force, rapid development of applications, application development.

A model of the subject area was created as a type of conceptual model, which was used to describe structural elements and their conceptual constraints. The model of the subject domain includes various entities, their attributes and relations, as well as the constraints that determine the conceptual integrity of the elements of the structural model of the structural model.

During the development of the software, which provides the possibility of "walking" on the university building, the necessary stage was the design of the structural scheme, which is shown in Figure 3. The information used by the information system is stored on the server.
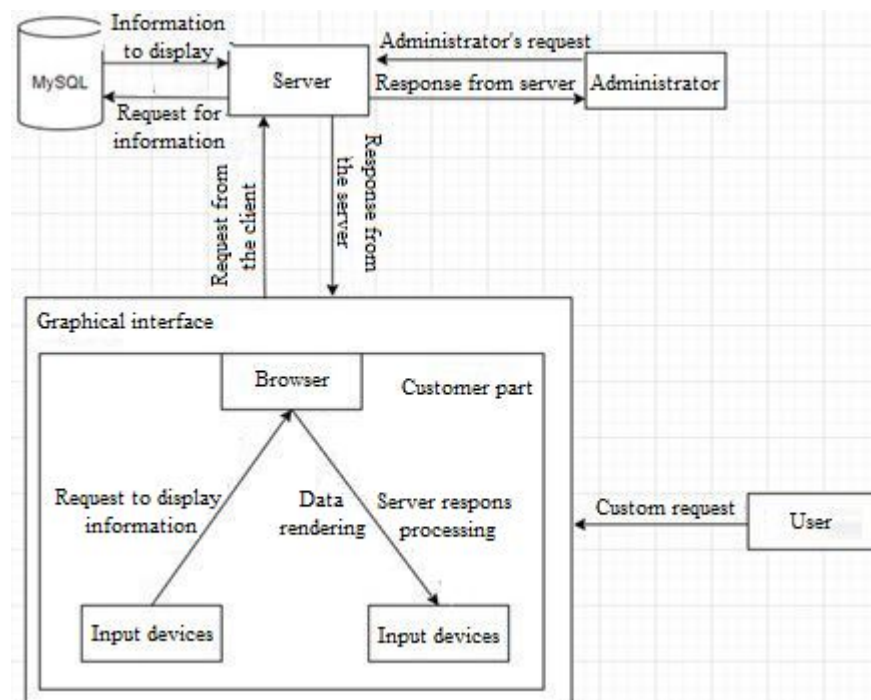

Figure 3: Block diagram of the information system "Virtual Tour"

End users can be a system administrator who designs a software tool for building virtual tours by educational institutions, or a user who wants to use a virtual tour with the help of a software developer.

The graphical interface allows users to view information about the educational institution in a visual form, i.e. to view panoramas, which have been digitized, use the capabilities of complementary reality for more information about the objects depicted in the panoramas.

The server part of the developed software product processes requests to the administrator, acts as a "router", which connects requests from the user to the database in which the information is stored, and the client part of the client.

5. Development and representation of algorithms of work of components of information technology of added reality

5.1. Block diagrams of algorithms

We use a block diagram to present an algorithm for solving or analyzing a problem using geometric elements (blocks) that denote operations, flow, data, and so on.

The functional scheme, or block diagram of the algorithm, consists of functional blocks, which are structurally separate parts (elements or devices) of the information system and perform certain functions. Functional schemes of the information system are made in the enlarged and expanded form. In the first case, the diagram shows the most important blocks of the information system and the links between them. After going to the site, the user gets to the main page of the information system, where he is given the opportunity to perform several operations, including:

- review of the latest news;
- receiving contact information;
- use a virtual tour.

In Figure 4 the algorithm of activity of the user after transition to the main page is displayed.
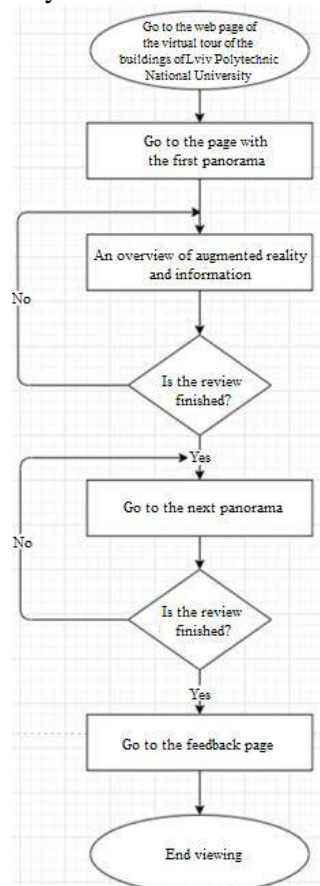

Figure 4: Block diagram of using the site.

When you go to the tab "Passing the tour", the user gets to the page where he can view the information, namely:

- Choose a walk through the main building of Lviv Polytechnic;
- Learn information about the history of the university;
- Go to the feedback page.

5.2. Construction of a diagram of precedents

The precedent diagram in the UML notation shows the relationship between the actors, that is, the entities that interact with the system, and the precedents, the system use variants [24].

In the precedent diagram, the designed system is presented in the form of a set of entities or actors that interact with the system through the so-called usage options. The usage option helps to present the services that system provides to the actor. In other words, each variant of using the information system is determined by a certain set of actions that it performs when interacting with the actor. It is not specified in what way the interaction of actors with the system will be realized. The general properties of the options for using the developed information system are presented in three different ways - with the help of relations of association, inclusion, expansion and generalization:

The association relationship was used in the construction of all graphical models of the information system in the form of canonical diagrams. The include relationship represents the relationship between the base use case and some special cases. The relationship of extension is the relationship of the basic variant of use with another variant of use, the functional behavior of which is not always involved in the basic, but require the involvement of additional conditions. The relationship of dependence (generalization relationship) is considered as the relationship between two elements of the model, in which the change of one element (independent) leads to a change of another element (dependent). In Figure 5 a diagram of options for using the information system for the website of the virtual tour by the buildings of the Lviv Polytechnic National University is shown. The actor (essence) is a user who is configured for the following usage options:

- view the image of the main body in a 360-degree panorama;
- approach and removal of objects located on the territory of Lviv Polytechnic National University;
- review of information added in the form of augmented reality;
- feedback.

A precedent that has an "include" relationship means that after the execution of one precedent, it includes the execution of another with which it is interconnected.
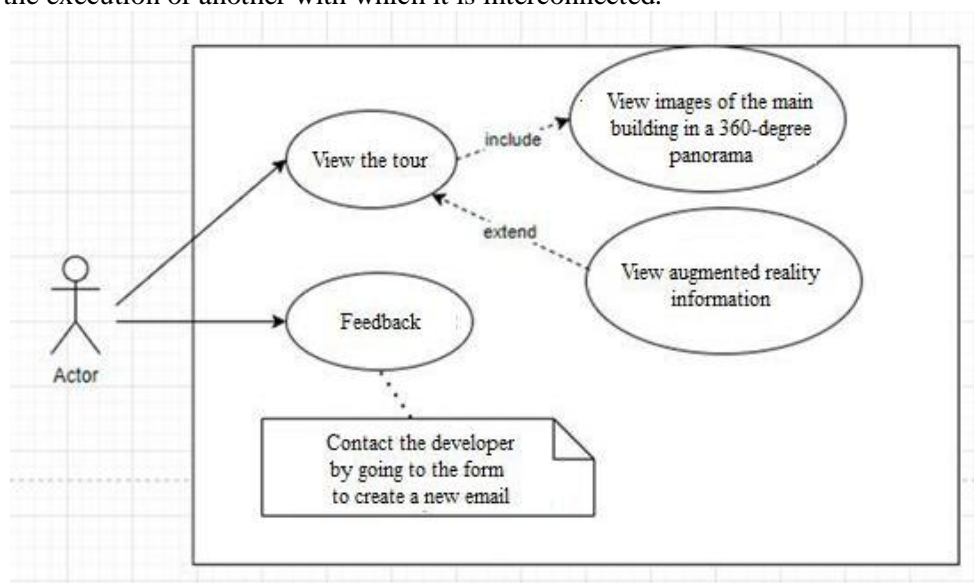

Figure 5: Use-case diagram

The precedents connected by the "extend" connection are used to extend the functions and may not be executed. For example, if a player enters the main menu, he can go to settings or connect to a virtual tour.

The following is a description of the existing relationships in the chart:

- there is an "include" link between the "Tour Preview" and "Main Body Images in 360 Degree Panorama" precedents. This means that the first action involves the performance of the second;
- there is an "extend" link between the precedents of the "Tour Review" and the "Augmented Reality Information". Accordingly, this means that the "Tour Review" precedent includes the ability to review additional information.
- the diagram to the precedent "feedback" indicates a comment that indicates that the user has the opportunity to feedback to the developers of the software using the form of the e-mail.

5.3. Construction of the IDEF0 model

We used Function Modeling methodology of functional modeling and graphical description of processes, designed to formalize and describe business processes. IDEF0 contributes to the hierarchical representation of objects, which greatly facilitates the understanding of the subject area. IDEF0 provides an opportunity to present logical connections between processes, without giving the sequence of their execution in time (WorkFlow) [5,25,26]. In the same way all management processes are displayed. It should be noted that this model is convenient and successfully used for the formation of management processes of our project and will contribute to the effective modeling of administrative and organizational processes of its implementation. The context diagram shows what data is fed to the input and what is the result of the information system. The context diagram presents the works that represent the activities of the website as a whole. This diagram is shown in Figure 6.

Inputs:
- user request;
- administrator's request;

Outputs:
- output of information;
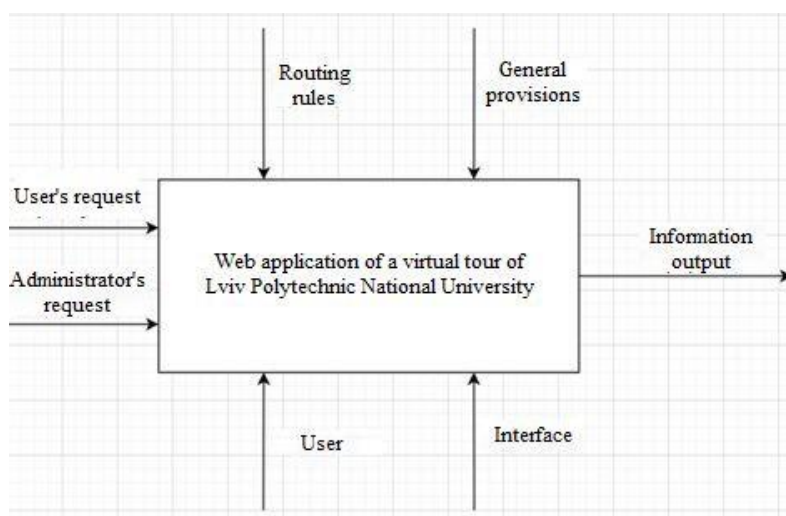
Mechanisms:
- user;
- interface.

Figure 6: Context diagram

Management processes:
- routing rules;
- general provisions.

Considering that Lviv Polytechnic National University is the oldest higher technical institution in Ukraine and Eastern Europe, founded in 1816 as a Real School with the permission of the Austrian Emperor Franz I., throughout its history the institution was headed by leading scholars of the region (Figure 7) [27].

Figure 7: A gallery of portraits of rectors is organized in the main building.

A gallery of portraits of rectors is organized in the main building. The information system of virtual tour of Lviv Polytechnic National University allows us, carrying out a virtual tour, to get acquainted in detail with the portraits of former rectors of the institution, and with the help of augmented reality technology to get information about their short biography (Figure 8).
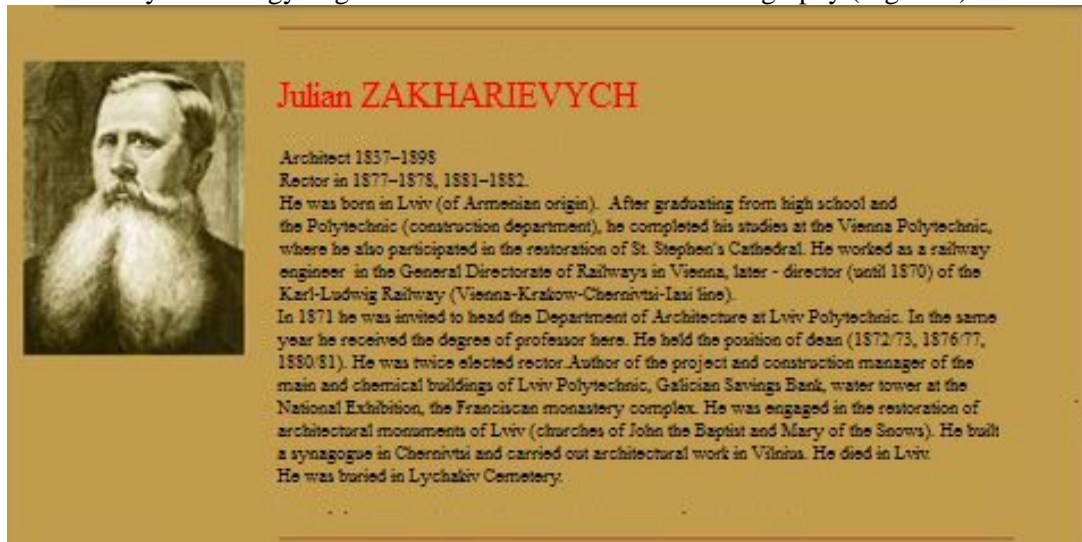

Figure 8: The portrait of the former rector.

6. Conclusions

The research is aimed at creating a web application for the formation of virtual tours of the buildings and the adjacent territory of Lviv Polytechnic National University with the use of

information technology technology. The urgency of the topic is due to the need to promote the school in the socio-communicative environment of Ukraine and the development of technologies that allow to expand the possibilities of marketing in the formation of sightseeing tours of places that are cultural monuments, attractions in the university. Virtual or augmented reality technologies are especially relevant to ensure a virtual university visit in a pandemic, due to quarantine, which limits people's ability to visit places of interest to them. The benefits we receive during the development of such a multimedia information product are as follows:

- the possibility of integration into the site, as the product will be presented in the form of a web resource;
- adaptability to the operating environments of mobile devices;
- possibility of audio accompaniment of the video during the virtual tour;
- the possibility of expanding the functionality.

The virtual tour will be useful for entrants, students, tourists who will be able to get acquainted with the structure and architectural features of Lviv Polytechnic National University remotely. As a result of the study, the following results were obtained:

1. The system analysis is carried out, in the course of which the basic purposes, tasks, problems are revealed and their analysis is carried out; constructed a tree of problems and a tree of goals for construction of software "Virtual Tour"; choice of a complex of technical means for realization of the set task is made.

2. The conceptual model of the chart information system (precedents), the IDEF0 model, which describe the functional capabilities of the developed system are analyzed.

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