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Information system for navigation in modern university campus



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Outline of the presentation

1. Urgency of the research.
2. Theoretical framework.
3. Stages of the system development.
4. Results, discussion & prospects.

The urgency of the work

Modern universities are important educational, scientific and cultural hubs that are daily attended by a large number of people on different purposes, who are unfamiliar with the location of its buildings and their topology,

and have a need for convenient navigation, which makes urgent the design and development of the appropriate information system for navigation.

The urgency of the work

It is necessary to search efficient solutions for **scientific and applied problem of in-door navigation** which has been getting urgency recently, but has not been solved in full measure.

Indoor navigation as a problem

Indoor navigation means detecting objects (devices or people) and orientation inside the building using **radio waves, acoustic signals, wireless networks (Wi-Fi), infrared sensors, magnetic field, Bluetooth technology** etc. The challenge of such navigation is that each building where it is necessary to orient, must have special devices configured to work with the navigation system. It makes the development of such a system expensive and long-term, and also adds certain difficulties to its testing, maintenance and expansion opportunities.

On the other hand, indoor navigation technologies based on the processing of visual images, as well as **QR codes**, are underused and unjustifiably forgotten, although they require less investments and have significant prospects for their using for the development of mobile and web applications.

In addition, the analysis of the functionality of existing systems for indoor navigation testify their limitations which caused the necessity of searching new efficient approaches to the design of information system for indoor navigation.

Theoretical framework

- (1) the analysis of the applications which realize similar functions of the subject domain
- (2) the approaches to solving the mathematical problem of the shortest path search in graphs
- (3) the technological solutions of digital maps building

The analysis of the facilities of the selected services of in-door navigation

the analysis of the analogues of indoor navigation systems, according to the following criteria:

(1) route building functionality;
(2) adaptability of the interface;
(3) convenience and ergonomics of the interface;
(4) quality of visualization of graphic content;
(5) design aesthetics;
(6) price;
(7) technological possibilities for use in devices of various types;
(8) possibilities of functionality extension and refining.

The analysis of the facilities of the selected services of in-door navigation

- **AAU Map** (software for navigation in buildings and area of Aalborg University (Denmark);
- **Mapsindoors** (extension of the MapsPeople platform built on Google Maps technology which ensures the transition from external to internal navigation and its rapid implementation);
- **AnyPlace** (a free open indoor navigation service that provides location determination using smartphones);
- **Situm Mapping Tool** (indoor navigation application that accompanies visitors in a specific building to find their way in real time mode);
- **BSB Navigator** (a smartphone application that navigates through the library on Ludwigstrasse in Munich and uses beacon technology based on smartphone Bluetooth).

The analysis of the facilities of the selected services of in-door navigation

Despite the significant functionality, these indoor navigation services have **the following set of limitations**.

Most of the analyzed analogues are able to provide navigation inside a specific building, but they are not suitable for use in other premises.

At the same time, they do not have a sufficiently developed functionality of extension and refinement.

They do not provide users with language localization. They are either web services or mobile applications.

These limitations cause the search for appropriate algorithmic, interface, and technological approaches to design of the information system for university navigation. They were also taken into account when determining the functional and non-functional requirements for the said system.

The analysis of the problem of finding the shortest path

To solve the specific practical problem of finding the shortest path for indoor navigation, an appropriate analysis was conducted to select an adequate search algorithm among such well-known algorithms as

Dijkstra, Bellman-Ford, Floyd-Warshell, Jonoson and others.

The main selection criteria for this problem are the properties of the graph, as well as the execution time of the algorithm.

As a result, there was selected Floyd-Warshell algorithm (which works based on the dynamic programming method).

INTERFACE, ALGORITHMIC, TECHNOLOGICAL SOLUTIONS

Specification of functional requirements for the navigation system

The analysis of the use cases enabled to provide detailed specification of the functional requirements for the system being developed. In particular, the set system for navigation has to supply for a user:

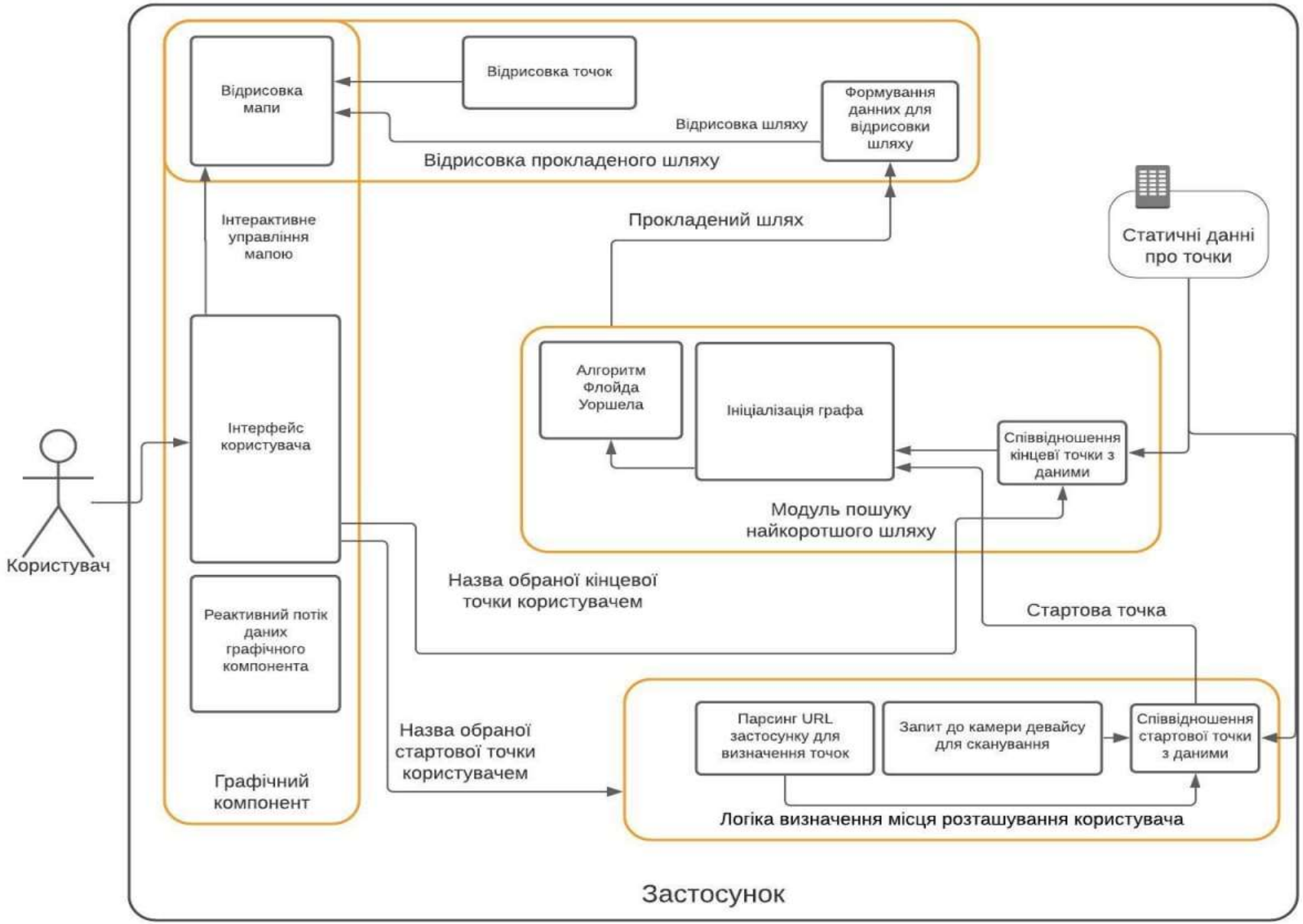
- language localization settings;
- selection of existing locations on the interactive map;
- determining the location of the user;
- finding the optimal route from the start spot to the final spot;
- visualization of the obtained route;
- review of the current floor plan;
- free change of floors on the interactive map of university premises;
- changing the scale of the interactive map;
- providing prompts on types of locations;
- adaptability of the interface to different sizes of devices and their graphic settings.

The technological approaches to the design and development of the navigation system

- Angular as a framework for SPA web-apps development

- RxJs – library for reactive programming
- svgdotjs – library for svg processing in OOP style
- zxing/ngx-scanner – library for QR-codes scanning in teal time

General architecture of the navigation system



- graphic module,
- module of detecting user's location,
- shortest path search module,
- module of the searched rout visualization

Graphical module as a key component of the system

Graphic module plays the role of an intermediary between the user and the entire logic of the application including data processing and execution of complicated algorithms of detecting the user's location and visualization of built optimal route from the start spot to the final spot.

Its role is to provide the user with a convenient and intuitively clear interface for interaction with the functionality of the system, as well as visualization of the interactive map and navigation information (names of specific locations, additional marks, etc.).

It provides not only the appearance of the application together with the means of interaction with the user, but also the logic of interaction of the data related to the visual part of the system (map scale factor, position relative to the screen, selected user setting, etc.).

The graphic module as a set of interface elements and program code

1) Зона пошуку, з двума елементами форми для введення стартової та/або кінцевої точки маршруту

2) Випадаючий список з автодоповнення

3) Елементи інтерфейсу для управління масштабом мапи

4) Кнопка відцентровування мапи

5) Елементи інтерфейсу для зміни поточного поверху та відображення його номеру

6) Кнопки для відкриття вікон з інструкцією, налаштуваннями, сканером відповідно зверху-вниз

Approach for development of the graphic module of the navigation system

- implementation of interface control components in the form of a *template*, *styles and controller*, *html*, *css and ts files* for each component;
- implementation of an adaptive user interface as a grouping of all control elements with additional display logic;
- organization of the business logic of the interface in the form of services that store data and means of their processing, using reactive programming based on RxJs library;
- the organization of utilitarian classes and methods that enable to remove repetitive parts of processing that are not directly related to the logic of the whole graphic module.

Graphic module of the system. Interactive map generation

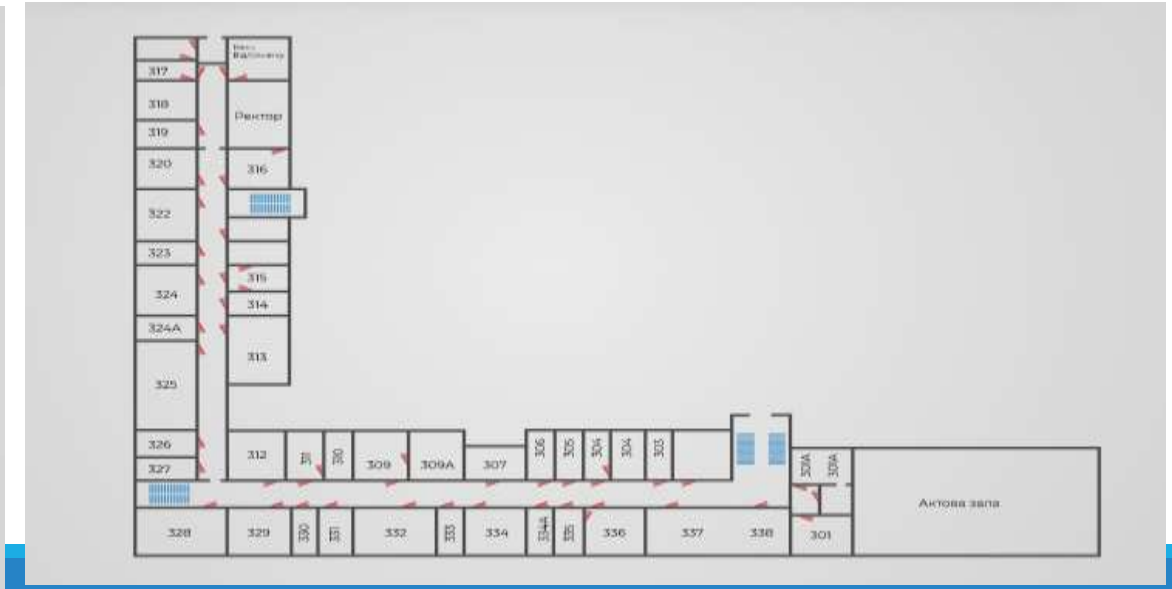
The interface solutions also include the interactive map generation by digitizing floor layout of university premises using the vector image editor Adobe Illustrator. The results of the digitization are used for interactive maps building.

Thanks to the application of vector graphics, a map was obtained for each floor in the form of a document with its own syntax and rules, which describes the corresponding graphic elements of the image using attributes and formulas.

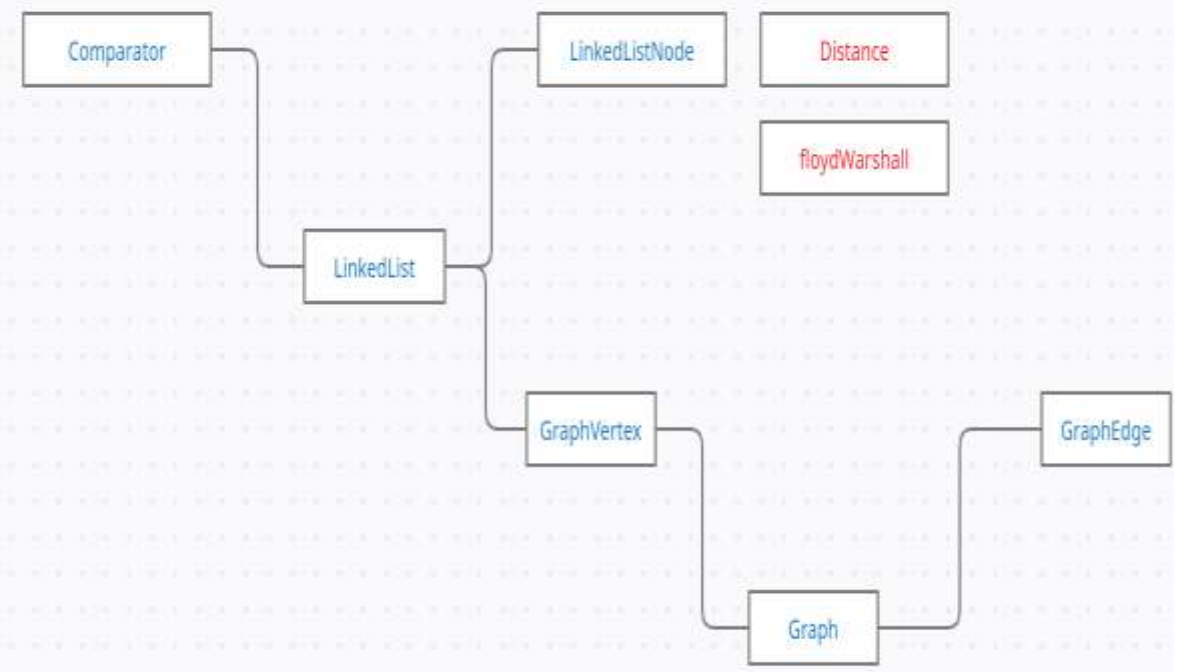
This provides dynamic interaction with such a document using program code, which will allow further adaptation of the input data of the graphic module to extend the capabilities of the system for its application to navigation in different premises.

In addition, it gives **an advantage in terms of loading speed and image quality**.

As well it ensure **the adaptability and flexibility of the whole navigation system**, it can be used both on computers (la



Algorithmic solutions in the design of the navigation system.
Shortest path search module



Назва модулю, папки	Призначення
Comparator.ts	Використовуються для порівняння двох вершин
Distance.util.ts	Утиліта для вимірювання дистанції між двома вершинами графу
floydWarshall.ts	Функція з реалізацією алгоритму Флойда-Уоршелла
Graph.ts	Клас з головною структурою графу
GraphEdge.ts	Клас ребра графу
GraphVertex.ts	Клас вершини графу
LinkedList.ts	Клас пов’язаного списку
LinkedListNode.ts	Клас пов’язаних узлів
Graph.service.ts	Сервіс для зберігання графу та логіки пошуку маршруту

Functionality of the university navigation system

- Free viewing of the scheme of the university premises on the interactive map; change of the current floor; change of map scale.

• Finding the shortest route from the start spot corresponding to the physically located QR code to any accessible university location.

• Visual prompts about the location of all available locations.

• Scanning of QR codes directly by means of the navigation system.

• Centering the map.

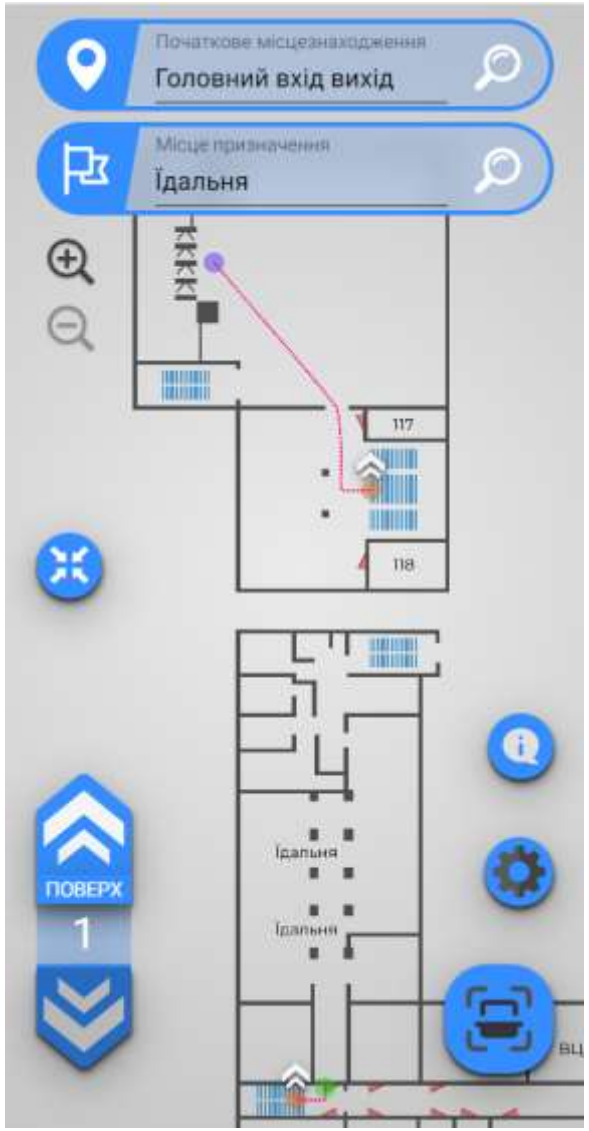
• Localization of the user interface in three languages.

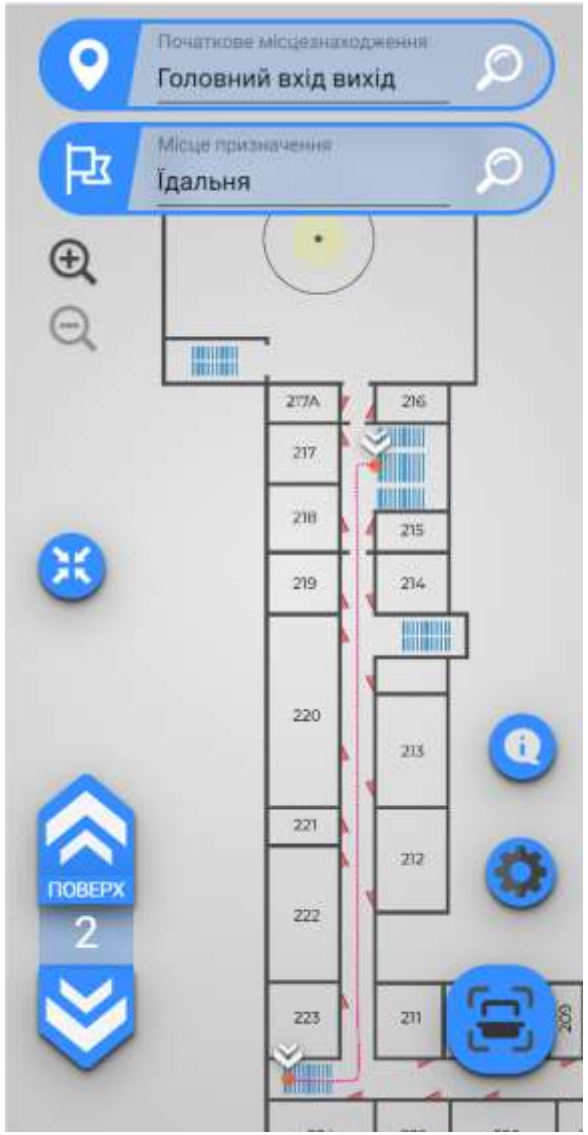
• Viewing the instructions for the system using and additional information.

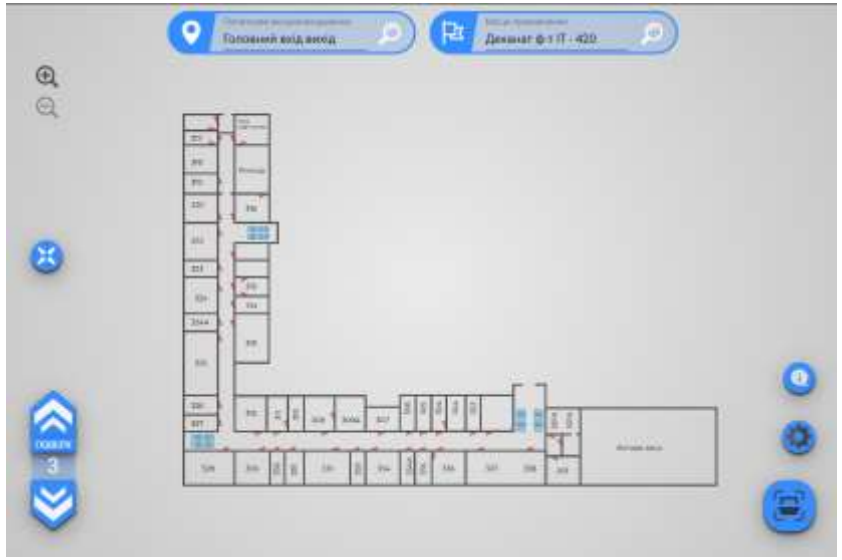
Additional functionality of the university navigation system

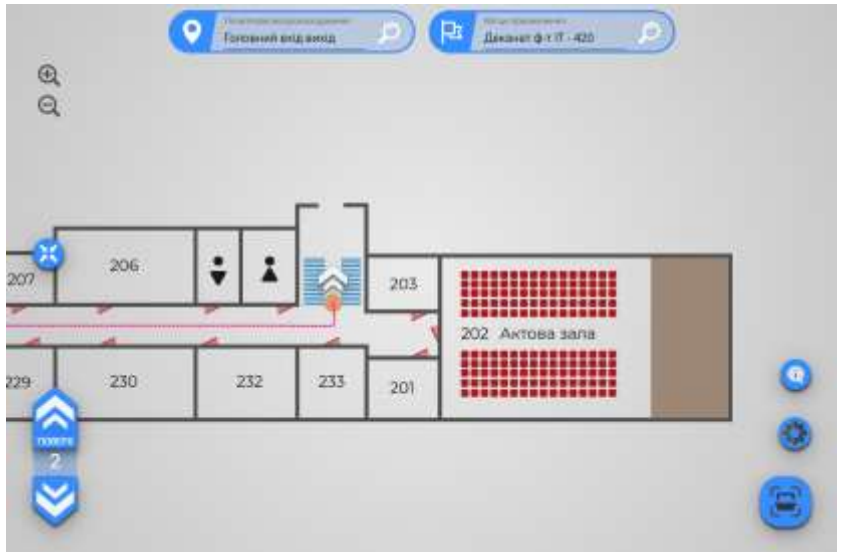
- Facility to scan QR codes with third-party software to move to the navigation system.
- The ability to download a web application to a mobile device from the user's browser and use it in a similar way as native applications, even offline.
- In addition to the location of the QR code itself, a user can also put any final point or start point in the QR code. This significantly expands the areas of use of QR codes for INS users.

Episode of the university navigation system work





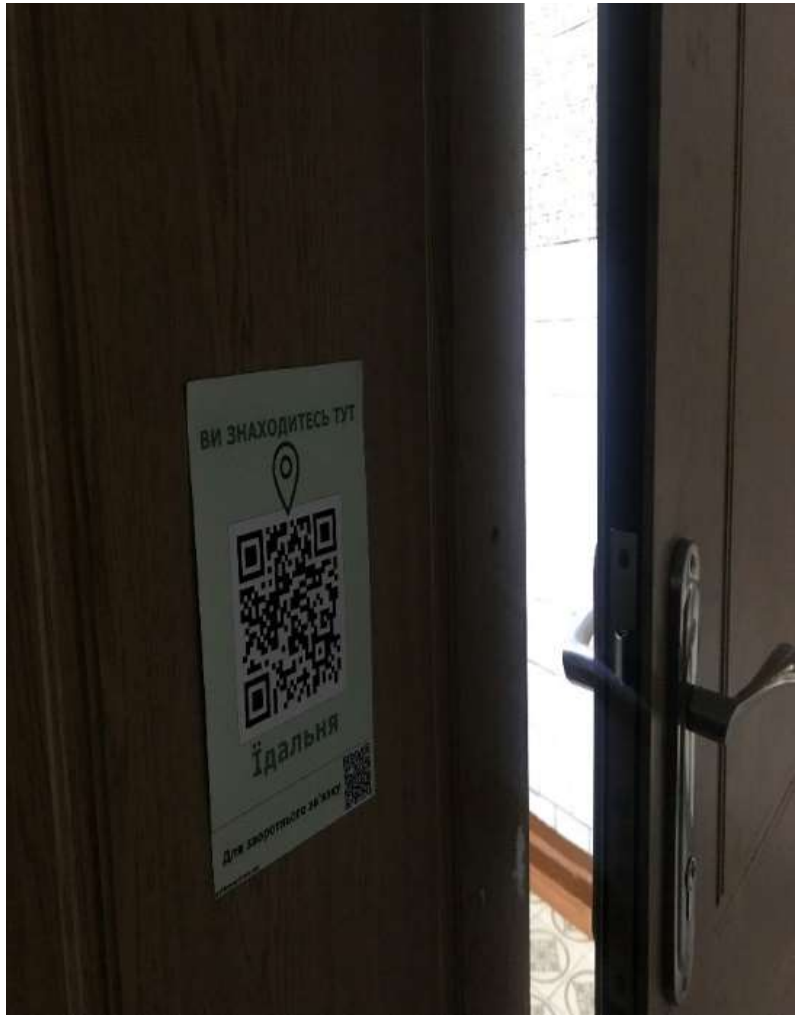




The navigation system implementation (S. KUZNETS KHNEU)

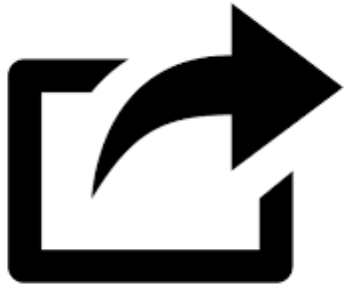
Implementation, feedback analysis, improvement

QR code labels were placed in the relevant locations of the university premises, which enables university visitors to access the system with their smartphones and use the functionality.
Feedback from the system users (university visitors of different categories) was collected and analyzed.
Users were asked to fill in a survey form evaluating the quality of implementation of both functional and non-functional requirements for the system on a five-point scale.



Ways of the system improvement

- ensure acceleration of application loading;
- implement the possibility of sharing a link with an already built route;
- to improve the quality of the animated visualization of the laid route.



CONCLUSIONS

- In the progress of the work there was developed the navigation system which was implemented into the educational practice of the university.
- Thanks to the proposed algorithmic, interface and technological solutions, during the design it was possible to overcome the main limitations inherent in similar systems implementing indoor navigation.
- The assessment of the navigation system in comparing with other analogues makes the prospect of our research.

Thank you for attention!