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GEOINFORMATION SUPPORT SYSTEM FOR REAL ESTATE MARKET

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ABSTRACT

Investing in real estate is one of the major investment areas in the world. While buying real estate people often consider – apart from standard analysis like size, standard, age, equipment – location and market prices. There is no doubt that the access to a large set of data describing and presenting property environment at present, market participants (targeted users = buyers and sellers) use the services of intermediaries or real estate appraisers, which generate extra costs, or they conduct the research using their own computers or mobile devices.
The main goal of idea is to create an automatically generated information system for real estate market members. The proposed solution can allow delivering filtered information to the user. It can be presented in conjunction with the location. The user can be able, while standing in or near the property. The proposed solution consists of: positioning based on the phone GNSS (Global Navigation Satellite Systems) receiver and radius specification. As a result, valuable information can be displayed in AR (Augmented Reality) technology or on a map where location and unit prices are visible.

Key words: real estate market dynamics, augmented reality, spatial analysis

INTRODUCTION

Geoinformation Support System (GSS) will determine a mobile device coordinates using GNSS systems (GPS, GLONASS, Galileo). It is possible to use the system to present the market (transaction prices) in augmented reality (AR) technology and generate statistics by the asking position/user. Currently, there are over 400 thousands of purchase/sell transactions made per year only in Poland. During the transaction, two sides- buyer and seller meet. They are potential users of the service (about 800 000 of people in total – there are at least two people per transaction) (Eurostat 2018, GUS 2018). Each of the sides is trying to reach to information on as many as possible recent transactions to make the right choice when it comes to the paid price. At present, the access to the real estate market analysis in chosen location can be assured by the experts (brokers or real estate appraisers). This service is both expensive and time consuming. GSS solution can allow collecting and filtering the information for the chosen location. Currently, there is no such service in Poland and in other european countries. Hence the assumption that potential buyers and sellers of real estate will be interested in such a system.

The second group of users are financial institutions, using the GSS system will be able to significantly automate the method of defining the risk when granting mortgages. The analysis, which is dedicated

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for specified location, will allow for market analysis together with the average real estate price estimation for chosen area. Within the financial institutions, the companies dealing with real estate investment will form a significant group of service receivers (Renigier-Biłozor et al. 2018, Kowalczyk et al. 2019). The proposed GSS system will allow tracking the market tendency based on distributed data sources from which valuable information together with location attribute about the market condition is generated. Currently, the reports describing only the global situation on the real estate market are available. The number of real estate transactions that were made last year consists over 2 mln of authenticated deeds. 412 000 of them concerned sell. The rest of them where other forms of legal status regulations. Both sellers and buyers are very interested in finding the optimum price by trying to get to know the prices that have been recently reported in the neighborhood of the sold property. The proposed business is about delivering, to over 800 thousands of people (over 412 thousands of transactions involves over 800 thousands of potential users each year – a buyer and a seller for each transaction), the selected and valuable information about the real estate sales (market conditions) in the chosen neighborhood each year. GSS is about delivering to nearly 800 000 people per year a selected information about the unit prices of real estate sold in the neighbourhood (understood as a location chosen by the application user). The Figure 1 shows the type of properties that were the largest group of sell transactions made in 2018. It follows that the largest group of transactions are contracts for the sale of premises and plots.

The user will run the application in a place selected for transaction. Based on the GNSS technology, the mobile device will determine user position. The user will select the type of desirable property and the radius from which the transaction prices should be displayed. As a result, the location report and a map showing transaction prices will be displayed. A visualisation of the transaction places in the neighbourhood (using AR technology) will be an extra option.

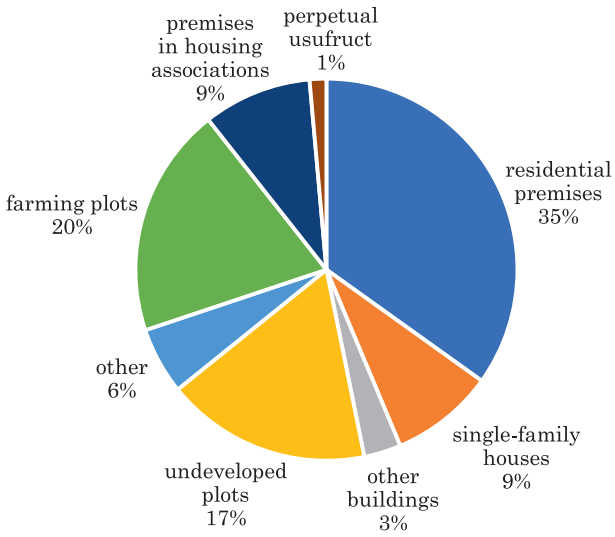

Fig. 1. The structure of real estate authenticated deeds in 2018 (GUS – Central Statistical Office)

Current knowledge confirms that users often ask counsellors for a summary of real estate market data from a given area in clear readings, including the number of buy/sell offers, the number of bids in time (the answer to whether the number of offers increases or decreases), and minimum, maximum and average prices.

The created service will have a very important feature of adapting to users' needs (Baier et al. 2015, Scholz and Smith 2016). The created database will allow for proper data filtering and sorting in order to create valuable information that is compatible with the expectations of different user groups.

Analyzing the market of mobile applications related to the real estate market in Poland, it can be concluded that augmented reality solutions are missing. Many solutions using AR in the international market are patent pending (Rese et al. 2017, Rauschnabel et al. 2019). Examples of such solutions are:

- real estate property project analysis using augmented reality user devices (Dintenfass 2018),
- augmented reality for maintenance management, asset management, or real estate management (Alonzo 2014),
- systems and apparatuses for providing an augmented reality real estate property interface (Zhang et al. 2018),

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– real-time analysis involving real estate listings (Calman et al. 2014),
– augmented reality property system for displaying moment file of user created content tagged to location including augmented estate owner content (Suiter et al. 2019),
– augmented reality real estate mls and virtual tours (Merati 2019),
– augmented Reality Based Mobile App for Home Buyers (Banerjee et al. 2015).

By following the offers of mobile applications a group of applications related mainly to apartments can also be found. Both with their equipment and display. The most important include:
– realtor.com (https://www.realtor.com)
– Commercial Real Estate AR (https://play.google.com/store/apps/details?id=com.cre.ar&hl=en_AU)
– Realar Places (https://www.realar.com/)
– IKEA Place (https://play.google.com/store/apps/details?id=com.inter_ikea.place&hl=pl)
– Drooms (https://drooms.com).

The aim of this paper is to present the possibilities of using augmented reality in the real estate market. The article presents the author's own vision of the system. In the further part of the work, technical and functional characteristics of the system were described, as well as the assumptions of augmented reality operation.

SYSTEM DESCRIPTION

At the moment, there is no viable solution (working in real time) on the market that would enable to properly make an investment decision. Currently available systems are just real estate valuations based on offers posted only on one portal. The restriction of these systems is to limit themselves to only one offer portal without obtaining data about actually executed transactions.

The innovation of the proposed solution is based on using mobile phone coordinates and defined range for market analysis. Based on the established data from the server powered by bid prices from the area (information obtained using search engine) and transaction prices from RCiWN (real estate price and value record) client will receive desirable information. Client will receive feedback as a report displayed with the use of expanded reality. There are market solutions that focus on individual elements like displaying real estate information using expanded reality, but they are based on data obtained from brokers. Such database is poor because of the specifics of the real estate brokerage market. In Poland, there are very few exclusive contracts between real estate agents and sellers. This results in no information about the real estate location in the sale offer. The proposed solution will use, except from big data, the information about completed transactions to generate final report. This will make it easy to evaluate the attractiveness of the offer. At the moment, there is no such solution on the market. Such analyzes are ordered individually, last for a very long time and require from investors to engage large capital. In contrast to the above, our solution will be attractive for everyone. Beginning with large investment funds, and ending with individual buyers looking for the apartment or a single plot.

Current knowledge confirms that users often ask counsellors for a summary of real estate market data from a given area in clear readings, including the number of buy/sell offers, the number of bids in time (the answer to whether the number of offers increases or decreases), and minimum, maximum and average prices (Oksman et al 2012).

After running the application on a mobile device in a place where one wants to buy a property, the user will have to determine its type and radius from which the transaction prices should be displayed on the screen along with a map. An additional option would be to visualize places (using AR technology) where transactions took place, which makes the service more attractive and allows for easy identification of the property in the neighborhood where a transaction took place.

The service will also have an automatic browsing system (robot) for the existing data sets about the buy/sell offers. It will allow generating statistics of the properties offered in the area of interest. The future price trends for the location will be displayed based on the artificial intelligence algorithms.

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While conducting projects using geoinformation for companies involved in infrastructure construction we have noticed unused potential of existing data sets stored in unreadable formats for a wide audience. It was an idea to process the data and create valuable information dedicated for a wider audience. The main assumptions for idea are (Jang 2012, Lang 2012, Yovcheva 2015):

- providing information to a wide audience in the areas most relevant for investment decision making,
- users decides what area to analyze the market,
- creating artificial intelligence algorithms to predict trends based on distributed data sources on real estate purchase/sell,
- using the latest visualization techniques – Augmented Reality.

The system will be a combination of technical solutions:

- determining user position (geolocation) based on the mobile device equipped with GNSS (Global Navigation Satellite System) module,
- geolocation of filtered transaction data for the need of conducting analysis in the chosen area (radius/distance from the user),
- creating augmented reality markers illustrating transaction place (sold real estate).

TECHNICAL CONCEPT

The architecture of the proposed solutions is shown in Figure 2.

The system will consist of three areas related to each other: data sources, server and client. Data presentation with the use of augmented/expanded reality demands the use of equipment that fulfils specific technical requirements. They result directly from the architecture of such solution that will consist of: client-location module, client-interaction module, client-presentation module, Database Browsing Server, Database Processing Server, Data Storing Server.

Client-location module – module responsible for real world analysis. The sensors built in devices (measuring sensors, camera, GNSS receiver) will be used at this stage. The process of location determination is multistage. The first stage determines the position using one or many sensors. Next, the information with fixed coordinates will be transferred to the system.

Client-interaction module – subsystem responsible for communication (application interaction) process with the user.

Client-presentation module – subsystem responsible for data display. In case of presenting data in AR

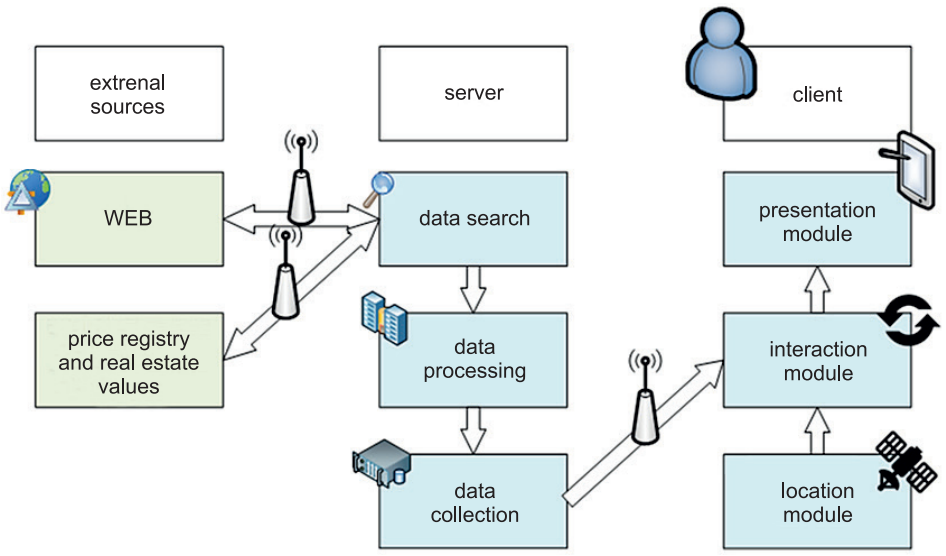

Fig. 2. Description of the proposed system architecture

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technology it is crucial to connect the camera signal from the device with visualized data.

Database Browsing Server – module that includes two search processes based on different algorithms: web search process with real estate sales and database search module with transaction price register.

Database Processing Server – module responsible for processing data which were obtained for database form that is essential for fast polling by the client module. Within this module, a geolocalization is conducted.

Data Storing Server – database consisting of peripheral devices which are used by the clients for polling. Robots which, based on the query containing client location data, will prepare statistics for the user will be created within this module (Judge 2018, Werner 2019).

SOURCE OF DATA ON TRANSACTIONS

A database is an integrated set of data from a certain field. The spatial database is a base extended additionally with a spatial factor, therefore, in addition to the descriptive attributes of objects, it also includes records regarding their geometry (Bydłosz et al. 2009). Such a database is the Real Property Price Registry, hereinafter referred to as "RCiWN" or the "register". It contains information on transaction prices of real property specified in the notarial deeds and the value of real estate included in appraisal reports, from which the statements are forwarded to the units that run the property cadastre. It is an integral part of the register of land and buildings, although it is a separate resource from it.

Taking into account the legal status of the register, it should be classified as:
- part of the spatial data base of the country's spatial information infrastructure
- part of the state geodetic and cartographic resource
- public information
- an element of the spatial information infrastructure (Siewicz 2012).

RCiWN is an administrative register constituting one of the sources of data in public statistics. The sources were divided into two groups according to the nature of their creation. These are data created for the needs of the public sector and the private sector. The Property Price and Value Register is included in the first category (Beręsewicz and Szymkowiak 2015).

The creation, functioning and sharing of the registry database is regulated by the Act of May 17, 1989. Geodetic and cartographic law (Journal of Laws of 2017, item 1566), hereinafter referred to as "PGiK". According to art. 4 par. 1a, RCiWN is a part of the spatial data infrastructure database maintained in the IT system, therefore it is also subject to the Act of March 4, 2010 on spatial information infrastructure (Journal of Laws of 2017, item 1566).

In accordance with §74.1 of the Minister of Regional Development and Construction from 29 March 2001 on the land and building (Journal of Laws of 2001., no. 38, item. 454), hereinafter

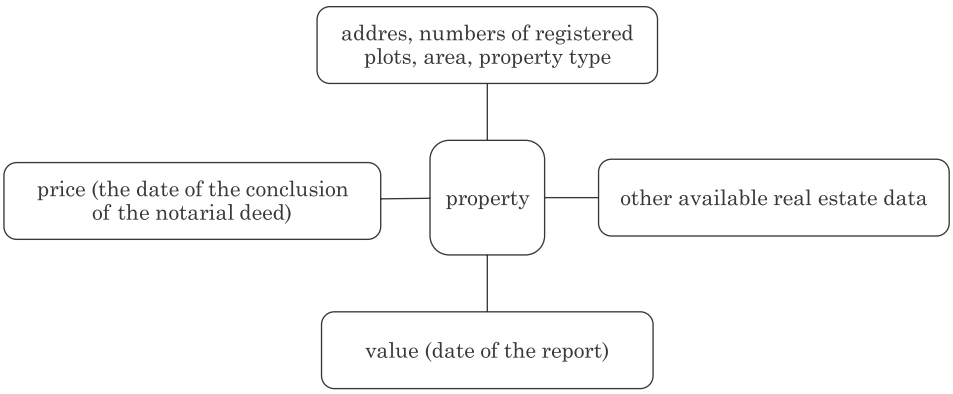

Fig. 3. The scope of data collected in the RCiWN

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referred to as „EGiB", the staroste is required to establish and maintain a register of prices and property values.

The detailed scope of information covered by the register and the scope of information covered by the register of prices and property values are specified in the EGiB Regulation issued pursuant to Art. 26 par. 2 PGiK. Figure 3 shows a graph of data connections contained in the RCiWN.

AR ENVIRONMENT

The potential area of operation of AR-based systems can be the basis for their classification. According to this criterion two basic solutions can be distinguished (de Macedo et al. 2014, Farshid et al. 2018):
– internal systems used in enclosed spaces (eg buildings)
– external systems used in the natural environment (in the open space).

Internal solutions have been developing dynamically so far. This was mainly due to the larger market for such solutions (laboratories, simulators, education, entertainment, medicine). In this solution, the location of the device and the displayed image is easier. It is caused by a limited area of the given solution's operation (eg limited number of changes in the device's location, known number of real world objects). Precise playback of AR objects is possible, among others, by supporting the Head-Up Display (HUD) type display by various sensors: wi-fi, gyroscope, accelerometers, etc.

The key element for the external solution used in the open space is the accuracy of location stability and credibility of the designated position. In this type of solution, the more accurate the location of the user / device, the better the placement of AR objects on the display. This is related to the right of transmission of Gaussian mean errors. The ability to display different types of information (from plain text to interactive 3D models) makes it possible to show objects invisible to the human eye.

The display of additional information in open areas is difficult because of classical solutions using markers or 3D models. Objects on the outside that can be used as objects to be recognized are usually characterized by low contrast (they are affected by weather conditions: sunshine or cloudiness) and relatively large sizes. This fact makes it difficult to use them in the device location process. Therefore, the best solution is to base on GNSS supported by IMU, which allows to determine the absolute position of the user. The operation of the discussed system was based primarily on the absolute position coming from the GNSS antenna. In addition to the position determined using the navigation satellites, the mobile application has the ability to determine the location via Android's Network Location Provider and determined based on the triangulation of base stations in the GSM network or Wi-Fi signal (Wi-Fi signal). This position is delivered using the Android programming interface (API) created by Google. The GNSS position is definitely more accurate, but it requires a longer initialization time and the discovered horizon. Implementation of the mobile application was done in the Unity 3D environment with the Vuforia extension supported by C # scripts (in .NET technology). Main factors for selecting the Unity 3D and develop the environment of the designed system are showed on Figure 4 (Microsoft Support 2019, Unity 3D 2019).

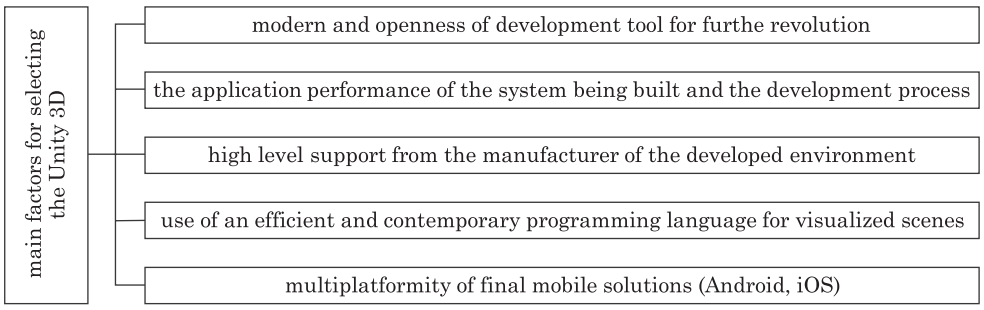

Fig. 4. Main factors for selecting the Unity 3D

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All these requirements meet the synergy of solutions in the form of UNITY 3D, which also includes other properties shown in the Figure 5.

The Vuforia environment allows to create an AR application based on five basic functionalities presented in the Table 1 (Lechner 2015, Vuforia Developer Portal 2019).

The main subject of the article is to propose a system of information about real estate/ transactions using new technologies in the field of AR, data processing and big data (Scholz and Smith 2016). Users/ customer, for the decision making process (at what price should the property be sold/bought), wants to get as much information as possible from the market in a short time. In case of the real estate market the location is very important (market conditions change along with the location) that is why obtained information should be filtered according to the questioning location (user/customer). At the moment, a great number of the fragmented data causes that the information that reaches the user doesn't have complete features. For example information about offers acquired from websites often does not include the exact location (brokers need to sign an exclusive agreement). Acquiring information on actual transaction prices takes time and analysis performed by a real estate appraiser. The proposed database will allow creating services dedicated for financial institutions (banks) to allow them to define the risk while offering credit for property purchase in the specified location. Also, investment funds will be able to easily assess their portfolio by accessing global statistics from distributed data sources (Fig. 6).

Taking into account the division of the use of AR technology into two internal and external environments, we can highlight the possibilities of its use regarding real estate (Carvalho et al. 2011, Mori et al. 2016). The first of them is the ability to display spatial models of residential real estate (Fig. 7).

Another option is to use AR in an external environment to display properties for sale (Pang et al. 2020). This solution has its limitations on the Polish market. There are very few exclusive contracts signed between brokers and sellers. This results in a small address database. Information without detailed addresses is placed on the Internet. The second lim-

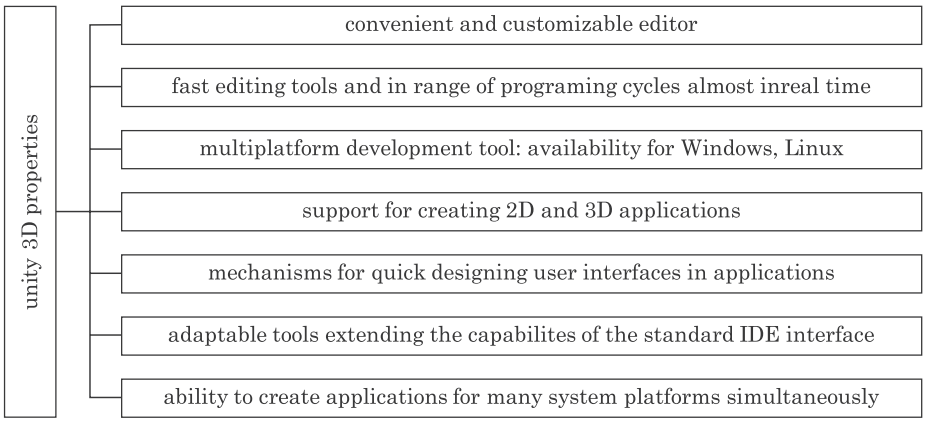

Fig. 5. Unity 3D properties

Table 1. Vuforia Features

Vision capabilities	Scalable recognition	Powerful creative palette	Supports popular tools	Supported devices
– images – objects – environments – text – markers	– Cloud Databases – Device Databases	– content: video playback – interactions: virtual buttons – FX: – background effects – occlusion management	– Xcode – eclipse – unity	– mobile devices (Android ICS and iOS) – digital eyewear (Epson BT-200 and ODG-X7)

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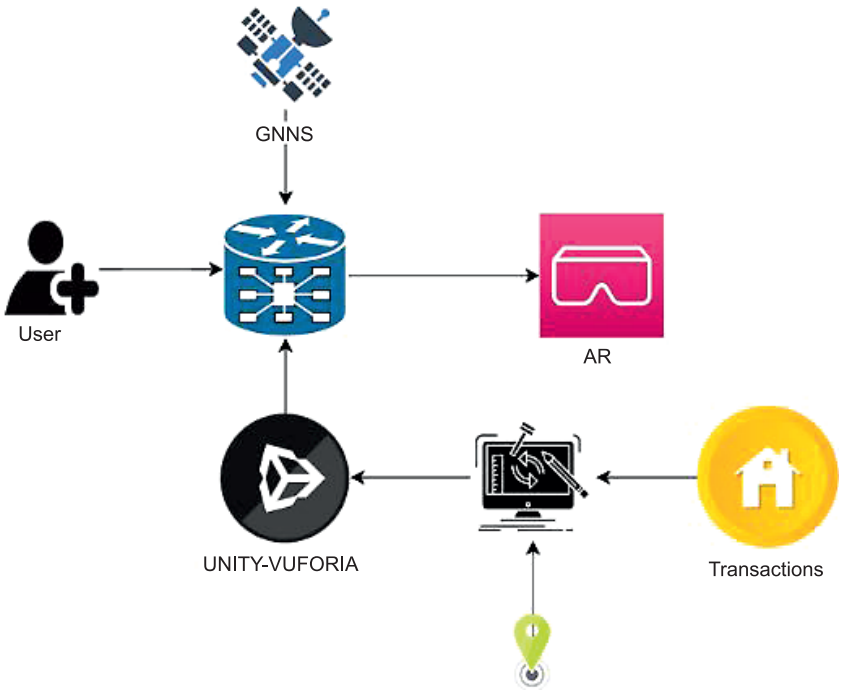

Fig. 6. Workflow

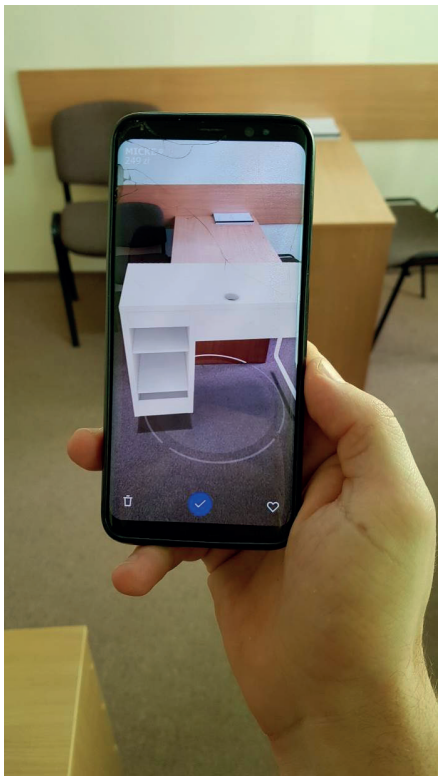

Fig. 7. Example of a flat with furniture in augmented reality (IKEA Place application)

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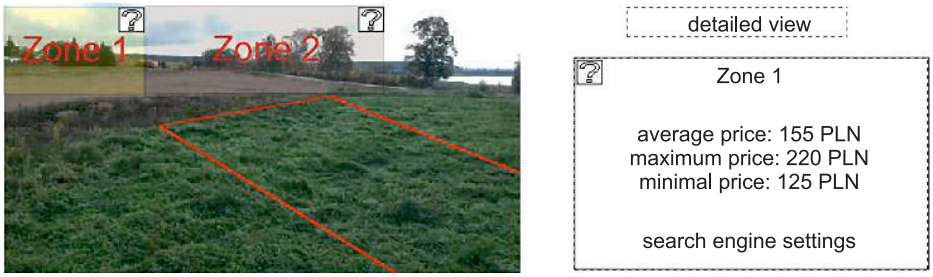

Fig. 8. An example of displaying information about transaction prices in a given area

itation is the poor accuracy (several meters) of determining the autonomous height based on single-frequency GNSS receivers in smartphones (Marchand et al. 2016). This results in the fact that the sample information displayed in the AR for an apartment on the 3rd floor will be displayed a few meters too high or too low, what may mislead the user. Therefore, the concept of displaying transaction price areas in a given area bypasses the limitation related to the precision of displaying information in AR. An example of a solution is shown in the Figure 8.

The user can choose the zone generated in augmented reality. Based on the detailed settings, the user selects the radius and direction of analysis. For the given settings, the main view displays the main information on average prices, maximum and minimum prices in a given area.

CONCLUSIONS

A public opinion poll on the functioning of the telecommunications services market and consumer preferences carried out by the Office of Electronic Communications in 2018 indicates that 74.8% of Poles have a smartphone. Smarfons are beginning to have more and more computing capabilities and are increasingly replacing computers in everyday use (Mekni and Lemieux 2014). Today, most websites are viewed on smartphones. That is why it is very important to create dedicated systems for mobile devices. Geoinformation Support System is such an offer. The GSS system uses the capabilities of smartphones (GNSS antenna, camera) in order to best display information about the real estate market. Each new solution appearing on the market has various limitations. At present, the biggest risk is seen in the area of technological solutions. In the system assumptions, three modules will be used: transaction data processing, data base search and transaction data storing and sharing (along with data sharing using AR technology). The current risks of the AR are classified based on the following aspects: technology, social acceptance, usability. However, there are still limitations with the technology that has to be overcome. AR system has to deal with vast amount of information in reality. Therefore, the used hardware should be small, light, easily portable and fast enough to display graphics. Also, AR tracking needs system hardware such as GNSS to provide accurate marker. These hardware obstacles need to be resolved for practical AR use. AR systems usually obtain a lot of information, and need software to filter the information, retain useful information, discard useless data and display it in a convenient way. Also, the creation of the database browsing system will be associated with the need to create appropriate dictionary search base. The use of augmented reality in the real estate market brings primarily benefits in four areas:

– new marketing options,
– clearer understanding of products,
– better engagement,
– Save time and resources.

The created service will have a very important feature of adapting to users' needs. The created database will allow for proper data filtering and sorting in order to create valuable information that is compatible with the expectations of different user groups.

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