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Hybridization of valuation procedures as a medicine supporting the real estate market and sustainable land use development during the covid-19 pandemic and afterwards

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A R T I C L E   I N F O

Keywords:
Real estate market infection
Hybridization of valuation procedures
Remote technology

A B S T R A C T

Currently we are facing the pandemic situation that occur all over the world. Regardless the country or even the region, the negative consequences that are expected could be very big and the level of crisis is not predictable. This situation is the challenge for the real estate market as well. Due to this fact, the authors believe that there is the time when deep transformation of approaches, procedures and awareness related to valuation domain be comes. Today, due to the fact of the global COVID-19 and pandemic restrictions is the best time to implement the automated models and advanced technological solutions to the valuation world.

The authors proposed the hybrid approach that is the way to reconcile the participants on the property market. Hybrid approach is understanding as the synergy in combining aspects of new (automated solutions) and traditional components that are developed in the agile mode system creation. The proposed solutions can be treated as a cure for some symptoms of the real estate market infection but also as a vaccine, which should to a large extent prevent restrictions and nuisance in real estate valuation in case of repeated infection.

1. Introduction

It is obvious that real estates are a very important aspect of our life. Real estate markets play an increasingly important role in the global economy and attract a growing number of international investors, which is why the demand for reliable decision support systems will continue to grow and become an essential challenge in the modern economy. The growing significance of the market prompts entities to search for tools which support cohesive analyses of it, real estate comparisons based on diverse criteria and determination of property investment potential. However, due to the complex specificity of properties (influenced by many unstable and stagnant features, unspecified relations, and strong behavioral impact), these are very difficult components of the decision-support systems.

Currently we are facing the pandemic situation that occur all over the world. The negative consequences that are expected can be very big and the range of e.g. economic and social crisis is not predictable. On the other hand, there are some positive aspects of the pandemic situation such as openness for the modern technology and remote solutions. This approach is the challenge for the real estate market as well. Both from the supply, demand and from the property valuers’ point of view. The crisis on the real estate market is certain and is repeated every several years. The biggest challenge is the recognition of the first symptoms of the problems that may occur on the market. The crisis can be compared to the diseases that is similar to the infection of the human organism. The most important is to recognize these symptoms and prepare the cure based on the experience of previous diseases and their course but also using modern medical achievements.

The main aim of the paper is to present a proposal for new technology and automatic solutions application in the real estate valuation domain, which will support property appraisers, especially with limited possibilities of using commonly accepted procedures of valuation. A “valuation” refers to the act or process of determining an estimate of value of an asset or liability by applying IVS (IVSC, 2020). The automatic valuation models are existing from many years (their origins in North America in 1960) but their utilization has both supporters and opponents (so called pros and cons). Nevertheless, spreading Covid 19 pandemic and the valuers’ confinement to whom “desk-top working” is
the very definition of incomplete, imprecise valuation practice, can causes the recognition of many benefits of the possibilities that give us remote and automatic solutions.

Regardless the general situation whether in pandemics or not, new technologies (Miskiewicz et al., 2019, 2020) are a chance for analysis improvement in various economic sectors decision support systems, objectify, acceleration and increase access to data and determining mutual realities. The literature and practice indicate that there is now a growing discussion about the use of modern technologies for collecting and processing real estate data. This observation inspired the authors of the article to make the following research hypothesis: During pandemic covid-19 the “hybridized valuation procedures” are a helpful and often only instrument in market analysis and real estate valuation.

Considering the problem, at first the definition of infected real estate market has been formulated. Then, several methodological recommendations were developed that can eliminate or reduce the negative impact of some symptoms or effects of infection on the property valuation process. The authors’ intention was to propose such solutions that would reduce not only obstacles to valuation (also a threat to the health of the property appraiser) but also uncertainty of the valuation carried out during the pandemic. As a result, this should lead to increased confidence in the estimated value.

Various research methods were used to achieve the assumed goal. A qualitative approach based on observation of the current situation of the impact of a pandemic on various spheres of life and functioning of the economy, on own practical experience in real estate valuation and on the analysis of dispersed sources of information has allowed the formulation of research assumptions. The research was based on international literature of the subject, professional standards of property appraisers, available legal provisions and online sources of information.

The work is structured as follows. Section 1 provides general information on standardized valuation methods and major organizations that aim to improve valuation quality around the world. Section 2 proposes the notion of infection on property market and identifies market disfunctions caused by it. Section 3 shows limitations on valuation procedures caused by infection. Section 4 provides constructive criticism and arguments for implementing hybridization of procedures in valuation domain. Finally, Section 5 presents the discussion and conclusions and future directions of research.

2. The main principles of valuation and property valuers’ professional bodies

Along with the development of the real estate market both within the borders of each country and its increasingly globalization, professions related to this sector of the economy began to flourish - sales brokerage, consulting, management and property valuation. Property appraisers are one of the most important due to the role of the “product” they provide to the market.

Today, the property valuer’s community brings together a large group of certified specialists, valuation companies associated in different professional national bodies all around the world, e.g. according to the recent information on the number of involved entities in TEGOVA member associations (72 professional bodies from 38 countries) and national organizations it exceeds the number of 350 000 (TEGOVA, 2020a). Number of qualified valuers in TEGOVA member associations was presented in Fig. 1.

They form many professional valuation organizations. Most of them operate at the national level, but large organizations have also been established that bring together appraisers from various countries or their national organizations. Along with the proliferation of cross-border capital flows and international companies, property valuations are becoming increasingly important. These facts reinforce the argument of these organizations seeking to develop and implement an international regulatory framework for the valuation profession. Four large organizations that set standards at national and international level are of the greatest importance in the world. Those are International Valuation Standards Council (IVSC), The European Group of Valuers’ Association (TEGoVA), The Royal Institution of Chartered Surveyors (RICS), The Appraisal Foundation (TAF). The importance of the Directives of the Commission of the European Union (EU) and the European Mortgage Federation (EMF), the Union of Pan-American Valuation Organizations, the International Federation of Surveyors (FIG) should also be emphasized.

Fig. 1. Number of qualified valuers in TEGOVA member associations.
Source: Authors’ own study on the basis of tegova.org
All these organizations have a real impact on the profession of property appraiser and valuation principles, e.g. RICS works closely with IVSC in developing international valuation standards (IVS), and through the Red Book they implement standards and ensure their enforcement against their members that was used by TEGOVA to developed Blue Book. TEGOVA publishes European Valuation Standards (EVS), which are in line with the EU regulatory framework. The Appraisal Foundation publishes Uniform Standards of Professional Appraisal Practice (USPAP).

Although it is noted that valuation techniques vary from one country to another, valuation methods and purposes for which value is needed remain almost the same. The word “purpose” refers to the reason(s) a valuation is performed. Common purposes include (but are not limited to) financial reporting, tax reporting, litigation support, transaction support, and to support secured lending decisions (IVS). The needs occur in different countries with different intensity. The most important factors affecting the effective valuation process and the correct value received are two tasks properly completed - property inspection and analysis of the property market. In an infected market, these conditions are quite often disturbed. This makes it difficult to interpret changes in the number of transactions concluded and prices obtained. The volatile market makes the valuation procedure even more difficult.

Summing up you can say that regardless of the method used, however, each property valuation is treated as a decision-making process, which consists of many milestones, which the valuer must correctly identify and evaluate to lead to accurate estimation of a value.

3. The property valuation in the situation of an infected market

3.1. Identification of infection on property market

Real estate market is a dynamic system that depends on a number of legal, economic and social factors (Brzezicka, 2020). Involved in such a diversified network connection it should not be considered as autonomous creation (that conclusion determined identification of both property market infection periods and infection chain presented in further part of the paper). Therefore, its’ concept is often compared to organism defined as a system having properties and functions determined not only by the properties and relations of its individual parts, but by the character of the whole that they compose and by the relations of the parts to the whole (Dictionary.com. 2020). Consequently, real estate market analyzes rely on nomenclature based on the assumptions of biology in organisms (e.g. real estate market mutation (Anghel and Hristea, 2015), market feeding, dormant/waking up market, fledgling/crawling market (therealdeal.com), overheated market (cnbc.com), hot/cold real estate market (Ceron and Suarez, 2006). Artificial intelligence domain methods find also increasing application in real estate market analysis. The methods considering informatics algorithm human-inspired and nature-inspired that mimic “cognitive” functions that humans/nature associate with other human minds/organism, such as "learning" and "problem solving". Bearing in mind the aforementioned organism real estate market analogy, it can be stated that it can be a subject of infection. The term infection (latin infectio) has its roots in medical science and means injurious contamination of organism (body or parts of the body) by infectious agent or by toxin that it produces. It is a disorder (disease) condition caused by the presence or growth of infectious agents. Infection may be local or generalized and spread throughout the organism.

They are classified by the causative agent as well as by the constellation of symptoms and medical signs that are produced. Once the infectious agent enters the host it begins to proliferate and reacts with the defense mechanisms of the organism producing infection symptoms and signs.

Real estate market likewise other organisms can be a subject of infection therefore particular infection chain stages can be noticed on it (Fig. 2).

The chain infection drawing (Fig. 2) is the authors’ original contribution and was based on the general infection model and property market/valuation domain compound. Each of the chain infection stages imposes disorganization in the valuation procedures of different intensity. The first symptoms of direct impact on the appraisal process emerge in the 3rd stage due to the valuer’s health risks. From a procedural point of view 4th and 5th stage is the most severe due to procedural limitations on the real estate market, misinformation, and transactions limitation. The longer the infection period, the greater the impact of infection.

Real estate market is usually compared to so called perfect markets. From that comparison’s perspective a number of dysfunctions/disorders is identified e.g.: speculation, monopolistic practices, large spread between prices quoted for similar real estates, low asset liquidity, sporadic market equilibrium, insufficient information (Renigier-Biataor and Wisniewski, 2011). What needs to be underlined is that the mentioned dysfunctions result from the real estate market specificity (imperfection) and ought not to be identified with infection symptoms to some extent.

The commonly identified features of infection include transmission, host resistance, virulence and pathogenicity, control of transmission and infection. The development of infection includes the following steps: onset and course, clinical signs and symptoms, diagnostic tests. Other sources distinguish the four stages of infection. The INCUBATION STAGE is the time between the entry of an infectious agent in the host onset symptoms. During this time the infectious agent invades the host and multiplies to produce an infection. The PRODROMAL STAGE is the time the onset of non-specific symptoms until specific symptoms begin to manifest. The infectious agent continues to invade and multiply in the host. The ILLNESS stage is the time when the patient has specific signs and symptoms of an infectious process. The CONVALESCENCE stage starts from the beginning of the disappearance of acute symptoms until the patent returns to the previous state of health.

Considering the mentioned above distinction of body infection stages the characteristic features of the real estate market infection were identified.

3.2. Dysfunctions/disorders on infected property market

As it has already been underlined real estate market ought not to be considered as autonomous creation that is why the non-specific symptoms justifying infection existence (proceeding the time of illness) should be identified in the particular elements involved in connection...
network – defined in previous chapter as the Reservoir. On the other hand, specific symptoms should be identified in the infected organism – real estate market. The infection on property market could be considered in the periods of infection presented in Fig. 3.

The uncertainty on the real estate market results from its specificity related to its inertia. It also depends on the local characteristics of the market, especially its participants, and on socio-economic conditions. These factors make the prediction of the trajectory courses difficult.

The scale of changes in the financial markets suggests that infectious agent (e.g. coronavirus) will interact with economies by many different mechanisms, which strength is yet unknown. As historical pandemic insight shows the strength of the consequences varied from country to country Fig. 4.

In that case, we are dealing with fundamental factors, i.e. those affecting business and psychological conditions, such as uncertainty or even panic. In the business factors, we can distinguish variables that have their impact on the economy and enterprise sector from the demand and supply side. That causes significant difficulty in the infection of the properties market by many branches. The division into goods and services produced in particular countries and imported to them is also important. The fall in demand for the latter will have a negative impact on the GDP of other countries. The structure of household consumption shows that in the case of manufactured goods and services, the greatest risk of falling demand may relate to retail trade, financial services and food-related services. The non-specific symptoms (indirect property market signs) could therefore include:

- closing or suspending business activities
- increase in unemployment / decrease in pay
- increased risk of insolvency,
- increase in forced real estate sales
- decrease in new investments
- tightening credit granting conditions
- decrease of notarial deeds
- decrease in demand
- oversupply of real estate.

In terms of property market, it should be underlined that the market is much more resistant to panic than the stock market, it does not react rapidly to crises. The history of the largest epidemics of the 21st century shows that the economic shock they caused was only of a short-lived nature, and real estate markets quickly recovered. According to the (Zillow., 2020), 9 months after the SARS outbreak, employment rates and real estate prices in Hong Kong (the country that felt the effects of SARS the most) returned to pre-crisis trends Fig. 5.

A similar development could be observed in the case of the MERS epidemic and the H1N1 virus. It was, but will the real estate market weaken by covid-19 regenerate similarly? The specific symptoms (direct property market signs) could therefore include:

- manipulation / speculation (misinformation),
- procedural limitations for property experts,
- difficult access to information,
- reducing the number of transactions,
- extension of the exposure period,
- fall in prices, values,
- disturbed price / value relationship,
- irrational behavior of market players.

When the infection chain closes its circle the injurious contamination of organism can be transmitted to another body/organism/sphere of life/profession – like property valuation.

4. Identification of restrictions on valuation procedures

As mentioned above, real estate valuation is a decision-making process consisting of many stages (milestones), whose correct implementation results in accurate estimation of value. Valuation is a process that requires proper planning of specific activities, their organization, proper implementation of previously planned and organized activities, and a critical assessment of all previous stages for the best end result (Kuraš, 2019). This procedure can be divided in 5 general stages (Fig. 6). The identification stage for every valuation procedure provides formal basis for valuation. The order specifies, amongst others, purpose of the valuation and scope therefore determine the appraiser’s further activities. Provision of basic information about the subject property (number of plots, address,) enables further property identification and description usually on the basis of public sources of information (property registers, cadaster etc.). The description step involves property inspection which allow determination of the property attractiveness, condition and advantages and disadvantages that might influence the value. This step is an important (in many countries obligatory) milestone in the valuation process. As a rule, the appraiser should collect data on those features describing the subject property that are relevant to the potential buyer. He is obliged to carry out a detailed external and

![Fig. 3. Periods of property market infection (disease).](Source: Author’s own study)
internal inspection of the property. Among other things, he should assess the size, shape, topography of the area, as well as the current state of land development and its development potential. The assessment inside the property consists, inter alia, of collecting data on the number and size of usable surfaces, the technical condition of the property, its equipment with installations, functional usability and unique features that may affect the value.

The next step - market analysis of the valuation process includes an analysis of the relevant market by the type of property being valued and the valuation methodology. The implementation of this second milestone requires knowledge and skills to properly determine the type of market, spatial extent of the market area, gathering data on those market elements that will allow to "capture" and express the strength of their relationship between supply, demand and price of real estate. The success of this valuation stage depends largely on the maturity of the real estate market, its stabilization, and normal, foreseeable operating conditions for entities. On the other hand, a large number of multi-threaded market data requires the ability to use methods and techniques to acquire, process and share them in a friendly form for use in the next stage of valuation.

Conduction the determination on the basis of acquired assumptions is called calculation stage. The last stage covers delivering appraisal report which can be understood literally (bringing report to person ordering it) and figuratively (valuation report preparation).

Any restrictions in the aforementioned steps of valuation procedure can significantly affect the obtained result. Governments of some countries, out of concern for the health of their citizens, have issued special recommendations how to work and life during COVID-19, for example Polish Ministry of Development (2020) “extraordinary and simplified solutions”; HM Government (2020) “working safely during COVID-19 in other people’s homes.

The COVID pandemic imposed a number of them called For instance, for the health and safety of its experts and clients, the Appraisal Institute issued the following guidelines: "Appraisers should take care not to put themselves in harm’s way while completing their assignments. Appraisers are advised to consult with their medical practitioners if they have concerns about exposure to the virus, and they should decline assignments if they feel their own health would be put at risk. "(Appraisal Institute, 2020). It should be emphasized that an integral part of any valuation process is market analysis. To date, it is not yet clear to what extent the virus threat will change market conditions.

In the valuation rules issued for this difficult time by the Appraisal Institute stresses, however, that it is not appropriate to attach a clause on the exclusion of the expert’s liability for correct analysis of market conditions. Other professional valuation bodies (RICS, 2020; TEGOVA, 2020b; PFVA, 2020) also imposed particular steps and named accepted restrictions in valuation procedure:

I Property inspection - it is permissible to determine the technical and functional condition of the real estate based on the written statement of the owner of the real estate and/or another person or institution possessing the necessary information, photographic documentation of the property certified by them as verified as being true, and also in the case of built-up real estate - based on all other documents provided by the client.

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**Table 1.** Historical pandemic consequences insight.

| Country (year) | Pandemic       | Consequences                                 |
|---------------|----------------|----------------------------------------------|
| Hong Kong (2003) | SARS          | 2.63% loss in annualized GDP                |
| China (2002)   | SARS          | 1.05% loss in annualized GDP                |
| Canada (2009)  | mild flu pandemic | Loss of industrial production of 1.2%    |
| USA (2003)     | mild/severe flu pandemic | 1%/4.25% loss of annualized GDP |
| Australia (1919)| severe flu pandemic       | 6% loss of annualized GDP                |
| New Zealand (1957)| severe flu pandemic      | 5%-10% loss of annualized GDP              |
| Sweden (1918)  | Spanish flu          | 7% loss of annualized GDP                  |

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**Fig. 4.** Historical pandemic consequences insight.
Source: Authors own study on the basis of (Lee and McKibbin, 2012; James and Sargent, 2006; Congressional Budget Office (CBO, 2006; Kennedy et al., 2006; Douglas et al., 2006; Karlsson et al., 2014)

**Fig. 5.** Transactions and real estate property prices in Hong Kong, 2001-2004.
Source: Zillow analysis of raw secondary transactions volumes from Midland Realty (2020) and quarterly unadjusted real residential real estate prices from St. Louis Fed’s FRED.
II Access to documents and registers containing data on real estate: it is advisable to contact the institutions and offices only by phone and electronically. Although many institutions and bodies have been closed for direct customer service, access to information is possible using ICT systems (including Electronic Land and Mortgage Registers, geoportal.pl website). Requests for access to necessary information, e.g. from a national geodetic and cartographic resource, may be submitted electronically.

All the mentioned above property valuation procedure simplifications can cause additional valuation disfunctions, that could be significantly decreased by modern technical solutions applications compounds.

5. The hybrid approach as a cure for appraisers for the symptoms (effects) of a pandemic infection

The hybrid approach in the frame of improvement of the valuation procedure on the infected market is understandable / defined as synergy in combining aspects of new and traditional components that are developed in the agile mode system creation – which means combination of iterative and incremental process based on feedback from client requirements.

In this specific domain the hybrid means interchangeable use (replacement) of human and computer approaches with manual and some kind of automatic solutions. Automatic solutions can be applied on this stage on valuation procedure where the direct access to data is impossible e.g. due to a pandemic or work efficiency is limited due to other, also human limitations in collecting data or processing mass information.

It must be underlined that, that human factor expressed by knowledge of local conditions and specialist knowledge will always be needed (Matysiak, 2018) and hybrid approach secure the consolidation of expert knowledge with automatic solutions (Benesia et al., 2012). This hybrid approach makes for better quality results with less development time and faster reaction to market changes or market failures and limitations. Hybrid methodologies accept the fluidity of processes and allow for a more nimble and nuanced approach to the work. They allow to choose the best solutions for every stage of the valuation procedure. During disturbances in the economy, caused for example by the covid-19, it is noticed that two key milestones in the real estate valuation are most affected by this disease. These are described in chapter 3 - DESCRIPTION of the valued property and MARKET ANALYSIS. The difficult situation during the pandemic caused the necessity to look for alternative solutions in many areas of life. This phenomenon is also visible in the area of property valuation methodology. It seems that as never before the valuation procedures has chance to be extended by the alternative solutions based on the modern technology (Bilozor et al., 2020; d’Amato and Renigier-Bilozor, 2017; Renigier-Bilozor et al., 2019b; Helling, 2019; Osorno-Covarrubias et al., 2015). Standard activities of property valuers performed at stages of the valuation procedure may (and during a pandemic should be) replaced or supplemented by modern technologies as part of the hybrid approach. It is worth emphasizing that the hybrid approach may in this case means a combination or extension of traditional solutions with new technologies described in detail in Fig. 7. Most mentioned solutions (technologies) are based on free access (to some extend). However, several can generate significant cost, especially those used incidentally (marked in Fig. 7 with €).

The essence of remote access to data from many sources, apart from the unquestionable advantage of being able to expand information sets and their mutual validation, involves the need for their dedicated storage, processing and interpretation. The multitude of various formats of data storage in digital form, their interpretation and even visualization methods requires the implementation of a solution that can use the available resource in the least troublesome way for the user. The processing of necessary data using only strictly remote access may also fail, due to temporary interruptions in access to information, time of data download and cost (especially in mobile solutions) and thus result in the inability to carry out integrated analyzes based on data available online.

Many websites provide data in a format that is difficult to analyze. Their use requires either manual extraction of this data through selection and copying to another format or the use of very popular technologies known as web scrapping (WS) (Ahmed et al., 2020) - automated data extraction from a website. Their use may be limited to single data downloads or cyclical automatic data import. When using these types of tools, one should pay attention to any restrictions on the legality of using this technology. Optimal use of data from many external sources (different authorities, different formats of data) should force their local storage and analysis of data (for technical implementation and legal processes) obtained remotely. Preparation of a dedicated RDBMS (Relational Database Management System) architecture, based on constraint rules - assuming full reference data integrity, allow data verification at the moment of their migration from a remote to local system. The spatial character of the data is usually expressed with spatial reference compatible with EPSG (European Petroleum Survey Group) Geodetic Parameter Dataset. Choosing a database system that supports modern spatial SQL standards allows to transform spatial data to a uniform format for spatial references when importing data and, above all, their integrated and flexible analysis. Obtaining descriptive data and storing them locally gives the possibility of limiting data transfer via the Internet, which with the gradual transition to remote solutions in many industries may become significant. Verification of data during its network search and comparison with a locally complex resource gives the opportunity to avoid distortions, inaccuracies and often contradictions of information from various sources. The compliance of property
identifiers in data packages from various sources also allows their aggregation, leading to the construction of more “full” resources as well as their re-use in other estimates without the need to resort to external resources (e.g. as similar properties). Once aggregated information on real estate and examined with the use of alternative solutions - assessment of the environment, neighborhood using Interactive Panoramas (IP) services such as Street View etc. may be considered valid for some time (Meadow et al., 2016). If one needs more current data than services updated with high time parallax, such as StreetView, Google Maps, Bing etc. one can use services with higher temporal resolution but lower spatial resolution, e.g. EO (Earth Observation provided in a WMS (Web Map Service) form) (Chen and Nguyen, 2017) imaging available for free - Sentinel 2. Generally available web sites allow you to make a quantified assessment of space, e.g. travel time to public facilities. The use of some of them is associated with the limitation of mass use or any commercialization of obtained data without paying license fees. Their size can be significant enough to cancel out use. The alternative is to use free tools run locally on the user’s machine, thereby increasing computing efficiency and giving them greater customization options, e.g. Nominatim - determining the time needed to travel between two points at a specific time of day and using elements of publicly available communication infrastructure (Inglot et al., 2018; Renigier-Bilozor et al., 2019a; Bailey et al., 2019). Each analysis generates results that can be used in subsequent processing, selection, etc. Their storage, especially in properly prepared and mentioned RDBMS structure with the indication of adding a timestamp of timeliness and data source will optimize the time and completeness of analyzes performed using SQL and its extensions.

The reduction of direct contact with other people during a pandemic force the search for substitutes for classic forms of work, especially in the field. Direct measurement of the geometry of real estate elements, which involves the necessity of real presence on its territory, can be reduced even with the use of mobile applications for remote measurements (e.g.: iOS ruler). They are rather suitable for interventional and unitary measurements. If you need more accurate data (especially geometric but not only), you should look for solutions in other currently available technologies.

Drone (UAV - Unmanned Aerial Vehicle) (Plummer et al., 2017) raids/flights to obtain a 3D point cloud of the examined area and images made in the visible light spectrum. Obtained external data of the object

| Proposed application areas | Milestones in valuation procedures |
|----------------------------|-----------------------------------|
| Types of necessary information | Description of subject / comparable properties | Market analysis |
| Legal status (rights to real estate, restrictions, public road access, etc.) | WMS |
| Plot boundary identification | AR + WMS + WFS |
| Plot area | UAV + WFS |
| Shape of plot | WMS |
| Slope | DEM |
| Existing and potential kind of land use | WMS + WFS + IP |
| Building architecture, type of construction / technology | CRP + DTM |
| Technical deterioration of the building | CRP |
| Usable floor area (UFA) of the building, premises | UAV + ML + WFS + DTM |
| Building dimensions/volume | CRP + CV |
| Interior finishing, functional usability of buildings/premises | OBI + INS + AR | WS + VR |
| Insolation | DEM |
| Existing technical facilities | AR + WMS + WFS |
| Neighbourhood features (natural, kind of land use, social) | UAV + ML + WFS + WMS |
| Location factors, spatial obstacles | WMS + WFS + IP |
| Property offers (rent/selling) | WS |
| Number of webpages offers visits | WS |

**Used abbreviations:**
- WMS – Web Map Service
- WFS – Web Feature Service
- IP – Interactive Panoramas
- UAV – Unmanned Aerial Vehicle
- DEM – Digital Elevation Model
- DTM – Digital Terrain Model
- CRP – Close Range Photogrammetry
- CV – Computer Vision
- AR – Augmented Reality
- INS – Interactive inspection service
- VR – Virtual Reality
- ML – Machine Learning
- WS – Web Scrapping
- OBi – On- Behalf- Inspection

**Fig. 7.** The modern technology application solutions in hybrid approach for particular property valuation activities.

Source: own study
are current and above all metric with high accuracy. They can support ongoing documentation of field work, e.g., investments, inventory of boundaries, construction of the field. DEM (digital elevation model) and even measurements of fuel storage facilities. Due to the cost and time of preparation of the data, the implementation is carried out today primarily for large area investments. The use of the drone can be based on image measurements but also LiDAR (Light Detection and Ranging), obtaining a 3D point cloud is then the default product of such measurement. LiDAR is considered a short-range photogrammetry technology (remote measurement method at a distance of not more than 1000 feet). Its advantage is a fast, comprehensive and very accurate measurement result without having to access the examined object, which due to a pandemic as e.g. spatial obstacles (water etc.) may be the only possible and safe solution to gather the necessary data. The use of photogrammetric technologies is increasingly larger - gives the ability to reproduce an accurate picture of the state of the object at the time of measurement. Increasing number of national directives indicate periodic implementation (e.g. annual) of such measurements for objects that are particularly technically significant, e.g. historic buildings. The periodicity of the measurement also allows for time differential (using time parallax) comparison of object states (not only architecture) - reconstruction value, deterioration. Short-distance classic photogrammetric photos due to their metric allow for accurate estimation of the size of e.g. elevation condition, displacement, extent of damage, their nature affecting the value of the property (Ciesiak et al., 2020a).

CRP (Close Range Photogrammetry) (Bernat et al., 2014; Janowski et al., 2006) imaging support with Computer Vision (CV) and Machine Learning (ML) (Koch et al., 2015; Marchewka et al., 2020) technology automates e.g. detection of crack etc. There will also be solutions indicating the possibility of estimating the usable area of architectural objects using the short-range photogrammetry products (UFA – Usable Floor Area). The use of images in the field of visible light to create a model of the analyzed space is gaining more and more popularity. It gives the opportunity to assess the space shown in the form of a realistic 3D scene using VR (Virtual Reality) (Ozacar et al., 2017) technology.

Acquiring data for such visualization, in addition to the indicated measurements by means of close range photogrammetry, is also possible with the tools that each property appraiser owns - a mobile phone (ReCap autodesk application - very good results - model preparation in postprocessing, or Qlone applications - 3D Scanning & AR Solution or 3D Scanner for ARCore - which create a 3D model in real time but do not give much accurate results yet). Property registration by its owner, sending this material to an appraiser who will visualize in the form of an almost full model of space in VR technology gives more complete access to the assessment than individual images.

VR extension with current image recording provides the basis for building AR (Augmented Reality) scenes. Although it requires presence on the property, it exempts from searching for all its hidden elements, e.g. field infrastructure, by synergies of its course (downloaded from public registers like WFS – Web Feature Service) and online image from the camera of a mobile device. Enriching such visualization with the possibility of measuring elements of reality by indicating the location of selected points directly on the device image without having to contact the required element gives the possibility of fast, non-invasive and above all during aesthetic measurement. The ability to move the location of objects in space by positioning them on the screen of a mobile device and placing artificial objects in them gives the opportunity to arrange solutions that can have a significant impact on the final (useful) value of the property. The use of AR is becoming more and more popular, placing POI information on AR images in the applications of the most important players of this market is slowly becoming everyday life facilitating immediate orientation in the field and assessment of space.

Restriction of movement for the purpose of data acquisition refers to both the micro and macro scale, i.e. necessity (when required by the task of valuation and obtaining data must be made by a professional) to go to a remote local vision (another poviat, province). The association of real estate valuation professionals in formal federations but often also within thematic groups implemented via social media gives the opportunity to support themselves in obtaining data from the vision of a local ‘colleague’ professional from the local market for the territory of the real estate being examined. The field vision documentation provided by him as part of On-Behalf-Inspection (OBI) (also made using the methods mentioned above) confirmed by his digital signature guaranteeing the legality of such valuation with maximum limitation of migration and contact of the population, Social media and exchange speed in their information also proves to be beneficial in the profession of appraiser.

Moreover, Interactive inspection service (INS) for example Zordon, that is an online based platform enabling real time remote indoor/ outdoor inspection realization usually based on mobile solution. The scope of functionalities depends on kinds of inspections aim of it and authorise users. The connection can be initiated by property valuer while the field inspection carried out by property owner/tenant/agent. Due to the fact that modern technology based on artificial intelligence, machine learning and computer vision enable to give solutions emulating “cognitive” functions related to human behaviour. Some experimental works based on mentioned technology can be very useful and give chance to create valuable solutions for future valuation procedures extensions:

- Standard/condition of property - door detection is becoming an increasingly important subject in building indoor feature detection (Quintana et al., 2018). Camera laser scanners for diagnosis of the indoor property features and outdoor measurements, delivering precise real-world information, without field inspection that can be very valuable source of information about real estate property standard - information not available for appraisers (examples of solution applying in the urban environment: Van Balen and Verstrynge, 2016; Delgado, 2016),
- Selection of comparable properties – crowdsourcing approach is how a group of people may converge on the solution to a problem that an individual, even an expert, may be unable to solve. It also refers to the ability of the crowd to converge on the truth (Capeneri et al., 2016). Crowdsourcing Websites that are collect mass information that empowers mapping citizens as voluntary sensors (in the defined process), can enable to select (detect) similar property markets based on map of both indoor and outdoor features expressed mainly in mass-defined visual form (Haklay, 2013; Dodge and Kitchin, 2013),
- Indication of property features significance – one of the applications of artificial intelligence using neural networks is the facial recognition from digital images and video frames (Błazek et al., 2014; Bobkowska et al., 2016). “Artificial intelligence methods” considers informatics algorithm human-inspired and nature-inspired that mimic “cognitive” functions can be useful for significance variables determination based on human emotion detection during visual form of features observations. These factors are based on emotions that can be recognized on the basis of facial (Bobkowska et al., 2016), vocal and body expressions. The facial emotion is one of the most common ways of emotion detection using mostly deep learning-based approaches (examples of solution applying related to emotion recognition: Wang et al., 2019; Li et al., 2017).

6. Summary and recommendations

These research directions relevant to the face of the challenges of market analysts and property appraisers in extraordinary situations, when the following circumstances occur most often - limitation of the number of real estate transactions, difficult access to data or limited or completely impossible access to the real estate. Today we faced the boom for remote solutions and its opportunity to underline the modern support of the valuers.
Today, due to the fact of the pandemic restrictions is the best time to implement the automated models and advanced technological solutions to the valuation world. The pandemic force people to resort to advanced solutions since the traditional ones are significantly limited and often useless.

It must be underlined that automated models and solutions have been used all over the world for decades for risk management and for determining the value of real estate (especially residential). It is noted that the proposed solutions are applied to all valuation methods, however, this mainly concerns the preparation of databases and market analyzes.

Their basic advantages - relatively lower cost and shorter time compared to classic valuation methods, make them more and more popular on the real estate market. The basic problem associated with automated solutions is considering them as the dehumanized tools and that they do not take into account the human element and thus those market features that may affect the behaviour of the parties to the transaction.

The authors proposed the hybrid approaches that is the way to reconcile the parties on the property market. This approach enables to use modern technology as the useful and effective supportive approach whose use must be supervised by professionals. Hybrid approach is understanding as the synergy in combining aspects of new (automated solutions) and traditional components that are developed in the agile mode system creation.

It should be emphasized that real estate valuation is a process that will ensure the correct final result only if it is carried out correctly at every stage. Therefore, in the valuation process, a key role is played by man - his knowledge and experience and the skills of proper use in specific circumstances. However, as confirmed by the research of the authors of the article, properly used valuation methodology and modern technologies of data acquisition and processing can ensure that the valuation process can also be carried out in extremely difficult circumstances.

This may seem irrational, but with various health risks of property appraisers and the limitations of real estate valuations, one can also see the positive aspects of the covid-19 pandemic. Established and duplicate valuation procedures had to undergo some modifications, even simplifications, which not only were accepted by regulatory bodies in many countries, but the same institutions issued recommendations as appraisers should implement them. At the same time, the existing restrictions are an impulse for scientists to develop new ones or to adopt methodological and technical solutions used in other fields. On the one hand, this creates a chance for progress in valuation procedures and legal or formal acceptance of the implementation of the proposed solutions in the practice of valuation. However, it should also be emphasized that many of these technological ‘novelties’ require property valuers to update their knowledge and mainly to have the ability to work in a team of specialists.

The proposed solutions can be treated as a cure for some symptoms of the real estate market infection but also as a vaccine, which should to a large extent prevent restrictions and nuisance in property valuation in case of repeated infection. It should also be expected, as is the case with vaccination against viruses, that among property appraisers there will be supporters and opponents of introducing innovations into practice. The reasons can be different - lack of trust, fear of new, unwillingness to continue learning, inability to assimilate new content. According to the authors of the article, however, it is worth putting an effort into the development and implementation of such a medicine.

**Funding**

This work was supported by the National Science Centre [grant number 2019/33/B/HS4/00072]

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**CRediT authorship contribution statement**

Małgorzata Renigier-Bilozor: Conceptualization, Methodology, Supervision. Sabina Żrobek: Conceptualization, Methodology, Formal analysis. Marek Walacik: Conceptualization, Methodology, Investigation. Artur Janowski: Methodology, Visualization, Writing - review & editing.

**Declaration of Competing Interest**

The authors report no declarations of interest.

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