The Future of AVMs

THE DEVELOPMENT AND INTEGRATION OF ARTIFICIAL INTELLIGENCE AND NOVEL VISUAL TECHNOLOGIES IN AUTOMATED VALUATION MODELS FOR RESIDENTIAL PROPERTIES

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Abstract

The long-standing challenge to improve the accuracy of Automated Valuation Models (AVMs) continues afield, typically focusing on the expansion of data sources, refining the use of algorithms, and incrementally improving established hedonic, regression, statistical, and genetic models.

Yet, there is also an important new, more advanced challenge underway, one that leverages the use of Visual Technologies and Artificial Intelligence to replace or enhance current AVM processing and output. The focus of this research is to investigate and evaluate how Computer Vision and other Visual Technologies can be used to accurately validate a residential property's description, construction quality and design, as well as to help identify the overall condition of the property, and to determine the impact that identified material and immaterial damage may have on the AVM estimate of value.

In their current state, AVMs assume that subject properties are in "average" condition for their age. Drive-by, exterior-only inspections are sometimes used to partially verify this "average" condition. In the future, vendors who are capable will rely on Computer Vision techniques to analyze interior and exterior still and video images of each subject property in order to assess how that specific property's condition affects the AVM estimate of its value.

The purpose of this paper is threefold, namely to:

- Examine weaknesses in the current state of AVM technologies.
- Identify some available methods for using technologies such as Computer Vision, Large Language Models (LLM), and Neural Networks to assess and label property condition.
- Analyze what problems these new technologies can and cannot solve, and discuss the new benefits and risks being introduced by their use in the AVM process.

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1. The Evolution of Automated Valuation Models
Promise and Limitations

Automated Valuation Models (AVMs) offer significant advantages in terms of velocity and cost efficiency, but their effectiveness is heavily contingent on the quality and breadth of the data used, as well as on the sophistication and flexibility of their underlying models. Continuous improvements in data collection and curation, model development, and integration of advanced Artificial Intelligence (AI) and Machine Learning (ML) solutions are key to addressing these challenges.

Although AVMs are widely used for property valuation in the lending and platform spaces, they present known challenges and weaknesses, especially concerning data quality and quantity, model accuracy, and modeling reliability.

A Data-Specific Challenges

In the absence of standardization, real estate data often lacks consistency across markets, resulting in similar information being recorded differently across regions or databases. Such inconsistency can pose a challenge for AVMs when it comes to aggregating and modeling data accurately.

Additionally, AVMs rely heavily on historical data for accurate valuations. In areas with limited sales history or with unique properties, the lack of sufficient relevant data might distort valuations.

An AVM's input data could also be susceptible to manipulation or bias, which would, in turn, lead to skewed valuations. This would be particularly concerning in markets where data is not regulated or audited.

Lastly, even something as mundane as incorrect or outdated property details (e.g., square footage, number of bedrooms or bathrooms) will inevitably and significantly reduce valuation accuracy.

B Modeling Difficulties

Real estate markets are dynamic and can be influenced by numerous factors like economic conditions, severe weather, hazard and local events, etc. If these dynamic changes are not picked up fast enough by AVMs to accurately reflect market reality, the resulting valuations will end up erroneous and outdated.

Additionally, AVM algorithms may not always capture the nuances of a local real estate market or the unique characteristics of an individual property (e.g., property condition, neighborhood desirability, and aesthetic appeal), relying, instead, on a 'one size fits all' approach that may miss out on subtle, yet relevant factors. This is especially true for outlier condition properties, as most AVMs will consider all evaluated properties to be in 'average condition'. If these AVMs fail to account for property material damage, even when known, their valuation accuracy will ultimately decrease.

Finally, leading AVMs that are using complex ML models may lack algorithm transparency, making it difficult for users to understand how a given valuation was derived, or how it was adjusted for increased accuracy.

Despite all of the above, at least in the short term, AVMs are likely to remain the most practical solution for valuation at scale, given their intrinsic velocity and cost effectiveness, especially as appropriate mitigations and continuous improvements are being applied to address data collection and curation, and to ensure responsible use of AI.

However, the AVM industry must be responsive to the regulatory and fair housing challenges on the horizon. The highest probability of success for meeting these challenges may belong to AVMs that are able to take advantage of advanced AI technologies, such as ML Convolutional Neural Networks (CNN), Genetic Algorithms, and Evolutionary Programming, to further increase valuation estimation accuracy.

2. The Effect of Undetected Property Conditions on AVMs

While AVMs provide a fast, cost-effective way to estimate property values, their accuracy can be highly impacted by undetected property conditions, especially when considering the widespread 'average condition' assumption and the limitations of exterior 'drive-by' inspections. Addressing these issues requires a multifaceted approach, including better data integration, improved standardization, and ongoing model refinement.

A The Problem

Inaccurate valuations affect multiple stakeholders, including homeowners, buyers, lenders, and investors, and can often lead to important financial decisions being based on incorrect information.

In this context, undetected property conditions pose a significant problem for most AVMs, particularly when considering that the 'average condition' assumption is most frequently factored into an AVM's valuation output, often as a consequence of insufficient or even completely lacking condition assessment. In other words, in the absence of detailed or consistent data on a property's interior condition, a valuation model will assume it to be in average condition for its age, location, size, architectural style, etc.

Evidently, such assumptions can lead to inaccurate valuations as they do not account for properties that are in either exceptionally good or very poor condition when compared to others in the area. As a result, properties that have either been significantly upgraded or are in disrepair can be misvalued. More to the point, a well maintained or a renovated property may be undervalued, while a property presenting material or immaterial damage and in need of repairs might be overvalued.

Additionally, AVMs routinely rely on public records or MLS data, such as general descriptions, property size, lot size, number of bedrooms, bathrooms, garages, and stories/levels. Significant internal issues like outdated plumbing, electrical problems, or structural issues may not be apparent or known unless a detailed inspection or an appraisal is performed.

Moreover, even when interior data is available, it might be outdated or not standardized, making it difficult to integrate into a valuation model. The assumption of 'average condition' due to lack of detail on interior or exterior conditions might overlook unique features of individual properties, leading to a homogenization that doesn't reflect the true variability present in any housing market.[1]

B The Solution

To address these limitations, some AVMs attempt integrating more comprehensive data, to improve data quality and standardization, as well as to refine and enhance current models.

In certain settings, the incorporation of detailed interior inspections, homeowner-provided information, and even crowd-sourced data has the potential to enhance the accuracy of AVMs, as advanced visual technologies like virtual tours, 3D blueprints, and AI-driven image analysis could provide more insights into a property's condition—with the caveat that uncontrolled variables like these may not be appropriate where required independent AVM model testing may be jeopardized.

Lastly, standardizing real estate data with the goal of ensuring accuracy and timeliness, also has the potential to significantly improve AVM output. That said, better data standardization is contingent on collaboration between various stakeholders in the real estate industry, and, as such, remains elusive.

As lower error rates and higher confidence scores are demanded by the market, continuous updates and refinements to the AVM algorithms, as well as improvements in data collection and analysis methods will be necessary in order to accommodate changing market conditions.

[1] Please note that while the topic of climate change is undoubtedly significant and intersects with discussing technologies that can elevate an AVM's ability to assess property condition, particularly so in the context of assessing long-term asset values, it is not covered in this paper. This exclusion is due to the discussion's specific focus on the immediate advancements in computer vision, LLMs, and NLP, along with their direct implications for AVMs. The potential complex interplay between unwinding the impact of climate change on property valuation and these evolving technologies encompasses extensive data sets and predictive modeling, warranting a dedicated analysis in order to do it proper justice. The importance of this subject is herein acknowledged and represents a potential area for future research, to explore the intersection of climate change and valuation models in the era of emerging technologies.

3. The Introduction of Computer Vision, Machine Learning, and Natural Language Processing in AVMs

The introduction and use of ML and CV technologies in AVMs, given the automation, increased accuracy, and scaling they offer, is proving to be an objective qualitative and quantitative advancement in the field of property valuation.

The integration of Natural Language Processing (NLP) and Sentiment Analysis technologies into property valuation solutions also holds promise. By facilitating access to unstructured information, they enable a more holistic view of a property's value, eventually increasing valuation accuracy.

However, while CV and ML can potentially enhance the quality and accuracy of AVMs, they may also raise new obstacles.

A Computer Vision

As a subset of AI, CV technology enables computers to recognize, understand, sort, and interpret visual content, such as digital images or video. The CV algorithms' intelligence is most often based on neural nets modeling, designed and trained on large data sets labeled with the relevant objects they contain. By using the scene a specific image depicts, CV can then recognize and classify content in a new image based on learned associated features and patterns for the different objects or images.

The training data sets and the images being evaluated can be interior and/or exterior images collected during an inspection or an appraisal, listing property pictures, as well as property aerial or satellite photographs. Videos can also be broken down in frames and used as if they were individual images.

CV object recognition and image classification algorithms can directly contribute to enhancing an AVM's property valuation capability by creating a more accurate and consistent evaluation of property condition and/or quality. These technologies can also be used to validate or invalidate the condition and quality assumptions made by AVMs.

i. Object Recognition

As applied to the real estate industry in general, and property valuation in particular, object recognition involves the recognition of various elements in a digital image or video that can be used to improve the valuation process.

As an example, object recognition in interior settings may include detection and recognition of specific kitchen, bathroom, or laundry room appliances (e.g., type, finish or brand for stoves, fridges, and dishwashers). It can also detect countertop and flooring material, type of light fixtures and bathroom vanities, as well as bathroom elements count.

When it comes to the exterior of a property, object recognition can identify window and door types and counts, roof and siding material, garage type and size, the presence of pools, sport courts, solar panels, and adverse external factors, such as powerlines or high-traffic streets.

When all of these are then fed into the property quality assessment, they will lead to improvements in the AVM's accuracy and consistency.

ii. Image Classification

Unlike object recognition, image classification involves assigning a label to an entire image, rather than to specific objects within the scene, and categorizing it into one of a number of predefined classes. In image classification, the same neural nets techniques are used to create the classification models, but the model learns the distinctive features of each image category during training. The image classification or scene recognition technology enables the detection or recognition of a room type (e.g., kitchen, bedroom, hallway, and dining room), property features or characteristics identification (e.g., house architectural style and number of stories), while also identifying the presence of decks, outdoor rooms, outbuildings, landscaping, or even the relative positioning of the property in the neighborhood.

Training the object recognition or image classification models to identify defects from an image set is another application of CV technology in the valuation space. Trained CV models could recognize physical damage in walls, ceilings, floors, siding, roofs, and foundation, driveway cracks, exterior deck damage, stairs damage, etc. Going even further, trained models could classify the type of damage—material or immaterial—based on its extent and prevalence within the analyzed property.

iii. Floor Plan and Gross Living Area Validation

The ability to validate a property's Gross Living Area (GLA) and/or floor plan is also key in confirming the valuation assumption in AVMs.

Visual Technologies encompassing CV, telemetry and image analysis are providing the technology framework for this capability.

CV mapping methods can vary from photogrammetry (extracting 3-D information from a collection of 2-D images) and visual telemetry (measuring objects' relative positions, distances, dimensions, and orientations from visual data usually taken from cameras recording relative movement), to odometry techniques (Visual Odometry (VO) and Visual Inertial Odometry (VIO)). Also worth considering are advanced mapping using Light Detection and Ranging (LiDARs) or other time-of-flight (TOF) technologies made possible through the use of high-end smartphones or dedicated mapping devices.

iv. Computer Vision Implementation Challenges

While all of these developments are exciting and promising, there are also many challenges in successfully implementing CV technologies in AVMs.

Many aspects, such as resolution (the number of pixels), quality (the picture definition mapped to number of pixels, usually an artifact of compression), or quality definition (how many bits are used to define the respective RGB resolution) may be limiting factors in model design and model training, as well as when it comes to the test output's accuracy expectations. For instance, pictures extracted from a PDF and already compressed will have a lower quality, frames extracted from a video will typically have a lower resolution. In both cases, the CV assessment may be affected negatively.

Additionally, mapping the property condition or quality CV assessment to the Uniform Appraisal Dataset (UAD) codes (C1-C6, Q1-Q6) is not always feasible at large scale. Since ML would be required in a large-scale CV solution, the challenge stems from the rarity or sparsity of either very low or very high condition or quality property occurrences in training and test datasets. As a result, the CV models would end up biased, over matching the training data distribution curve for the desired recall/precision parameters.

Also, importantly, there is no consensus in the valuation industry on how to define material damage. Without an agreed-upon standard for material damage, determining a property's condition or quality assessment using CV damage detection solutions might lead to confusion. The unavoidable implication is that, in the absence of a subjective evaluation by a human appraiser, there will remain a disconnect regarding how the identified damage alone should influence the valuation for the given property.

B Machine Learning

Even though ML is an integral part of a CV solution as described above, its most salient contribution in AVMs is likely in the direct valuation calculation modeling.

AVM models process vast amounts of data available in AVM data lakes, including all available properties characteristics, historical property prices, neighborhood trends, relevant economic indicators, comparables data, etc. Although most often hedonic in nature—the value estimation is based on the property characteristics themselves—there are many types of ML models that could be leveraged in AVM development. These include basic Linear Regression (assuming linear correlation between property characteristics and property value), Decision Tree (where data is split hierarchically before decisions are made and the property characteristics are taken into consideration sequentially based on assigned relevance), Random Forests (where a collection of decision tree predictors is used), and advanced CNNs.

Overall, CNNs are capable of considering non-linear relationships between property characteristics while accounting for additional inputs and general data patterns in valuation estimation.

In the end, AVM developers may rely on significantly more sophisticated valuation solutions in their quest for a best-in-class competitive industry offering. This is where the implementation of complex AVM Cascades or Deep Learning techniques, including multilayer learning and multilayer data transforms, becomes significantly relevant.

C Natural Language Processing

NLP, the ability of computer algorithms to understand and interpret human language, can be used as input for property valuations based on analyzing available textual data such as property descriptions, listings information, user reviews, and neighborhood information, or in support of a CV-based decision regarding assessment of damage, property condition or quality rating, upgrades, etc.

Natural language textual input can also be extracted as direct data (e.g., property parameters, location information, and stats), or can be analyzed for text "sentiment." Sentiment Analysis, the identification and classification of opinions expressed in text, applied, for instance, to a property description or to inspection or appraisal notes could produce output or insights of qualitative aspects in text that would either not be otherwise considered or would be difficult to quantify. Examples of subjective features, shortcomings, or hints about quality or condition that might not be otherwise captured are "as-is condition", "elbow grease", "exceptional view", "friendly neighborhood", "inviting floorplan", "desirable schools", "recently renovated", etc.

Agent comments can complement property images when it comes to inferring a property's condition and, ultimately, its valuation. Case in point, remarks implying bad condition might be included even in the absence of listing photos illustrating said condition. For instance, a comment about "roof condition" would provide insight that could not be otherwise ascertained from street-level photos. Conversely, agents could mention complete remodels that would not be visible in listing imagery.

Sentiment Analysis applied over time can also reveal improving or declining trends in a neighborhood, thus influencing future property values. However, this can be problematic as it involves the use of subjective data to make ostensibly objective assessments. Deployment and trailing data analysis for NLP contributions may, in time, provide deeper understanding for an axis of weighted validity with regard to the subjectivity vs. objectivity of commentary from licensed appraisers compared to listing agents, inspectors, and other real estate professionals.

Dictionary-based or even rudimentary NLP sentiment analysis solutions have been available for a while, but the ability to process human language has, in the recent short term, increased asymptotically with the launch and popularizations of LLM-based NLPs, such as OpenAI's ChatGPT, Meta's BART and LlaMa, Google's BERT and Gemini, and many others. Although each of the available LLM-based NLPs may have their own strengths and weaknesses—a different model size may provide a different ratio of accuracy vs. cost and response time, for example—they all exhibit much more advanced capabilities to process natural language than any prior solution.

Outside of AVM use, sentiment and text analysis outputs could be applied to improve comps selections in Broker Price Opinion (BPO) reports, for example. They can also be a very helpful exploration tool for buyers, especially online buyers, looking for properties with very specific features by facilitating the identification of properties that best meet their criteria, overall refining the buying and selling valuation or recommendation processes.

As for CV technologies, it should be noted that the major concern regarding the introduction of Sentiment Analysis into AVM models is the need for extensive calibrations, and for effective detection and mitigation of possible biases.

4. Benefits and Risks of Employing New Technologies in AVMs

The use of CV, NLP, and AI in real estate AVMs improves valuation accuracy and reliability, while enhancing auditability, helping mitigate biases, and enabling greater trust and acceptance in the market. These technologies represent a significant advancement in the approach to property valuation, aligning it more closely with the dynamic and variable nature of real estate markets.

Ensuring transparency in AI decision-making processes while maintaining a balance between automated and human-driven valuation approaches can be effective in addressing bias concerns. Regular updates and training of AI models with diverse and up-to-date data sets are critical in reducing biases.

While driving innovation, these new technologies may also bring specific risks to the valuation process. AVM developers will need to be cognizant of these risks and proactively build in effective technology and/or process-specific mitigations to fully address them.

A Improving Valuation Accuracy and Reliability

Visual Technologies and CV modeling can easily acquire and process property imagery at scale and with objectivity, while assessing a wide range of relevant parameters such as condition, features, improvements, etc., thus leading to more accurate property valuations.

The use of satellite and aerial imagery can facilitate assessments of street, neighborhood, and overall location factors impacting property values, such as powerlines or other nuisance characteristics.

NLP technologies can extract insights from real estate listings information, real estate market reports, news articles, etc., to understand market specifics or trends, as well as their impact on property valuations.

Processing natural language holds the potential to evaluate public sentiment on specific properties and real estate markets with significantly greater accuracy, thereby adding a qualitative dimension to valuations.

B Enhanced Downstream Auditability, User Trust, and Market Acceptance

Technologies like AI and NLP can help ensure transparent and explainable valuation processes, increasing trust among users. Also, the use of AI and CV for property valuations guarantees a high level of consistency and standardization, which is critical for market acceptance.

For instance, natural language engines could generate detailed valuation reports, including textual analysis of market conditions and trends.

Also, AVM vendors could provide visual and textual audit trails by including in their valuation reports the actual images and the relevant comments that contributed to the resulting property value estimate.

The traceability and references available through the use of CV and Sentiment Analysis would provide a much better line of sight for a subject property alignment to its proper set of comps.

Additionally, even though ML models are considered black boxes, there are ways to make them more transparent and auditable, such as by using class activation maps for neural nets, or real-time AVMs for valuation.

C Improving Guardrails on Bias Mitigation

AI/NLP bias detection algorithms could be developed to identify and mitigate biases, such as those based on location or historical data, in property valuation models.

AI/CV solutions could be implemented to identify and mitigate bias-generating visual or non-visual property information, such as ownership race, religious affiliations, or economic status, either through flagging a bias situation for further evaluation, or by removing/occluding of bias-generating elements, ultimately reducing subjective biases by human appraisers.

D Inherent Risks

This said, there are also risks in the use of Visual Technologies, CV, and AI solutions in real estate valuation. The primary concerns revolve around image data privacy and accuracy issues, as well as potential biases inherent in ML models.

i. Visual Data Privacy Concerns

Prominent among image data-related privacy concerns is the fact that Visual Technologies or CV systems used to analyze property images may capture, either on purpose or inadvertently, private or sensitive information, such as personal belongings, individuals, iconography, or confidential documents left on view or visible through windows, mirrors, etc.

Correspondingly, even with state-of-the-art practices on information security in place, there will always be a risk associated with storing of images or private property details, especially in cloud-based environments, which are vulnerable to breaches and unauthorized access.

Moreover, data use or misuse for purposes other than property valuation, such as targeted advertising or surveillance, without the consent of the property owners, are also concerns.

ii. Visual Data Accuracy Issues

Especially in today's world, where generative AI could build and deliver any desired reality, Visual Technology-enhanced valuation solutions will need to address data authenticity, as well as location and time tagging.

Content veracity (i.e., "Is the image real or an AI-generated fake? Was the image altered through content editing, by adding or removing elements, etc.?") will remain a concern in this space, and mitigating solutions will continue to evolve and will need to be monitored.

While we may be able to tell today if an image was AI-generated, we may not be able to distinguish between an unaltered captured photo and a carefully edited one.

To avoid fraud, the pictures or videos harvested for the purpose of determining or adjusting a property's valuation based on its condition will need to be linked, tagged, or authenticated to the specific property's location and/or time of harvesting. There are several solutions currently available to address this issue, from picture metadata validation to more sophisticated security methods for location tagging and timestamping. However, it is important to note that in some current AVM usages and applications, such as AVM use in Home Equity lending, it may be inappropriate to introduce *any* AI-related variables regarding condition assessment since these may interfere with the integrity of independent AVM testing.

iii. Potential Biases

The potential ML modeling biases are well understood, and effective mitigations, with proper modeling and validation techniques, are available to AVM developers.

One such example is algorithm bias that could be introduced during model development if the training data is not large and/or representative enough of the diverse property types and locations. Such an occurrence might result in unfair valuations for certain properties, areas, or corner cases.

Additionally, AI-based AVM models often rely on historical data which might no longer be valid, or may contain and reflect past biases or socio-economic disparities. This situation, too, can lead to subjective appraisals, perpetuating inequalities in property values based on location, neighborhood demographics, or other factors.

The plausible inability of an AI model to identify and consider either unique property features or local market individualities that a human appraiser would recognize can also play a role and lead to inaccurate valuations.

Finally, the lack of transparency that may be associated with deep learning models, which, given their self-learning nature, are losing the ability to trace how a particular valuation was calculated, would make it challenging to identify and correct potential biases.

5. Future Outlook

The continuous evolution in residential property valuation is reshaping stakeholder roles and, some may suggest, requires robust regulatory frameworks to ensure fairness, accuracy, and efficiency in the real estate market.

The dawn of next generation mobile computing triggered by Augmented Reality (AR) and Mixed Reality (MR) technologies and its in-development supporting infrastructure, along with the use of LLMs and contextual AI, is positioned to change the way data is collected, acquired and processed, from computer vision, to data analytics and human interaction, all of which will likely provide new, revolutionary ways to address real estate valuation accuracy and integrity.

A The Trajectory of AVM Technology Development

Predictive analytics should continue to play a crucial role in the evolution of AVM technology, as identifying patterns and trends on very large amounts of data will remain the predominant input and approach of a valuation model.

The ability to follow data in real time, along with the inclusion of social data, environmental factors, economic conditions, interest rates, local market trends, social sentiments, etc. should only enhance the model's ability to make a more accurate valuation prediction, while offering solutions and mitigations for modeling customizations, cost effectiveness, risk assessment and management, etc.

Used today with various levels of success by AVM developers, a continuous learning approach is another vector to be considered towards further improving AVM technologies.

Given that property markets are dynamic and evolving, AVMs would need to be regularly updated to reflect the market conditions at given times.

Continuous learning based on ground truth, such as constantly comparing the models' prediction to the actual market outcomes (i.e., actual sale prices or appraisal values) would allow AVMs to automatically adjust and refine their algorithms based on new data on an ongoing basis, leading to more accurate and reliable valuations.

The role of LLMs in AVM technology, while relatively new, is potentially transformative. LLMs' capability to process unstructured data, such as news articles, social media posts, and economic reports, would allow for a more nuanced understanding of market sentiment and trends, something still challenging for traditional AVMs to analyze. Furthermore, LLMs can assist in automating and enhancing the reporting and explaining aspects of property valuations, making them more accessible and comprehensible to users.

Looking forward, the real estate industry may need to follow the likely evolution of predictive analytics, from the currently established data mining, modeling, and ML solutions, to LLMs-based predictive AI technologies.

It is hard to say at this time at what level the CNN methods may be displaced in data modeling and predictive analytics by the continuing development and evolution of large language models. However, LLMs should be considered as the next/new generation technologies to be exploited in overall improved valuation solutions.

Although today LLMs are assumed to be synonymous to NLP, therefore proving their applicability into text and natural language generative AI, the continuing development of predictive AI through LLMs should render this technology into a more powerful alternative to convolutional networks in valuation solutions development.

B The Evolving Landscape of Residential Property Valuation

The impactful integration of these new technologies and methodologies in residential property valuation has significant implications for stakeholders and may necessitate careful regulatory considerations.

Buyers and sellers expect valuation accuracy, accessibility, and transparency. In light of their impact on both selling prices and derived property taxes, valuation methods must produce the lowest valuation errors and best fair market results possible. Novel, more advanced valuation tools could provide the above, while delivering more accessible and comprehensible property value information to homeowners, such as traceability for the valuation amount, relevant comparable sales, and supporting data.

Real estate agents and brokers may need to adapt to these new valuation technologies, and will likely require better understanding and additional training, as the emerging new valuation methods might significantly alter real estate strategies and the client-agent interaction framework.

Of course, while these advanced valuation techniques could enable various levels of automation and streamlining of mortgage processes, they might also improve risk assessments and the overall lending decision-making process for lenders and financial institutions.

The appraiser's role could be affected as well. As reliance on data and data analytics will likely continue to increase in the process of property valuations, appraisers may need to become skilled in data analysis and interpretation, and on drawing from data processing automated systems. Future appraisers may be less "boots on the ground" measuring and image capturing data within the property, as such efforts wane in favor of increasing the role of technology and improving the division of labor, with more cost effective cohorts assigned to capture on-site property images and data. In this regard, appraisers with an eye to the future may find their licensed skills best applied as valuation model auditors, with drastically reduced site visits, larger weekly thruput, and increased economic opportunities.

The insurance industry and property taxation sector may also be impacted. Improved valuations should lead to more accurate insurance risk assessments and policy pricing, while more precise valuations should impact the planning around property tax revenues and assessments.

Accuracy and reliability standards may need to be considered to ensure that new valuation methods are precise, reliable, and bias-free. The valuation model should provide not only the actual valuation, but also its own uncertainty around it. Listing confidence intervals or a meaningful Forecast Standard Deviation (FSD) along with the modeled valuation will deliver a more complete solution, accuracy-wise, to the industry.

The increased use of digital data should prompt increased scrutiny on how homeowners' privacy and secure sensitive information is protected. AVM developers' and AVM service providers' adherence and compliance to information security standards may become necessary and required.

Special attention may be applied to ethical and bias risks. Standards and regulations may be necessary to effectively and consistently address potential biases in AVMs, especially those related to neighborhood demographics and historical data.

Meanwhile, good practices and validations can be put in place by AVM developers or AVM service providers to ensure that responsible development principles are in use and effective. Many AVM developers have already acknowledged and took steps to address this gap, at least temporarily.

C How Emerging Technologies and the Next Generation Mobile Computing Could Enhance the Valuation Process

The development of AR/MR technologies, currently spearheaded by Apple, Meta, and others, is seen by most as a 'moon shot', or, at best, as a 'distant scenario'.

However, with the foreseen likelihood that AR/MR tech will eventually become available, it could also quickly become mainstream and socially acceptable. This would take the visual technologies into ubiquity sooner, rather than later, and so break the last barriers for commoditization of objects recognition, mapping, localization, anonymization, on-device processing, etc.

It is a fair hypothesis to consider that as the AR/MR hardware (e.g., glasses, wrist devices, and other wearables) gets introduced, initially as a companion to smartphones, it may then, in short order, displace the phones themselves and thus trigger the next generation of mobile computing—with a new-found focus on augmenting and enhancing human perception and interaction.

As a bi-product, all this could make possible the democratization of image processing capabilities, image collection and processing, and 2D/3D mapping. This, along with the use of predictive and contextual AI, may change the mainstream technology approach to pictures and/or video taking and mapping, all feeding into next generation property valuation solutions that today are deemed too expensive or still unfeasible.

While the certain impact of AVMs' future precision and auditability remains currently unknown, the capability arc these potentially transformative technologies can have on AVMs suggests to customers and vendors alike that the wisest course is to engage with those vendors who have both the skills and capability to lead the field in this eventual determination.

6. Conclusion

The overall value and feasibility of using AVMs in property valuations is now a well-established solution, demonstrated through its proven scale and scalability, velocity, and cost efficiency.

However, the industry's quest to further improve the accuracy of AVMs remains contingent on the sophistication and flexibility of the underlying models they employ, as well as on the quality and breadth of the data used to build and validate these models.

Improvements in data collection, as well as the curation and integration of advanced AI and ML solutions in AVM development are key to addressing these challenges.

The use of Visual Technologies and AI, in particular the use of CV, NLP and ML, are poised to offer solutions to the biggest valuation problem left to solve for AVMs—the 'average condition' assumption.

Through object detection, scene recognition, and image classification, CV and Visual Technologies can provide to AVMs accurate and consistent signals on property visual information (e.g., rooms and features recognition, architecture style, and number of stories), on property quality (by identifying interior and exterior construction materials, types of appliances, etc.), and, particularly, on property condition (by detecting interior and exterior damage, and by assessing the damage impact into the estimated property value).

The integration into AVMs of NLP and Sentiment Analysis technologies is providing access to text-centric, unstructured or qualitative information such as property descriptions, listings qualitative information, published articles, neighborhood information, etc., thus enabling models to now consider data otherwise unavailable to valuation algorithms.

While CV, NLP, and ML are enhancing the quality and accuracy of AVMs, they are not without risks. Not only are bias and lack of transparency concerns to be addressed in the expected evolution of AVMs, but the technology itself may provide a better answer to currently existing valuation methodology concerns through traceability, validation, and the ability to use far more diverse data for training.

The continuing innovation within AI in general, the use of LLMs and contextual AI, and the future introduction of next generation mobile computing enabled by AR/MR technologies along with in-development supporting infrastructure, are poised to change entirely the way data is acquired and processed. This would revolutionize image and object recognition, mapping, and data processing, overall providing new, innovative ways to deliver real estate valuation with the foremost accuracy and integrity.

Through the introduction and heavy use of new technologies, the evolution in residential property valuation is changing the stakeholders' roles. To ensure valuation fairness and accuracy, and to mitigate risks, in the context of developers' self-imposed good-development practices, the industry may require the introduction of more robust regulatory frameworks to achieve improved standardization, better data integration, and bias mitigation.

7. About the Author

Claudiu Bulai, Chief Innovation Officer of Quantarium, has decades of expertise as a technologist and organizational leader, driving the research, development and launching of a vast number of complex hardware/software products across various industries, from startups to Fortune 500 environments.

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