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Modern approaches to assessing the residual value of restored cars in the US dealer market.

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Abstract: This study aims to provide a comprehensive review of contemporary approaches to estimating the residual value of rebuilt vehicles in the U.S. dealer market. The relevance of this work is driven by the scale and dynamics of the auction segment for rebuilt and salvage vehicles, whose revenue rivals that of the midsize new-car market, and whose online segment is projected to grow at a compound annual rate of 13.7% through 2030. The novelty of the research lies in bringing together various types of data. This data comes from VIN parsing, operational logs from Copart, IAA, OpenLane, telematics streams coming from Geotab, and high-precision visual checks. It has been observed that the shift from expert visual appraisal to digital valuation methods has significantly reduced the mean absolute error in RV forecasts, while also shortening the days-to-sale and decreasing cosmetic damage arbitration rates. UVeye, Mitchell+PAVE, and Ravin AI systems will incorporate models with visual features, while conformal quantile regression will ensure guaranteed coverage, enabling automatic adjustments to financial terms. However, new risks have emerged: the increase in deepfake manipulations of photographic content, alongside regulatory requirements (SB-362), will impose very stringent demands on verification as well as the protection of personal and telematics data.

This article will be of use to analysts, dealers, AI solution developers, and researchers in the fields of residual value estimation and risk management in the used-vehicle market.

Keywords: residual value, rebuilt vehicles, U.S. dealer

market, computer vision, telematics, big data, ensemble regressors, conformal quantile regression, risk management, data verification.

Introduction: The volume of auction sales of rebuilt vehicles in the United States is comparable to that of the midsize new-car segment: in 2023, combined "whole-car + salvage" auction revenues totaled USD 3.32 billion, with 13.84 million units transacted, a significant share of which held rebuilt or salvage titles [1]. By 2024, the online segment of salvage auctions alone is estimated to be worth USD 3.42 billion, and Grand View Research projects a compound annual growth rate of 13.7% through 2030 [2]. The magnitude and momentum of this sector make the accuracy of residual-value (RV) estimation a central factor in the financial stability of dealers who handle these vehicles.

For dealer operations, an error in RV prediction translates directly into financial loss: overestimation leads to losses upon resale, while underestimation results in excessive discounts and tied-up capital. In a volatile used-car market, dealers aim to narrow this forecast corridor and accelerate inventory turnover. The transition from expert-based, paper-driven appraisal methods to the integration of big data and artificial intelligence algorithms offers a path to reducing uncertainty. Platforms such as ACV Auctions scan vehicles upon intake using computer vision, extract structured features, and—leveraging a database of over 3 million inspections—generate an instant report that reduces arbitration rates and mitigates transaction risk [3].

Thus, the evolution of valuation tools is shifting residual analytics from subjective allowances to quantitative modeling, creating a new fulcrum for risk management in the rapidly expanding U.S. restored-vehicle market.

MATERIALS AND METHODOLOGY

This study of contemporary approaches to residual-value estimation for rebuilt vehicles in the U.S. dealer market is based on an analysis of 21 sources, including auction platform operational logs, telematics provider reports, computer vision implementation case studies, and publications on quantitative risk estimation methods. The theoretical framework comprises works on the integration of computer vision and big data in RV analytics: Hari Bhushan [3] described the application of CV inspection at ACV Auctions; Manokhin [10] presented a conformal quantile-regression method for reliable interval forecasting; and Jung et al. [15] compared YOLOv7 and YOLOv8 effectiveness in detecting body defects. Industry reports from Geotab on telematics [8, 9], technical documentation for UVeye Atlas/Helios [11, 12], the Mitchell + PAVE mobile solution [13], and OPENLANE's Visual Boost case studies [14] were also reviewed.

Methodologically, the study combined:

- Comparative analysis of visual technologies—juxtaposing stationary portals (UVeye Atlas/Helios) and Copart C360 panoramic imaging with mobile apps (Mitchell + PAVE) and the hybrid Ravin AI solution; assessing the impact of feature-quality on RV-forecast accuracy [5, 11, 14].

- Systematic review of big data—aggregating Copart, IAA, and OPENLANE operational logs with VIN parsing and processing of 40 configuration attributes [4], alongside Geotab telematics streams to account for wear and battery condition [8, 9].

- Content analysis of operational metrics and case studies—examining the influence of AI valuation on arbitration reduction and evaluating model sensitivity to macroeconomic factors and salvage-title types.

RESULTS AND DISCUSSION

Traditional practice for valuing rebuilt vehicles relied on expert visual inspections. It averaged insurance tables: structural-geometry losses were recorded manually, and the discount relative to a "clean" analogue was determined empirically by experts. The first step toward reducing subjectivity was extensive digitization. The wide adoption of VIN parsing and the integration of telematics streams have enabled the automated extraction of configuration codes, service and mileage history, and current electronic control-unit errors. Today, aggregators process data from 145 online auctions in real-time, including price, mileage, and 40 configuration attributes per VIN [4]. Concurrently, Copart introduced its own 360° C360 module in 2021, complementing the existing set of twenty high-resolution HD frames for an objective visual channel [5]. The growth of telematics closely mirrored the expansion of datasets: the automotive telematics

market is projected to rise from USD 9.87 billion in 2024 to USD 17.24 billion by 2030 at a 9.84% CAGR [6].

In parallel, marketplace infrastructures integrated data collection and transactions. Copart, handling over 4 million lots in fiscal 2024 across 250 locations, has become the primary distribution channel for total-loss vehicles, where standardized content is the norm [7]. Thus, subjective expert practice has evolved into a continuous digital stream model, in which the quality of incoming data sets the lower bound of RV-forecast error.

Three major data streams constitute the input for RV models. The first comprises operational logs from Copart, IAA, and OpenLane, where each listing may include up to 100 parameters, including type of damage, VIN attributes, bidding history, and final sale price. The sector's scale provides the statistical foundation: the U.S. vehicle auction market reached 13.84 million units in 2023, with a projected annual growth rate of approximately 3.7% from 2023 to 2028 [22].

The second stream originates from insurers. Aggregated databases, which cover a significant share of the auto-property insurance market, provide data on damage types, total-loss calculations, and actual repair costs, enabling the alignment of forecasted and realized recovery expenses. These variables are critical for adjusting the "insurance" discount, as they differentiate total losses due to non-structural (hail, flood) versus structural (collision) damage.

The third source is telematics providers. According to Geotab analytics, by 2024, approximately 340 million vehicles were connected to its cloud platform [8], with the EV fleet within that network growing 63% year-over-year and surpassing 700 million real-world miles driven [9]. Continuous odometer, usage-mode, and battery-condition streams expand feature sets beyond the "moment of accident," allowing models to account for material wear and powertrain component degradation.

Training datasets remain heterogeneous, as each VIN is annotated with its legal status ("salvage," "rebuilt," "flood," "hail," or "theft recovery"), regional lot location, and macroeconomic context. Macro factors inject volatility: for instance, an FOMC rate cut immediately reduced the average used-car loan payment, altering dealer demand elasticity in interest-sensitive segments. Consequently, the final dataset is augmented with time-localized variables (Fed Funds, CPI, WTI) and an export-orientation indicator, while title-type labeling encodes a priori discount differentials.

Since dealers are concerned not only with point forecasts but also with deviation ranges, conformal quantile regression (CQR) is applied on top of ensemble models to compute confidence intervals. This method trains two auxiliary boosting models on the 0.05 and 0.95 thresholds and calibrates them on a hold-out sample, ensuring 90% coverage even under shifting market regimes [10]. The resulting interval width serves as a natural risk score: lots with a bandwidth greater than 18% trigger an automatic increase in financing rate. Within the ACV ArbGuard ecosystem, this scoring has already reduced cosmetic-damage arbitrations and consequent seller losses.

Thus, the "heterogeneous dataset → ensemble regressor → conformal calibration" pipeline converts RV estimation from a static expert procedure into dynamic risk management, adaptable to both macro shifts and micro-demand fluctuations across salvage-title types.

Computer vision completes the "data–valuation–price" chain, formalizing visual inspection into a numerical-feature source. Among stationary solutions, drive-through portals lead the field: the UVeye Atlas/Helios scanner, deployed at 300 U.S. dealer locations, captures up to 2,000 multispectral frames per pass and generates a full-body condition report in 20–30 seconds, processing over 0.5 million vehicles monthly [11]. Its eight high-resolution cameras and laser profilometer array detect thickness deviations that previously required panel disassembly. The algorithm immediately segments the body into standard elements (hood, doors, quarters, bumpers, sills) and assigns quantitative metrics—area, depth, and defect type—to each zone. These vectors feed into the ensemble RV regressor, where the "visual" feature contribution reduces RMSE. An example of a UVeye installation is illustrated in Fig. 1, and a corresponding report is presented in Fig. 2.

Fig. 1. UVeye scanner [12]

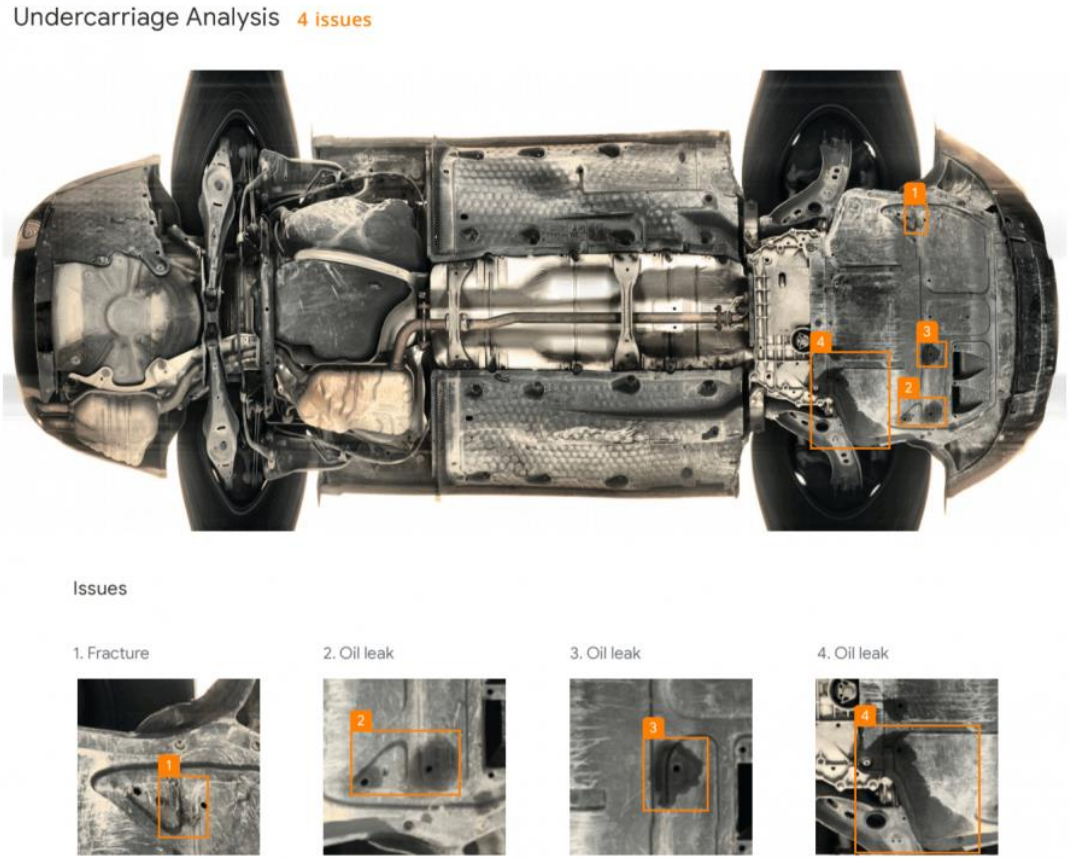

Fig. 2. Example of a report after scanning via UVeye [12]

Mobile solutions address the same tasks where no stationary portal exists. The Mitchell + PAVE alliance is most illustrative: in September 2024, partners integrated a guided-capture app into the Mitchell Intelligent Damage Analysis cloud, enabling an eight-to-ten photo smartphone condition report that instantly calculates parts, labor, and tax costs [13]. This format benefits small dealers and insourced fleets for which a physical drive-through is not cost-effective.

Complementing stationary and mobile approaches is the hybrid Ravin AI solution on the OPENLANE marketplace. Visual Boost overlays thermal masks of detected defects directly onto condition-report photographs, eliminating the typical "difficult" angles and micro-cracks that are invisible to the average buyer [14]. An example of this technology is shown in Fig. 3. Integration increased conversion rates on rebuilt-lot bids, confirming the hypothesis that informational deficits drive elevated salvage-title discounts.

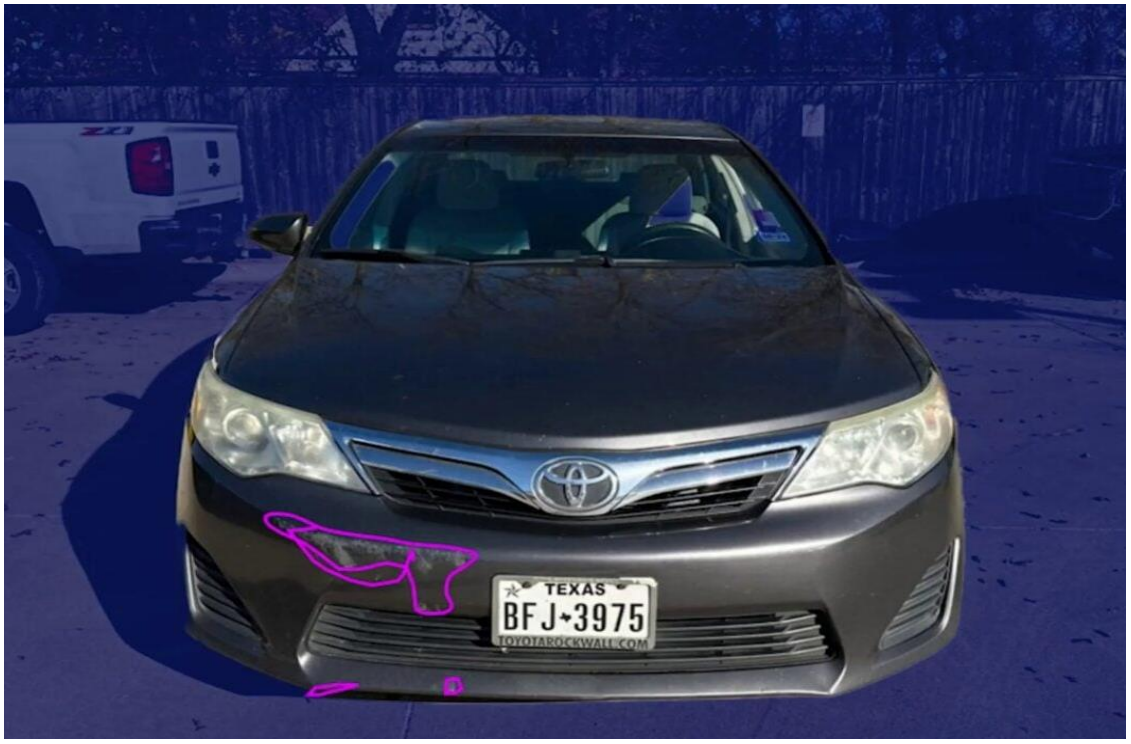

Fig. 3. Example of OPENLANE Visual Boost AI [14]

Across these solutions, segmentation and hidden-damage detection algorithms play a key role. For large panels, CNN hybrids with panoptic segmentation partition images into superclasses and localize defect "fibers" with sub-millimeter precision, while also producing corrosion-probability heatmaps from indirect texture cues. Smartphone workflows in Mitchell + PAVE employ a "YOLOv8 → GAN-augmentation" scheme. Jung et al. [15] report that upgrading from YOLOv7 to YOLOv8 increased mAP on body-defect detection from 0.84 to 0.88 while maintaining real-time performance. To account for uncertainty, detection results undergo a time-based Canny-based ensemble and are calibrated with conformal predictive intervals; that interval width then factors into the dealer-financing risk score described above.

Thus, the spectrum of CV technologies—from millimeter-precision portals to smartphone apps—forms a data hierarchy fed into a unified RV model. The richer the segmentation map and the more accurate the "invisible" corrosion prediction, the narrower the price-confidence interval and the lower the dealer's financial risk on rebuilt vehicles.

Risk reduction emerges as early as the bidding stage, where ensemble CV-augmented models enable dealers to narrow the gap between forecasted and actual salvage-lot purchase prices. A study [16] demonstrated that AI-based valuation reduced the mean absolute error by 13.5% compared to traditional statistical regression methods. Operational risk—typically linked to arbitrations and returns due to undetected defects—has also declined: ACV Auctions' ArbGuard inspection platform, powered by over 3 million historical inspections and employing computer vision with acoustic analysis, predicts hidden-damage probabilities and, according to the 2023 Analyst Day report, has already reduced cosmetic arbitration volumes by automatically highlighting risk zones at listing [17].

Financial risk is measured by inventory turnover and ultimate profitability. Reducing forecast error and

arbitration frequency directly accelerates days-to-sale: dealers using integrated AI valuation systems turn inventory roughly five days faster than those relying on traditional pricing, even before factoring in lower floor-plan costs.

The effect scales under tight market conditions: according to Cox, the U.S. used-car supply fell to 39 days of supply by early April 2025—the lowest in four years. Consequently, precise pricing, lower claims costs, and faster turnover collectively mitigate the systemic risks historically associated with rebuilt-vehicle transactions, transforming the segment from high-risk to sustainably margin-accretive even amid macroeconomic volatility [23].

While RV-model accuracy curbs classic pricing risks, it introduces new vulnerabilities tied to data authenticity. Insurer Allianz reported a 300 % increase in claims based on artificially "added" body damage—that is, shallow/deepfake photo manipulation—and Zurich UK labeled such fraud "one of the fastest-growing threats" to auto insurance [18].

At the same time, the U.S. Treasury's FinCEN issued an advisory on schemes utilizing generative imagery and documents to circumvent Know Your Customer (KYC) procedures, highlighting a rise in suspicious transactions involving deepfake content in banking and insurance filings. The corporate sector is also alarmed: in mid-2024, Microsoft publicly urged Congress to enact federal deepfake-fraud legislation, warning that the absence of synthetic-media labeling would escalate financial-market risks [19]. For dealers, this implies potential replacement of genuine "x-ray scans" of vehicle bodies with fabricated images, leading to erroneous lot valuations.

The expansion of datasets also raises concerns about privacy. Telematics streams record precise routes and usage modes, and photographic material often contains personal identifiers. In the legal realm, California's Delete Act (SB-362), effective January 2024, mandates that registered data brokers—including auction aggregators and telematics providers—offer a unified mechanism for consumers to request deletion of personal data [20]. Consequently, dealers and their technology partners must balance the completeness of information for accurate pricing models with new obligations to minimize and purge personal attributes.

The systemic response to these dual threat vectors is the development of end-to-end verification standards. At the media-source level, the open C2PA specification, jointly advanced by Adobe, Microsoft, Intel, and others, defines a cryptographic "Content Credentials" architecture to record a file's transformation chain from capture to publication [21].

To summarize, the application of big data and computer vision to high-precision RV-estimation algorithms significantly reduces financial risks for dealers in the restored-vehicle market. These technologies not only improve forecast accuracy but also enable faster vehicle turnover, which is crucial in highly dynamic markets. On the downside, the new benefits also introduce threats from data manipulation and compliance with privacy requirements. The future development and implementation of universal verification and data protection mechanisms will be crucial for the sustainable growth of this market segment.

CONCLUSION

A part of the automotive business that has grown in recent years is the rebuilt-vehicle market, especially in the U.S., where proper detailing and residual value estimation are crucial for financial stability among dealers. Recent approaches to RV valuation have shifted from subjective visual inspections and judgments by one or two experts to greater objectivity and quantification of accuracy, made possible through big data analytics and artificial intelligence. Computer vision, combined with telematics, makes residual value forecasting more accurate—this enables faster processing and reduces handling costs.

Group regressors, combined with conformal quantile regression and information from bids, sellers, and telematics companies, yield a high-precision risk assessment (RA) model. This model considers not just the true condition of the vehicle but also prospective larger economic changes so it can be used in unstable market conditions.

Computer-vision implementations—from UVeye's stationary portals to guided-capture mobile apps—convert visual assessments into standardized,

numerical inputs. This standardization, in turn, significantly reduces valuation error, bolsters market participant confidence, lowers arbitration rates, and speeds up inventory turnover. Such advances enable dealers to forecast RVs more accurately and improve the profitability of rebuilt-vehicle operations.

However, alongside these clear advantages, new RV-estimation methods carry risks, primarily related to potential data-manipulation schemes, such as deepfake imagery, and privacy challenges in handling telematics and visual data. The threats will necessitate the establishment of robust data-verification and protection standards that ensure transaction transparency and security. Emerging technologies, like blockchain, play an important role in keeping market resilience while fostering sustainable growth. To sum up, the use of modern RV-estimation methods in dealer workflows reduces typical price risks and lays a solid groundwork for additional growth and improvement within the U.S. rebuilt-vehicle market.

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