Technical White Paper

Control Statistics and Risk Scoring Automated Valuations

by Carl Cozine
Chief Scientist

IntelliReal™
REAL INTELLIGENCE

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IntelliReal LLC
215 Union Blvd., Suite 100
Lakewood, CO 80228
303-688-8994

www.IntelliReal.com

Overview

IntelliReal's proprietary technology and data aggregation system provides enhanced data mining, accuracy, speed and reduced-cost valuation solutions. IntelliReal has developed a proprietary process to produce an accurate, meaningful and transparent confidence score to its AVM solution.

Most AVMs deliver an arbitrary confidence score methodology. The IntelliReal solution is grounded in quantifiable statistics. Each property is given a high, medium or low confidence score or Estimated Standard Deviation (ESD). High confidence is a score of 13% or less, medium is greater than 13% and less than 20%, and low is greater than 20%. The ESD is derived though the proprietary modeling methodology. Further, these risk scores are quantified in terms of the actual projected dollar risk associated with each property and may be summarized in the aggregate for a batch of loans.

This white paper describes how IntelliReal's Control Statistics and Risk Scoring Automated Valuations produce confidence scores representative of the dollar value of the risk inherent in each individual valuation and an overview of the measures used to select the best valuation. Additionally, it describes IntelliReal's mean error and estimated standard deviation of errors for each subject confidence score offering a key feature that may be tailored to a customer's unique subject and market indicators.

Market Segmentation

The IntelliReal system initially segments markets into demographically, socially, and economically similar geographical building blocks that are physically close and have similar housing characteristics for each property type (detached single family dwellings, condominiums, etc.). Each market segment requires sufficient sales within a defined time period for a small geographic model to assure neighborhood and subdivision differences are not lost.

Proprietary algorithms and sophisticated statistical modeling technologies segment the US into 18,000 unique market segments. Discovery of the optimal segmentation and creation of the optimized models are self-constructed by the system. This insures that every value-influencing nuance is captured; and insures the most accurate resulting valuation.

Competing Models — Cascading Values

The Intelligence Engine fully automates market segmentation, modeling, model validation, model quality control, and valuation confidence scoring system that produces multiple competing valuations on each property. The competing valuations are produced by hedonic, trending, hybrid and explicit models on each market segment.

A typical IntelliReal valuation:

Property ID	8564
Value	$179,625
Confidence level class	High
Maximum inherent financial risk in this valuation (95% confidence)	$41,945
Estimated mean percent residual	-1.53%
Estimated standard deviation of percent residual (ESD)	11.63%
Mmodel test sample size	3,000

Geographically optimized market segments are selected to provide optimal granularity of models; small and specific enough to capture the unique local market for a particular property type yet large enough to produce robust and accurate models. Each competing model produces a valuation on every property.

Only the best valuation is provided to the client requiring an accurate method of measuring and choosing or calculating the best valuation. This paper will provide an overview of some of the measures used to deliver the best valuation and how these same measures are reported in terms useful to the user of the valuations.

Quantifying Transaction Risk

Automated Valuation Models (AVMs) are primarily utilized to quantify transaction risk. Therefore, it is essential that every derived valuation be accompanied by one or more control measures to characterize valuation risk in terms that are easy-to-understand, meaningful, replicable, and useful in subsequent computations. The control statistics provided by IntelliReal address the following items:

- Confidence or risk scoring algorithm
- Methodology for calculating and reporting risk measurements
- Approach to defining and quantifying the actual dollar risk value assigned to each individual valuation
- Reporting aggregate valuation risk inherent in a portfolio of valuations

Performance Measurements

IntelliReal's system allows direct and unbiased comparison of multiple models delivering the advantages of a cascading AVM from within a single valuation system. The system segments the market so that there are multiple models valuing the same geography using consistent quality and risk metrics across all modeling methodologies. The approach provides optimal granularity of models; small and specific enough to capture the unique local market for a particular property type yet large enough to produce robust and accurate models. Each competing model produces a valuation on every property.

For example, the model for detached single family dwellings will be made on the smallest set of similar geographic units that yields a large enough sample to make a good statistically significant model and to rigorously validate and test the results.

The model for condominiums will be made on another set of building block geographies even though those geographies may overlap with another property type, they will in general be a different geography.

Discovery of the optimal segment profile and self-construction of the optimal model are handled automatically by the IntelliReal application.

To monitor performance and report on risk factors, IntelliReal utilizes a number of control statistics:

Expected Value (EV)	IntelliReal's best estimate of the most probable transfer value of the subject property as the result of an arms-length transaction on the Effective Value Date.
Effective Value Date (EVD)	The effective date for which the Expected Value was calculated. Due to the dynamic nature of the real estate market, Expected Values vary from day to day. Expected Values can be computed for any past date or for any date that is not too far into the future.

Confidence Level Class (CLC)

This is an intrinsic categorization of the uncertainty associated with Expected Value expressed as:

H (high) less than 13% ESD
L (low) greater than 20% ESD
M (medium) greater or equal to 13% and less than or equal to 20% ESD

If a score has a 13% ESD it means that about 68% of scores made with the particular model that produced the score fell within a range of +/- 13% of the reference value.

If a score has a 17% ESD it means that about 68% of scores made with the particular model that produced the score fell within a range of +/- 17% of the reference value.

Maximum Inherent Financial Risk (IFR) For this Expected Value (stated percent confidence)

IFR is the expected maximum dollar value that the Expected Value (EV) could vary within the stated confidence.

The dollar-valued score conveys the maximum expected variability of the Expected Value (EV) within a combined confidence interval of the mean and the variance at a 95% confidence (or any other user specified confidence level).

IFR can be interpreted as a combination of the maximum expected variability of the mean residual and the maximum expected variability of the residual standard deviation of dollar valued residuals around the Expected Value at 1.96 standard deviations (for 95% confidence, or any other value depending upon the confidence most useful to the user).

The Expected Mean Percent Residual (MPR)

MPR is the mean value of the percent residual for the Expected Value (EV), and, together with the Expected Standard Deviation (ESD), fully defines the probability density of the percent residuals associated with the results when the generating model was run against its test sample.

The Expected Standard Deviation (ESD)

ESD is expressed as the percent absolute Expected Value (EV) residual within which approximately 68% of all valuations produced by applying the model generating the Expected Value against a hold-out sample.

ESD is the percent residual that marks the expected outer limit of plus or minus one standard deviation from the mean residual of a given valuation.

Together with the Expected Mean Percent Residual (MPR) the statistic fully defines the probability density of the percent residuals associated with the results when the generating model was applied against its test sample.

The Model Test Sample Size (TSS)

TSS is the number of records in the test sample. TSS provides information necessary to calculate the provided statistics to allow the array of Supervisory Statistics to be flexibly employed for other statistical calculations if the user so desires.

An example of the control statistics as reported on a batch of sample properties.

Property ID	Expected Value EV ($)	Expected Value Date EVD	Confidence Level Class CLS	Selected Confidence of IFR Confidence	Expected Maximum Inherent Financial Risk IFR ($)	Expected Mean Percent Residual MPR	Expected Standard Deviation ESD	Model Test Sample TSS
10517005555	144,966.48	5/1/2006	H	95%	17,005	1.7%	7%	2 ,794
1545105159	216,050.22	5/1/2006	H	95%	15,634	1.1%	4%	2 ,873
1093900551	149,027.25	5/1/2006	H	95%	32,177	-2.4%	10%	2 ,707
1094500459	161,175.59	5/1/2006	H	95%	252	0.0%	0%	2 ,997
1545106109	223,872.26	5/1/2006	H	95%	10,431	0.7%	3%	2 ,918
1108605809	161,966.83	5/1/2006	H	95%	36,269	-2.5%	10%	2 ,696
1102015959	239,833.24	5/1/2006	M	95%	84,210	-4.0%	16%	2 ,523
1545106159	244,926.20	5/1/2006	M	95%	80,837	-3.7%	15%	2 ,552
1102016059	229,069.83	5/1/2006	M	95%	70,634	-3.5%	14%	2 ,581
1102006109	413,567.32	5/1/2006	M	95%	143,160	-3.9%	16%	2 ,530
1545105659	229,065.02	5/1/2006	H	95%	12,324	0.8%	3%	2 ,906
1102016009	229,265.48	5/1/2006	H	95%	4,080	0.3%	1%	2 ,969
1102024609	459,767.26	5/1/2006	H	95%	53,629	1.7%	7%	2 ,795
1545105909	238,615.49	5/1/2006	H	95%	7,475	0.5%	2%	2 ,945
1545106209	273,445.22	5/1/2006	H	95%	63,616	-2.6%	11%	2 ,684
1545105309	229,143.02	5/1/2006	M	95%	78,893	-3.9%	16%	2 ,533
1423300001	156,303.87	5/1/2006	H	95%	941	0.1%	0%	2 ,989
1545105359	239,710.28	5/1/2006	M	95%	70,804	-3.3%	13%	2 ,599
1051701603	137,795.03	5/1/2006	H	95%	2,903	0.3%	1%	2 ,963
1099300959	216,963.60	5/1/2006	H	95%	48,715	-2.5%	10%	2 ,695
1545105459	285,624.38	5/1/2006	H	95%	2,415	0.1%	0%	2 ,985
1545105609	229,260.86	5/1/2006	M	95%	76,978	-3.8%	15%	2 ,544
1102015859	228,053.59	5/1/2006	H	95%	54,997	-2.7%	11%	2 ,673
1102015909	205,773.31	5/1/2006	M	95%	70,558	-3.9%	16%	2 ,535
1127241758	270,527.02	5/1/2006	H	95%	21,011	1.1%	5%	2 ,864

STATISTICAL METHODOLOGY

Overview

IntelliReal compiles a database of properties for a carefully selected market segment — including for each property a set of attribute measures and a recent sale price on a given date. The data are then randomly divided into two subsets. One subset is used to develop the model; the other subset is used to determine how well the model performs in predicting the sale price. The test data results are captured and represent the performance of the model. The performance of the model is measured with a set of supervisory statistics, which are used to select or calculate the best valuation for each property.

A detailed description of the statistical methodology employed in generating the Estimated Value (EV) and the associated supervisory statistics.

The value of a subject property as generally defined in practice is the sale price of the property when the property is transferred as part of a negotiated free market exchange between a willing buyer and a willing seller. The reason that a valuation is requested in the first place is that the party requesting the valuation does not know the value of the subject property. In fact, the exact "value" of a subject property transaction is unknown and unknowable in advance. This is an important point. Even the eventual selling price, also called transfer price, may or may not represent the true market value — even if the sale is a free market exchange. Nevertheless the transfer value is typically used as the reference value; even though on a different day the same buyer and seller might have negotiated a different selling price on the same property.

Estimating True Market Value

Since the true market value of any property is unknown and unknowable, the transfer value must be estimated. This can be accomplished by a licensed appraiser in the traditional walk-through appraisal, by broker price opinion or drive-by appraisal, or by an AVM. While each of these methods has cost, risk, advantages, disadvantages, and sources or error, the scope of this paper will be limited to predictive models called AVMs in this context.

Any or all of these value estimation methods could well be, and perhaps should be, subjected to the statistical scrutiny discussed here for AVMs. Also noteworthy is that AVMs employ a variety of modeling strategies, such as hedonic models, home price index (trending) models, explicit models, and hybrid models. Any of these valuation methods will produce an estimate of the probable transfer price in a free market exchange, and as such, has errors that can be scrutinized, quantified, and in turn predicted with a calculable degree of certainty.

Confidence Scoring

For the purpose of providing confidence scores and other control statistics, the accuracy of the method, algorithm, or mathematical model employed estimates the reference value of a future sale is critical. All valuation methods can be evaluated and the results reported using the techniques described below. Since AVMs are the subject of this paper, and if the reader is to follow the presentation fully, an appreciation of modeling in general, together with its limitations and sources of uncertainty or error, is helpful.

Selecting training data from the market segment and creating models using proprietary advanced methodologies to generate a number of competing models.

For all model types and forms of testing or performance validation, there is a consistent high level process of generating the model. In general, all models must be trained, validated, and then deployed to predict the outcome of future cases. The input data consists of a set of cases (transactions) together with a number of attributes or features that are available for substantially every case for which a value will be required. This availability constraint tends to limit the usable attributes to a lowest common set. A subset of the data is selected that includes known values of the target variable: The attribute for which the prediction is desired. In this case, the target variable is the transfer price on a selected past date. These cases are used to create (train) and validate the model.

The subset for which a result is known is further randomly divided into at least two new subsets; a training set and a test or validation set. The optimal model is determined using a variety of techniques which operate on the training set. To test the quality or performance of the model, the resulting equations or algorithms are applied to the validation set — which has never before been subjected to study (ignoring that the valuation for each case in the set is already known).

The comparison of the valuation to the reference valuation

The output valuations of the modeling algorithm (the predicted valuations) are compared to the previously known "real" valuations, by simply subtracting the predicted valuation from the real valuation for each record. The result of this subtraction is called the error or residual of each case. While this difference is often termed "variance" in this context, the preferred term is the "residual"; because the strict statistical definition of variance (the average of the sum of squared deviations from the mean) is an altogether different item. IntelliReal does not utilize the term "error", because that term would indicate that the real value is in fact known and invariant — when in fact it is not. It is the characterization of these residuals that will be used to create a confidence score.

Supervisory Statistics

Before understanding the statistical reasoning that allows the computation of the supervisory statistics, the reader must first examine the sources of these residuals (also called errors or uncertainties depending upon the context) to give the reader an appreciation of what a confidence score might measure and to further provide a sense of how good any model could be expected to perform.

Residuals arise from uncertainties or unpredictable variability in the inputs to the free market process, the data inputs to the model, and/or the inability of the model to accurately capture patterns that exist in the data.

One important cause of variability in valuations is natural transaction variability. There are many random factors affecting the final outcome of a free market transaction other than the attributes of the property as measured by the transfer price. These random factors may include the perceived value of each of the property's attributes which differ from buyer to buyer. The participation of any particular potential bidder is random, and each buyer and seller have personal attributes including motivations that may be unpredictably changing. So, depending on many uncontrolled factors in the buyer, the seller, and the market chance differences in the sale price of a particular property can be expected.

Another important cause of variability arises from errors in the input data itself. These imperfections are the result of data entry errors, errors resulting from the base data being manipulated by intermediate handlers of the data, and simply the unavailability of certain data in various geographies. In general, most available data does not contain all the attributes that actually determine the transfer price — and much data are erroneous.

Other input uncertainties arise from assumptions, generalizations, and techniques inherent in the modeling process itself. These attributes are the only variables that can be controlled in the modeling process. Even a model that accounts for all of the information in the data produces results that vary from the ultimate selling price due to uncertainty, random variability and missing information.

Quantifiable Confidence Score

The primary goal of a confidence score is to succinctly quantify the uncertainty in any given valuation.

Most statistical measures dealing with residuals are based upon a certain set of assumptions that must be met for the statistics to be meaningful. These assumptions are: That the residuals behave as random drawings from a fixed distribution with fixed location and variation.

Taken together these assumptions add up to a statement that the distribution of the tested variable must look like a normal distribution, the Gaussian or bell curve that would be familiar to anyone who has even a nodding acquaintance with statistics. Of course, the raw residuals of any AVM do not in any way resemble the bell curve.

Fortunately a simple, intuitive, and meaningful transformation of the raw residuals provide the normal distribution needed to proceed. That is, one can divide each residual by the known transfer price of its subject property producing a new measure called "percent residual", any reasonably good AVM should and usually will generate a distribution that is approximately normal. Fortunately, too, the distribution does not have to be exactly normal for the statistical measures to disclose needed insight. With one more logical observation one can draw a map to the final destination.

That observation is that the Gaussian distribution is also a well-defined probability density function. Since a histogram of IntelliReal's percent residual measure approximately follows one of a family of Gaussian distributions, the probability of the occurrence of a particular percent residual is equal to the area under the curve of its particular Gaussian distribution — a number that can be calculated or looked-up in a table.

In addition, the mathematical nature of the Gaussian distribution allows for one to fully describe the particular probability distribution using just two easy-to-calculate numbers: The mean (or average) of the percent residuals and the standard deviation of the percent residuals. With these two numbers, one can express the full probability profile of a set of percent residuals and determine where on the curve each case falls. This in turn allows for expressing the case's probability of having a particular percent residual.

By calculating these two numbers, IntelliReal discovers the best fit residual probability density function that completely describes the distribution and probability of residuals for each unique model. Since the mean and standard deviation of the probability density are based upon a sample of the data, each of these statistics is subject to sampling errors and must be taken into account in order to meet the requirement of statistical rigor.

The next step is to utilize this observation to calculate the specified statistic(s). Recall that the reference or "real" value for any of the valuations will be returned, primarily because they are future values from the perspective of the sales history on a particular property.

However, the modeling set can be used to compute how the model will perform on similar properties within its test set or a real estate market segment. The definition of "similar" is flexible, but could include geographical area considerations at granularity such as county, city, census tract, subdivision neighborhood, as well as other attributes such as property type, area under roof, year of construction, or other attributes in combination to create a meaningful, distinct, definable and statistically significant market segment.

IntelliReal creates a number of unique models for each of these segments (many thousands) and each model is considered to have its own well-defined probability density function of residuals defined by the mean and standard deviation of the percent residuals calculated from the model test set.

The individual supervisory statistics are calculated as follows:

ESD	The aforementioned knowledge of test results of the model is used to calculate the standard deviation of the residual probability density function for each particular model and report the percent residual that corresponds to the cutoff value for one standard deviation from the mean.
MPR	The Mean Percent Residual is the arithmetic average of the percent residuals calculated on the test set.
TSS	The Test Sample Size is a count of the number of EV in the test sample.
IFR	To determine the IFR, the confidence interval of the MPR is calculated and the confidence interval of the ESD at a given confidence for the degrees of freedom defined by the TSS. This in turn defines a family of probability density curves defined by these confidence intervals. The maximum inherent financial risk in a given EV is defined by the range of expected percent residuals corresponding to the desired confidence probability area under these distributions, which are in turn reverted to dollar values based upon the particular EV.

Pooling the risk:

The maximum pooled risk would then be the sum of the IFR for all EVs in the pool. This allows the user to selectively eliminate individual EVs to reduce the pooled risk. Pooling the risk in this way provides the most conservative (highest) total risk.

Summary

IntelliReal's proprietary technology reports valuations on a set of properties with a set of rigorous and useful information about how good each valuation is expected to be. The IntelliReal valuation system follows the steps outlined below:

1. Gathers and computes residuals from sample.
2. Converts raw residuals to percent residuals creating normal distribution.
3. Computes statistics on the percent residuals that define the normal probability density function of the percent residuals.
4. Because in fact, the true mean and variance (square of the standard deviation) of the population is unknown, IntelliReal requires the user to define the degree of confidence required and calculates interval width needed to build and capture the "actual" mean and variance with that degree of confidence.
5. The system computes the confidence interval of the mean and the confidence interval of the standard deviation concluding the center of our distribution of residuals fall between X and Y with a known confidence and that the shape of the curve can be wider or narrower within a known confidence.
7. The system defines the left extreme of the mean and constructs the widest normal curve within the confidence centered and captures the percent residual at a given confidence achieving the percent residual. The process is repeated for the right extreme mean, standard deviation and percent residual.
8. Results are then applied to the actual sale by noting that the maximum percent errors are percents of our valuation. The extreme values represent the maximum lower bound percent error times the valuation amount and the maximum upper bound percent error times represent the valuation amount. The difference between these two values is reported as the maximum error as the difference divided by two.

For more information about IntelliReal property intelligence solutions visit our website at
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Email info@intellireal.com

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