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# DATASET DESCRIPTION

## Problem Statement

We are trying to ***predict*** if a car bought at an auction by an auto dealer is a **Good buy** or a **Bad buy.**

## 1.1.1 Background

` When we go to buy a car at auto dealership we expect to get a good selection of car. Also we expect to trust in the condition of the car we are buying. These auto dealerships buy these cars from auctions and they have the same intent as us. However the problem which dealers face is with the cars which have some serious conditions and they turn out to be bad buys. These are called “kicks”, and this can happen due to variety of reasons.

## Motivation

It would greatly benefit both the auto dealers and the end buyers if there is a way to determine a car will be a kicked car. A simple analysis of the same is presented below.

*Note: All values are assumed values as per Auction Direct (a company which deals in second hand cars)*

|  |  |  |
| --- | --- | --- |
| **Legends** | **Amounts** | **Information** |
| Average number of cars bought and sold by a dealer | 15000 | By Auction Direct |
| %age kicked cars | 12.3 % | By Dataset |
| Number of kicked cars | 1845 | By Calculation |
| Average price of car sold | $ 10000 | By Auction Direct |
| Profit on good sale | $ 2000 | Average profit = 20% |
| Profit on bad sale (kicked car) | $ 500 | Due to repairs etc |
| Loss of potential profit | $ 1500$ |  |
| Total loss | **$ 2767500** |  |

This huge amount of potential profit can be converted into actual profit if there exists a model to predict a kicked car. Thus we chose this dataset.

## Feature Description

Dataset contained 32 unique features with 73,041 samples.

|  |  |
| --- | --- |
| **Field Name** | **Definition** |
| RefID | Unique (sequential) number assigned to vehicles |
| **IsBadBuy** | **Identifies if the kicked vehicle was an avoidable purchase** |
| PurchDate | The Date the vehicle was Purchased at Auction |
| Auction | Auction provider at which the vehicle was purchased |
| VehYear | The manufacturer's year of the vehicle |
| VehicleAge | The Years elapsed since the manufacturer's year |
| Make | Vehicle Manufacturer |
| Model | Vehicle Model |
| Trim | Vehicle Trim Level |
| SubModel | Vehicle Submodel |
| Color | Vehicle Color |
| Transmission | What type the transmission of the car Auto or Manual |
| WheelTypeID | The type id of the vehicle wheel |
| WheelType | The vehicle wheel type description (Alloy, Covers) |
| VehOdo | The vehicles odometer reading |
| Nationality | The Manufacturer's country |
| Size | The size category of the vehicle (Compact, SUV, etc.) |
| TopThreeAmericanName | Identifies if the manufacturer is one of the top three American manufacturers |
| MMRAcquisitionAuctionAveragePrice | Acquisition price for this vehicle in average condition at time of purchase |
| MMRAcquisitionAuctionCleanPrice | Acquisition price for this vehicle in the above Average condition at time of purchase |
| MMRAcquisitionRetailAveragePrice | Acquisition price for this vehicle in the retail market in average condition at time of purchase |
| MMRAcquisitonRetailCleanPrice | Acquisition price for this vehicle in the retail market in above average condition at time of purchase |
| MMRCurrentAuctionAveragePrice | Acquisition price for this vehicle in average condition as of current day |
| MMRCurrentAuctionCleanPrice | Acquisition price for this vehicle in the above condition as of current day |
| MMRCurrentRetailAveragePrice | Acquisition price for this vehicle in the retail market in average condition as of current day |
| MMRCurrentRetailCleanPrice | Acquisition price for this vehicle in the retail market in above average condition as of current day |
| PRIMEUNIT | Identifies if the vehicle would have a higher demand than a standard purchase |
| AcquisitionType | Identifies how the vehicle was aquired (Auction buy, trade in, etc) |
| AUCGUART | The level guarntee provided by auction for the vehicle (Green light - Guaranteed/arbitratable, Yellow Light |
| KickDate | Date the vehicle was kicked back to the auction |
| BYRNO | Unique number assigned to the buyer that purchased the vehicle |
| VNZIP | Zipcode where the car was purchased |
| VNST | State where the the car was purchased |
| VehBCost | Acquisition cost paid for the vehicle at time of purchase |
| IsOnlineSale | If the vehicle was sold online |
| WarrantyCost | Warranty price (term=36month and millage=36K) |

## Key Observations in data

* Redundant data: VehYear and VehAge mean the same thing
* Poor Quality of variables: PRIMEUNIT only 4.6% records were no
* Class Imbalance: 87.7 % Good Buys, only 13.3 % Bad buys
* There were no Manual transmission vehicles which were bad buys
* Only 0.11% records with RED category in AUCGUART

## Data Preprocessing

* Removed redundant features
* Removed features with more than 95% missing values
* Handles Null/Missing values
  + Continuous data: took average
  + Discrete data: created new category NULL
* Normalized all the continuous values in range [0, 1]
* We were left with 22 features to work with

# Results and Approach

## 2.1 Class Imbalance

There was class imbalance in dataset. We tried to address this by creating datasets using:

1. Oversampling with replacements
2. SMOTE (Synthetic Minority Oversampling Technique)
3. Undersampling of majority label

## 2.2 Feature Engineering

We tried multiple ways to get the best features for the predictions:

* + - * 1. We met an expert form Auction Direct and was recommended that best features will be :

VehOdo

VehicleAge

MMRCurrentAuctionCleanPrice

MMRCurrentRetailAveragePrice

Transmission

* + - * 1. We tried Chi Sqaure Ranks which gave us the following results

Unbalanced Data: Best Score for All 22 features

Balanced Data: Best Score for 17 features

* + - * 1. We tried Recursive Feature Elimination which gave us best features to be:

MMRAcquisitionAuctionAveragePrice

MMRAcquisitionretailCleanPrice

MMRCurrentAuctionCleanPrice

MMRCurrentAuctionAveragePrice

WarrantyCost

Recursive Feature Elimination did not consider discrete features. However it was correct with respect to MMRCurrentAuctionCleanPrice and MMRCurrentAuctionAveragePrice as they indeed were important features.

## 2.3 Dataset Samples

|  |  |
| --- | --- |
| ***Dataset1*** | UnBalanced Data |
| ***Dataset2*** | Balanced Data by Oversampling |
| ***Dataset3*** | Balanced Data by SMOTE |
| ***Dataset4*** | Balanced Data by Undersampling |
| ***Dataset5*** | Unbalanced Data; \*Selected features |
| ***Dataset6*** | Balanced Data by Oversampling; \*Selected features |
| \*Auction, VehicleAge, Make, Transmission, WheelType, VehOdo, Nationality, Size, TopThreeAmericanNames, MMRAcquisitionAuctionCleanPrice, MMRAcquisitionRetailAveragePrice | |

## 2.4 Classifiers Tried

|  |  |  |
| --- | --- | --- |
| J48 Pruned | J48-Unpruned | Logitic regression |
| Adaboost | LogitBoost | Bagging |
| Random Forest | Naïve Bayes | SVM with c = 1, 0.1 and 0.001 |
| 1,3 and 5-NN | Ensemble (Average Vote) |  |

## 2.5 Evaluation Criteria

For Balanced data

Accuracy is a good measure

For Unbalanced data

F measure and AUC ROC Score is a good measure

## 2.6 Results

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

Figure 11

Figure 12

Figure 13

Figure 14

Figure 15

Figure 16

Figure 17

Figure 18

# Detailed Analysis

If we look at the accuracy for balanced and unbalanced data. Ideally Accuracy is bad measure for Unbalanced data thus it should be at least less than balanced data. This is not the case, we hypothesize that classifiers are overfitting for balanced data.

Figure 19

This was made sure by looking at the results for bagging.

Figure 20

We can that for Bagging Accuracy of Balanced data is at par with that of Unbalanced data. We know that Bagging is known to reduce Variance thus reduce the tendency to overfit,

K Nearest neighbor

Figure 21

Figure 22

Figure 23

For Unbalanced data:

If we look at F Measure and ROC Area they tend to improve as we increase the k, this clearly shows that KNN is overfitting for k = 1

If we look at Accuracy for Balanced data we would have expected accuracy to increase as value of K increases however this does not happen. We hypothesized that KNN works best for K = 1 for Balanced data because of duplicate data points. These points are generated by oversampling with replacement. Also when we use SMOTE data synthetically generated is close to the original points in the sample. Thus we get these results.

Random Forest and Ensemble

Figure 24

Figure 24

Figure 25

Figure 26

Figure 27

If we look at Accuracy, F Measure and ROC for Balanced data both Ensemble and Random Forest do very well.

They can be considered to be best algorithms for synthetically generated balanced data

However if we look at unbalanced data F Measure and ROC Scores of these two are significantly less as compared to other classifiers like Decision trees and Logistic regression.

If we look at Naïve Bayes from figure we can clearly see that Naïve Bayes performs really bad. This happens because the fundamental condition of Naïve Bayes that features should be independent of each other is violated. Features in this dataset have clear dependence. For example Odometer reading and Age of Vehicle are related. Price of Vehicle, Vehicle Age and Warranty Cost are related.

Also Oversampling worked better than SMOTE and even better than Undersampling.

This shows that SMOTE cannot always give better results.

@TODO

Comments about decision trees

Comments about logistic regressionss

# Conclusion