# Investigating the Performance of Naive- Bayes Classifiers and K- Nearest Neighbor Classifiers

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# Presentation Outline

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- **Problem Statement and Motivation**

- **Literature Review**
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  - Naïve Bayes Classifier
  - K- Nearest Neighbor Classifier

- **Application of Classifiers**
  - **Credit Card Approval**
  - Experimental Results

- **Conclusion, Comments**

# Classification- Overview

- Goal of machine learning is to program computers to use example data or past experience to solve a given problem
- Classification is an application of machine learning
- Takes raw data and classifies it as belonging to a particular class based on required parameter set
- **Selection of right classification algorithm for machine learning is a big issue**

# Classification Scheme

- Selection of classifier depends on the application and the information available from that application

- Machine learning uses the theory of statistics in building mathematical model for classification, because the core task is making inference from a sample
  - Inference is a big deal

# Problem Statement

- Key Question?
  - Is there any way to generalize the classification techniques?
  - How to determine which technique is suitable for a specific problem?
  - How to improve a specific classifier by changing the parameters for a specific application?

- **Investigating the performance of the classifiers could be one solution to reach that goal.**

# Literature Review

- A wide range of algorithms are available for classification from Bayesian classifiers to more powerful Neural Network.
- Bayesian theory is basically works as a framework for making decision under uncertainty- a probabilistic approach to inference
- The probability of the future events could be calculated by determining the earlier frequency:
  - To see the future, look at the past
- The predictions are based completely on data culled from reality
  - The more data obtained, the better it works
- **Bayesian models are self-correcting**
  - **When data changed, so do the result**

# Literature Review (cont'd)

- In classification, Bayes rule is used to calculate the probabilities of the classes and it is a big issue how to classify raw data rationally to minimize expected risk.
- What if the dimension of the inputs is so high?
- Naïve Bayes classifier is one of the mostly used practical Bayesian learning methods.
  - Very effective when the dimensionality of the input is very high
- In some domains, it's performance is comparable to that of neural network
- K- Nearest Neighbor algorithm is the most basic instance-based method
  - Store the training instances in look up table and interpolate from these

# Bayesian Theory

- Most practical learning approach for most learning problems
  - Based on evaluating explicit probabilities for hypothesis
- Bayes theorem states that:

$$P(h \mid D) = \frac{P(D \mid h)P(h)}{P(D)}$$

  - *P(h)*: Prior probability of hypothesis *h*- prior
  - *P(D)*: Prior probability of training data *D*- Evidence
  - *P(D|h)*: Probability of D given *h*- Likelihood
  - *P(h|D):* Probability of *h* given *D*- Posterior probability

- The posterior probability of class $h_i$ is calculated and finally the best hypothesis ($h_{MAP}$) is selected- Maximum a posteriori probability

# Naïve Bayes Classifier

- It requires a small amount of training data to estimate the parameters necessary for classification
- Highly practical Bayesian learning method
  - Particularly suited when dimensionality of the input is so high
- Assumption:
  - The attribute values are conditionally independent given target value
  - It ignores the possible dependencies, say correlations among input
- Reduce a multivariate problem to a group of univariate problems

# K- Nearest Neighbor Classifier

- In parametric methods, we assume a model is valid for over the whole input space
  - Practically this assumption does not hold and we may incur a large error if it does not, solution?
- In nonparametric estimation we assume similar inputs have similar outputs.
  - It does not use any model to fit data
  - Based on memory/ training data.
  - Called instance-based/ memory based learning algorithm
- **KNN is instance-based classifier**

# KNN Classifier

- KNN is the most basic instance-based learning method
  - Result of new instance query is classified based on majority of KNN category
  - Assumption: The world is so smooth and functions changes slowly.
- Find the similar past instances from the training set
  - Uses suitable distance measure, k
- It is common to select k small and odd to break ties (typical value 1, 3, 5)
  - Larger k values help reduce the noisy points

# Implementation, Training and Testing

- Naïve Bayes and KNN classifiers are implemented to apply "Credit Card Approval" application.
- It is important for a bank/ financial institution to be able to predict in advance the risk associated with a loan
  - The probability that the customer will default and not the whole amount back
- Make sure that the bank will make profit and also to not inconvenience a customer with his/her financial capacity.
- Usually, the information about the customer includes income, savings, collaterals, profession, age, passed financial history and so forth

# Story Behind the Datafile

- The source of the datafile:
  - *ftp://ftp.ics.uci.edu/pub/machine-learning-databases/credit-screening*
- All attribute names and values have been changed to meaningless symbols to protect confidentiality of the data.
- Contains information about 671 applicants, whether they were approved or rejected.
- Each application is described by 9 attributes and classified as approved ("+") or rejected ("-")
- Each of the 9 attributes is a one letter symbol that is a shorthand for a more meaningful English language description.

# Attributes of the Datafile

| Attributes | Value |
|---|---|
| A1 | b, a |
| A2 | u, y |
| A3 | g, p, h |
| A4 | i, k, c, g, q, d, a, m, x, w, j, r, e, b |
| A5 | h, v, f, d, b, j, z, m, o |
| A6 | t, f |
| A7 | t, f |
| A8 | t, f |
| A9 | g, p, s |

# Experimental Results

- Training set examples: 470, Testing set example: 201
- Using Naïve Bayes classifier at first the tables are constructed from the attributes A1 to A9 using the training set
- Sample table is shown for attribute A9

Table: P(A9|accept) and P(A9|reject), Total accept: 215, Reject: 255

| A9 | Accept | Reject |
|---|---|---|
| g | 0.9581 | 0.9020 |
| p | 0.0047 | 0.0039 |
| s | 0.0372 | 0.0941 |

# Experimental Results (Naïve)

- The test set is classified based on the probabilities estimated from training set
- Each example is picked from testing set and then its class is predicted
- The predicted class is compared to the target value that is given in the test set.
- If mismatch, example becomes error

- The classification is shown in Table, Total testing example: 201

| Classification | Number | % |
|---|---|---|
| Correct | 176 | 87.57 |
| Incorrect | 25 | 12.43 |

# Results- KNN

- Different values of k are tried, for example k=1, 3, 5, 11, 51, 101
- Distance metric is calculated- Euclidian distance, for mismatch distance set to 1, else 0
- Based on the value of k, the k number of smallest distance training examples are picked up and calculate their corresponding accept or reject
- The larger value is the predicted value for this testing example and it is compared to the target value. If mismatch, example becomes error

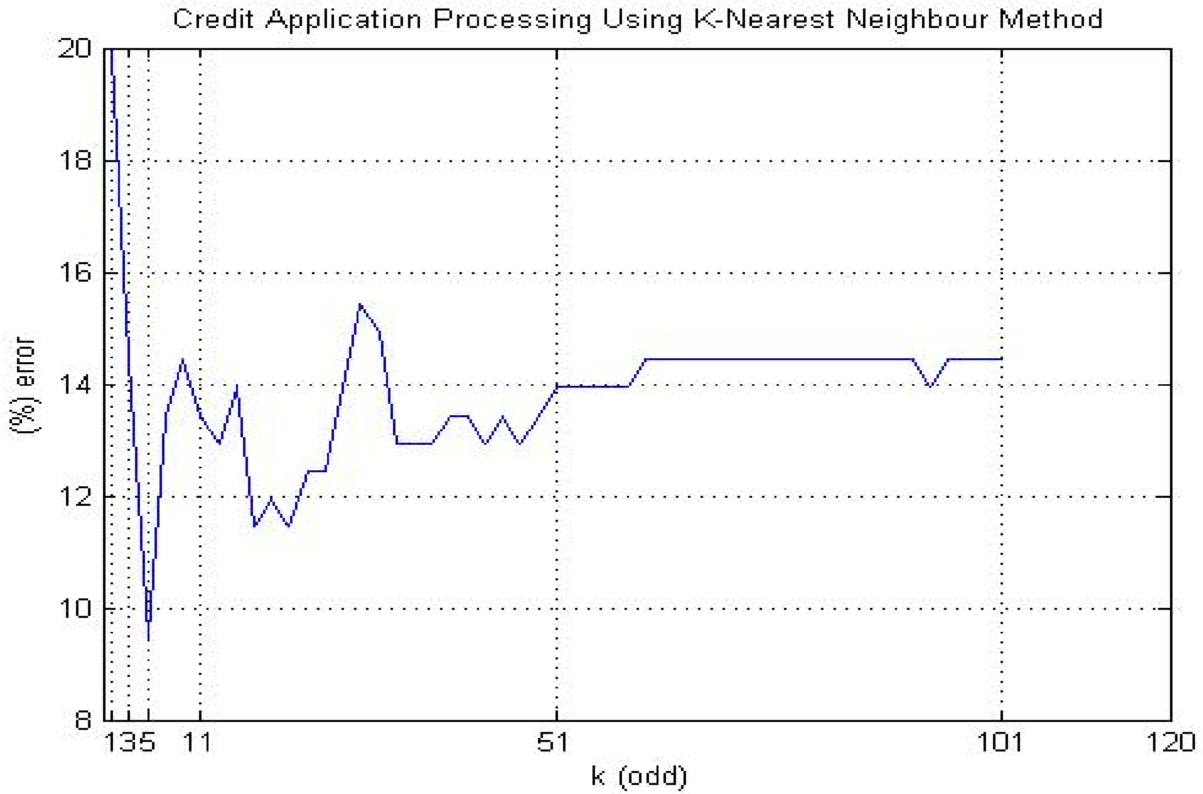
# Results- KNN (Cont'd)

- For different values of k, the testing set is classified
  - % of error for different k using KNN, testing example: 201

| K | Correct (%) | Incorrect (%) |
|---|---|---|
| 1 | 80.10 | 19.90 |
| 3 | 85.57 | 14.43 |
| **5** | **90.55** | **9.45** |
| 11 | 86.57 | 13.43 |
| 51 | 86.07 | 13.93 |
| 101 | 85.57 | 14.43 |

# Results- KNN (Cont'd)

- For different values of k, the testing set is classified
  - % of error for different k using KNN, testing example: 201



# Comparative Statement (KNN and Naive)

- Naïve Bayes and KNN classifier is compared in terms of correct classification and misclassification rate
- The classification is shown in Table, Total testing example: 201
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| Classifier | Correct Classification | | Misclassification | |
|---|---|---|---|---|
| | Number | % | Number | % |
| **Naïve** | 176 | 87.57 | 25 | 12.43 |
| **KNN (k=5)** | **182** | **90.55** | **19** | **9.45** |

# Conclusions (Bayesian)

- ‘Credit card approval’ application is selected for investigating the performance of widely used classifiers Naïve Bayes and KNN classifier.
- The result of Bayesian inference depends strongly on prior probabilities.
- Bayes theorem provides a principled way to calculate the posterior probability of each hypothesis given the training data and select the most probable one

# Conclusions (Naïve Bayes, KNN)

- Naïve Bayes classifier is applied to the credit card approval testing data set and found 12.43% error of classification
- Instance-based methods are sometimes referred to as “Lazy” learning methods, because they delay the process until a new instance must be classified
- In KNN, the selection of K is application dependent. To simplify the problem, it was fixed to odd number so that no tie can happen
- At K=5, the misclassification rate is 9.45% (minimum), so k=5 is the best value for the application

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Thanks for your patience

Questions?