Assignment 1 Analysis  
ML 7641

Ryan Wingate

RWingate8

GTID# 903453413

Implementation Strategy

For this assignment, I used the **scikit-learn** Python library, specifically, version 0.21.2. Additional dependencies include Jupyter Notebook (4.5.0) for convenient iteration and inline documentation of code, pandas (0.25.1) for data manipulation and cleaning, and Matplotlib (3.1.1) for charts and visualization.

The package manager I used was Anaconda (4.7.11), and the Python version was 3.7.4. For additional details on replicating the environment used for this assignment, reference the README included with this report.

Specific Algorithm Implementations

For each of the algorithms outlined below, I used the appropriate scikit-learn implementation.

Decision Tree

DecisionTreeClassifier, imported via:

• from sklearn import tree

Neural Network

MLPClassifier, imported via:

• from sklearn.neural\_network import MLPClassifier

Boosting

AdaBoostClassifier, imported via

• from sklearn.ensemble import AdaBoostClassifier

Support Vector Machine

NuSVC, imported via

• from sklearn.svm import NuSVC

*K*-Nearest Neighbors

KNeighborsClassifier, imported via

• from sklearn.neighbors import KNeighborsClassifier

Classification Problem Description

The problems I selected for this assignment are two famous datasets, both of which are designed for binary classification tasks. They have a similar number of features but differ in the number of available samples by a factor of roughly 50. This was intentional, so that I could experience the differences in training time between the various algorithms when the sample count varies widely.

Exact dataset preprocessing steps are available in Jupyter notebooks I provided in the submitted GitHub repository. A high-level overview of the data-preprocessing steps I completed:

• Discard irrelevant features,

• Fill nan values,

• Replace nominal and ordinal categorical data with numeric representations,

• Create dummy variables for all nominal categorical data with 3 or more possible categories (dropping one column, to prevent multicollinearity), and

• Normalize continuous data.

Following processing, for both datasets, I randomly extracted 20% of the data using scikit-learn’s train\_test\_split function. I used the remaining 80% as training data. I used 20% of the training data as a cross-validation set.

Titanic Dataset

The first dataset is the well-known Titanic Survival dataset, downloaded from <https://www.kaggle.com/c/titanic>. I consider the dataset interesting for a few reasons:

• Ability to successfully learn a variety of ML algorithms, despite its small size,

• Accuracy values empirically shown to be in the high 70s to mid 80s, which falls into the “interesting” range for most datasets,

• Subject matter provides interesting social commentary,

• Possibility of deriving interesting features from raw data (Deck from Cabin, for example),

• Widely considered by the data science community as being “interesting,”

• Personal desire to work with this dataset as a data science rite of passage.

The raw Titanic dataset consists of 1309 samples with 12 features.

Table 1: Raw Titanic dataset features and types.

|  |  |
| --- | --- |
| **Feature** | **Data Type** |
| PassengerId | Integer |
| Pclass | Category (3 value) |
| Name | String |
| Sex | Category (2 value) |
| Age | Float |
| SibSp | Integer |
| Par/Ch | Integer |
| Ticket | String |
| Fare | Float |
| Cabin | String |
| Embarked | Category (3 value) |
| Survived | Category (2 value) |

I discarded the **Ticket**, **Name**, and **PassengerID** features as non-useful data, and used **Cabin** (“C123”) to derive an 8-value classification **Deck** (“C”), where possible, then I discarded **Cabin** as well. **Sibs** and **Par/Ch** were the count of siblings and count of parents/children also on the boat, respectively. **Sibs**, **Par/Ch**, and **Pclass** were interpreted as Ordinal categories and left as integers in the data. **Survived**, **Pclass**, **Sex**, **Embarked**, and **Deck** were interpreted as Nominal categories and processed into dummy variables. **Age** and **Fare** were normalized.

Table 2: Processed Titanic dataset features and types.

|  |  |
| --- | --- |
| **Feature** | **Processed Data Type** |
| Pclass | Ordinal Category |
| Sex | Nominal Category (2) |
| Age | Float |
| SibSp | Ordinal Category |
| Parch | Ordinal Category |
| Fare | Float |
| Deck | Nominal Category (8) |
| Embarked | Nominal Category (3) |
| Survived | Nominal Category (2) |

Following processing, the dataset consisted of 1309 rows and 17 columns.

The task for the Titanic dataset is to predict whether or not a given passenger was likely to survive the Titanic disaster.

Adult Dataset

The second dataset is the Adult dataset, downloaded from <https://archive.ics.uci.edu/ml/datasets/Adult>. I consider the dataset interesting for a few reasons:

• Relatively large size is an interesting point of comparison with the small Titanic dataset,

• Accuracy values empirically shown to be in the high 70s to mid 80s, which falls into the “interesting” range for most datasets,

• Personal interest in the factors driving compensation,

• Availability of another, larger but very similar dataset (“Census,” 200K+ samples) with similar information and actual compensation values, should I need more, or more precise, data, and

• Widely considered by the data science community as being “interesting,” as evidenced by 1.6 million web hits since 2007, making it the second most popular dataset on the UCI ML dataset repository.

The raw Adult dataset consists of 46012 samples and 14 features.

Table 3: Raw Adult dataset features and types.

|  |  |
| --- | --- |
| **Feature** | **Data Type** |
| age | Integer |
| employment-type | Category (8) |
| fnlwgt | Float |
| education | Category (15) |
| education-num | Integer |
| marital-status | Category (7) |
| occupation | Category (14) |
| relationship | Category (6) |
| race | Category (5) |
| sex | Category (2) |
| capital-gain | Float |
| capital-loss | Float |
| weekly-hours | Float |
| native-country | Category (41) |
| compensation | Category (2) |

To reduce the overall dimensionality of the dataset, I also discard **fnlwgt**, **marital-status**, **relationship**, **capital-gain**, **capital-loss**, and **native-country**. I also discard **education-num** as being redundant with **education**. I exclude all samples that do not have a **workclass** or **occupation** assigned, or which have a **workclass** that has value “Without-pay,” as all of these would be highly correlated with low income and therefore uninteresting

Due to the large number of available categories, I map:

• **education** to 6 categories from 15,

• **employment-type** to 3 categories from 8, and

• **occupation** to 13 from 14.

**Employment-type**, **occupation**, and **race** were interpreted as Nominal categories and processed into dummy variables. **Age** and **weekly-hours** were normalized.

Table 4: Processed Adult dataset features and types.

|  |  |
| --- | --- |
| **Feature** | **Processed Data Type** |
| age | Integer |
| employment-type | Nominal Category (3) |
| education | Ordinal Category (6) |
| occupation | Nominal Category (13) |
| race | Nominal Category (5) |
| sex | Nominal Category (2) |
| weekly-hours | Float |
| compensation | Nominal Category (2) |

Following processing, the dataset consisted of 46,012 rows and 24 columns.

The task for the Adult dataset is to predict whether a given person earns more than $50K.

Hyperparameter Tuning

Decision Tree

Titanic

Figure 1-1 shows the learning curve for a default decision tree trained on the Titanic dataset. The model exhibits the high variance characteristic of an overfit. This is expected as the default hyperparameters allow the decision tree to grow arbitrarily complex.

A close up of a map

Description automatically generated

Fig 1.1: Learning curve for a decision tree with default hyperparameters, except for the split quality criterion.

Adult

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Forthcoming Book

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Agrawal, A.; Batra, D.; and Parikh, D. 2016. Analyzing the Behavior of Visual Question Answering Models. arXiv preprint. arXiv:1606.07356v2 [cs.CL]. Ithaca, NY: Cornell University Library.

Published Book

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Paper Presented at Meeting and Published in Proceedings

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Scholarly Society Technical Report

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