**MACHINE LEARNING PROJECT**

**Milestone #1**

**A. Dataset Building and Normalization**

1. **Source of Dataset**

* UCI Machine Learning Repository – Center for Machine Learning and Intelligent Systems http://archive.ics.uci.edu/ml/datasets/Diabetic+Retinopathy+Debrecen+Data+Set
* Dr. Balint Antal, Department of Computer Graphics and Image Processing Faculty of Informatics, University of Debrecen, 4010, Debrecen, POB 12, Hungary antal.balint '@' inf.unideb.hu
* Dr. Andras Hajdu, Department of Computer Graphics and Image Processing Faculty of Informatics, University of Debrecen, 4010, Debrecen, POB 12, Hungary hajdu.andras '@' inf.unideb.hu

1. **Description of Dataset**

Number of original features: 20

Sample size: 1151

This dataset contains features extracted from the Messidor image set to predict whether an image contains signs of diabetic retinopathy or not. All features represent either a detected lesion, a descriptive feature of a anatomical part or an image-level descriptor. The underlying method image analysis and feature extraction as well as our classification technique is described in Balint Antal, Andras Hajdu: An ensemble-based system for automatic screening of diabetic retinopathy, Knowledge-Based Systems 60 (April 2014), 20-27.

1. **Name, Description and type of each feature**

A Result of Quality Assessment-----------------------------------------------------------------------------------Real = [0 - 1]

B Result of Pre-screening------------------------------------------------------------------------------------------ Real = [0 - 1]

C-H Results of MA detection----------------------------------------------------------------------------------------- Real = [0 - 1]

I-P Results of MA detection for exudates------------------------------------------------------------------------ Real = [0 - 1]

Q Euclidean distance of the center of the macula and the center of the optic disc----------------- Real = [0 - 1]

R The diameter of the optic disc--------------------------------------------------------------------------------- Real = [0 - 1]

S The binary result of the AM/FM-based classification----------------------------------------------------- Real = [0 - 1]

T Class label--------------------------------------------------------------------------------------------Binomial ⊆ [false, true]

The attributes were set from Numerical to Binomial, from Nominal to Numerical, and then normalized to attain a linear and more robust relationship.

1. **Processed/Normalized dataset**

https://www.dropbox.com/s/ukzgzmqoz1hm9ay/Milestone-1-diabetic-retinopathy-normalized.xlsx?dl=0

1. **Number of features that were removed and the reason for their removal**

None

**B. Performance of kNN, Decision Trees, Bayesian Network on Different Feature Sets**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 61.25 % | 68.20 % | 63.34 % | 67.16 % |
| **kNN (k=3)** | 62.29 % | 71.42 % | 64.47 % | 64.64 % |
| **kNN (k=5)** | 63.16 % | 72.20 % | 66.20 % | 65.68 % |
| **kNN (k=7)** | 64.73 % | 70.89 % | 68.03 % | 67.33 % |
| **kNN (k=9)** | 63.94 % | 70.89 % | 65.94 % | 68.20 % |
| **Decision Trees** | 53.69 % | 54.39 % | 54.39 % | 53.26 % |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 60.30 % | 65.68 % | 65.07 % | 59.77 % |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 1 – Accuracy**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 0.225 | 0.365 | 0.267 | 0.341 |
| **kNN (k=3)** | 0.247 | 0.429 | 0.291 | 0.292 |
| **kNN (k=5)** | 0.265 | 0.446 | 0.326 | 0.315 |
| **kNN (k=7)** | 0.296 | 0.420 | 0.362 | 0.348 |
| **kNN (k=9)** | 0.281 | 0.422 | 0.321 | 0.366 |
| **Decision Trees** | 0.069 | 0.030 | 0.093 | 0.017 |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 0.233 | 0.322 | 0.313 | 0.201 |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 2 – Kappa**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 0.500 | 0.500 | 0.500 | 0.300 |
| **kNN (k=3)** | 0.660 | 0.736 | 0.675 | 0.684 |
| **kNN (k=5)** | 0.680 | 0.771 | 0.703 | 0.713 |
| **kNN (k=7)** | 0.694 | 0.761 | 0.717 | 0.725 |
| **kNN (k=9)** | 0.696 | 0.767 | 0.708 | 0.731 |
| **Decision Trees** | 0.549 | 0.548 | 0.565 | 0.529 |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 0.689 | 0.678 | 0.700 | 0.652 |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 3 – AUC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 64.40 % | 71.60 % | 66.67 % | 69.19 % |
| **kNN (k=3)** | 65.83 % | 75.09 % | 68.23 % | 67.59 % |
| **kNN (k=5)** | 66.91 % | 76.89 % | 70.48 % | 69.22 % |
| **kNN (k=7)** | 68.60 % | 75.75 % | 71.97 % | 71.10 % |
| **kNN (k=9)** | 67.88 % | 76.85 % | 70.02 % | 72.15 % |
| **Decision Trees** | 56.27 % | 53.80 % | 58.24 % | 53.54 % |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 81.56 % | 73.28 % | 74.59 % | 64.45 % |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 4 – Precision**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 60.39 % | 66.45 % | 61.87 % | 68.74 % |
| **kNN (k=3)** | 60.23 % | 69.07 % | 61.87 % | 64.16 % |
| **kNN (k=5)** | 60.56 % | 68.09 % | 62.52 % | 63.67 % |
| **kNN (k=7)** | 61.87 % | 66.45 % | 65.14 % | 64.81 % |
| **kNN (k=9)** | 60.88 % | 64.65 % | 62.68 % | 65.20 % |
| **Decision Trees** | 57.28 % | 99.67 % | 49.75 % | 90.34 % |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 32.57 % | 55.65 % | 51.88 % | 54.01 % |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 5 – Recall**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Classifier** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | 62.33 % | 68.93 % | 64.18 % | 68.97 % |
| **kNN (k=3)** | 62.91 % | 71.95 % | 64.89 % | 65.83 % |
| **kNN (k=5)** | 63.57 % | 72.22 % | 66.26 % | 66.33 % |
| **kNN (k=7)** | 65.06 % | 70.79 % | 68.38 % | 67.81 % |
| **kNN (k=9)** | 64.19 % | 70.22 % | 66.15 % | 68.56 % |
| **Decision Trees** | 56.77 % | 69.88 % | 53.66 % | 67.23 % |
| **Bayesian Network**  **(e.g. Naïve Bayes)** | 46.55 % | 63.26 % | 61.20 % | 58.77 % |
| **MLP**  **(Training Cycles = 10)** |  |  |  |  |

**Table 6 – F-Measure**

**C. Discussion of Results**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Classifier** | **Performance Measures** | **Complete Feature Set** | **Feature Selection using Forward Search** | **Feature Selection using Backward Search (Backward Elimination)** | **Top 9 features (with higher coefficients) based on 3 Components of Principal Components Analysis (PCA)** |
| **kNN (k=1)** | **Accuracy** | 61.25% | 68.20% | 63.34% | 67.16% |
| **Precision** | 64.40% | 71.60% | 66.67% | 69.19% |
| **Recall** | 60.39% | 66.45% | 61.87% | 68.74% |
| **F-Measure** | 62.33% | 68.93% | 64.18% | 68.97% |
| **AUC** | 0.5 | 0.5 | 0.5 | 0.3 |
| **Kappa** | 0.225 | 0.365 | 0.267 | 0.341 |
| **kNN (k=3)** | **Accuracy** | 62.29% | 71.42% | 64.47% | 64.64% |
| **Precision** | 65.83% | 75.09% | 68.23% | 67.59% |
| **Recall** | 60.23% | 69.07% | 61.87% | 64.16% |
| **F-Measure** | 62.91% | 71.95% | 64.89% | 65.83% |
| **AUC** | 0.66 | 0.736 | 0.675 | 0.684 |
| **Kappa** | 0.247 | 0.429 | 0.291 | 0.292 |
| **kNN (k=5)** | **Accuracy** | 63.16% | 72.20% | 66.20% | 65.68% |
| **Precision** | 66.91% | 76.89% | 70.48% | 69.22% |
| **Recall** | 60.56% | 68.09% | 62.52% | 63.67% |
| **F-Measure** | 63.57% | 72.22% | 66.26% | 66.33% |
| **AUC** | 0.68 | 0.771 | 0.703 | 0.713 |
| **Kappa** | 0.265 | 0.446 | 0.326 | 0.315 |
| **kNN (k=7)** | **Accuracy** | 64.73% | 70.89% | 68.03% | 67.33% |
| **Precision** | 68.60% | 75.75% | 71.97% | 71.10% |
| **Recall** | 61.87% | 66.45% | 65.14% | 64.81% |
| **F-Measure** | 65.06% | 70.79% | 68.38% | 67.81% |
| **AUC** | 0.694 | 0.761 | 0.717 | 0.725 |
| **Kappa** | 0.296 | 0.42 | 0.362 | 0.348 |
| **kNN (k=9)** | **Accuracy** | 63.94% | 70.89% | 65.94% | 68.20% |
| **Precision** | 67.88% | 76.85% | 70.02% | 72.15% |
| **Recall** | 60.88% | 64.65% | 62.68% | 65.20% |
| **F-Measure** | 64.19% | 70.22% | 66.15% | 68.56% |
| **AUC** | 0.696 | 0.767 | 0.708 | 0.731 |
| **Kappa** | 0.281 | 0.422 | 0.321 | 0.366 |
| **Decision Trees** | **Accuracy** | 53.69% | 54.39% | 54.39% | 53.26% |
| **Precision** | 56.27% | 53.80% | 58.24% | 53.54% |
| **Recall** | 57.28% | 99.67% | 49.75% | 90.34% |
| **F-Measure** | 56.77% | 69.88% | 53.66% | 67.23% |
| **AUC** | 0.549 | 0.548 | 0.565 | 0.529 |
| **Kappa** | 0.069 | 0.03 | 0.093 | 0.017 |
| **Bayesian Network (e.g. Naïve Bayes)** | **Accuracy** | 60.30% | 65.68% | 65.07% | 59.77% |
| **Precision** | 81.56% | 73.28% | 74.59% | 64.45% |
| **Recall** | 32.57% | 55.65% | 51.88% | 54.01% |
| **F-Measure** | 46.55% | 63.26% | 61.20% | 58.77% |
| **AUC** | 0.689 | 0.678 | 0.7 | 0.652 |
| **Kappa** | 0.233 | 0.322 | 0.313 | 0.201 |
| **MLP (Training Cycles= 10)** | **Accuracy** | 70.46% | 73.41% |  | 69.5% |
| **Precision** | 79.9% | 80.98% |  | 79.09% |
| **Recall** | 60.24% | 67.1% |  | 59.23% |
| **F-Measure** | 68.21% | 72.66 |  | 66.66% |
| **AUC** | 0.797 | 0.8 |  | 0.776 |
| **Kappa** | 0.416 | 0.47 |  | 0.396 |

**Table 7 – All Performance Measures**

Based on the results, the following characteristics were observed:

1. In the Complete Feature Set, kNN (k=7) was the best classifier.
2. In the Feature Selection Forward Search, kNN (k=5) was the best classifier.
3. In the Feature Selection Backward Search, kNN (k=7) was the best classifier.
4. In PCA, kNN (k=9) was the best classifier.

This shows that overall, kNN (k=7) was the best classifier.

**D. Problems Encountered**

None