Automatic Detection of Blood Vessels From Retinal Images Using Convolutional Neural Network

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A genre of a song can be estimated based on its music signal's characteristics . In this work we use two classifiers, Bayes Classifier and Logistic classifier, to classify songs into one of ten possible genres. The two classifiers are trained against the training data and their performance is compared against each other. In this work we show that both classifiers perform much better compared to random guess. However their capability to classify all songs is clearly limited the accuracy for both classifiers being around 60%.

I. INTRODUCTION

Several studies have used neural networks in automatic blood vessel detection from retinal images. These methods can be roughly divided into two groups: patch based segmentation of blood vessels and methods based on fully convolutional neural networks. In patch based image segmentation the image is traversed through pixel by pixel. For each pixel a patch of fixed size, centered at the pixel, is taken from the image and fed to neural network that classifies the pixel into certain class. The advantages of patch based method are their simplicity and ease of training. However, their main disadvantage is the high computational load when doing inference, because for each pixel separate patch is taken that is fed to neural network. Fully convolutional neural network are the current state of the art method in image segmentation. The huge advantage of fully convolutional neural network is the huge speed up compared to patch based methods, because the whole image is fed only once as whole to the neural network. In addition there is more contextual information available in fully convolutional neural networks because the whole image is processed at once instead of using smaller patches.

In classification problem the object is classified into a certain class based on it's characteristics called features. A linear classifier does the classification by making a linear combination of the features and converting the resulting value into a class or a probability that the object belongs to given class. In logistic regression the feature vector of the object is transformed into a probality by taking a linear combination of features and mapping the result into interval $[0, 1]$ using a sigmoid function. The Bayes-classifier in contrast assumes that the feature vector is drawn from a multidimensional-Gaussian distribution. The posterior probability of the object belonging to a certain class is then obtained as a product of the prior of the class and the probability to sample the given feature vector from the multidimensional Gaussian distribution.

The paper is organized as follows. The used data-set and the computational methods are described in detail in Sec. II. In Sec. **??** the results for the both logistic regression- and Bayes-classifier are given. Sec. III is a summary of the results and the differences between the two classifiers are discussed.

II. USED DATA-SET AND COMPUTATIONAL METHODS

A. Used data-set

The data-set consisted of 4363 songs and was divided into training and test data sets including every third song to test set and rest of the songs to training set. Each song contained 264 features and the songs were labeled to 10 different categories. The gatecories were: 1 Pop Rock, 2 Electronic, 3 Rap, 4 jazz, 5 Latin, 6 RnB, 7 International, 8 Country, 9 Reggae and 10 Blues. The musical characteristics of the songs were packed to a feature vector of length 256. The first 48 elements in the feature vector can be associated to timbre, the next 48 elements to pitch and the final 168 features to rhythm. The distribution of the features resembled in most cases a Gaussian distribution or a skew symmetric distribution. This is illustrated figures **??**a and **??**b.

B. Computational methods

In this work two different methods were used to classify the songs to different genres. First method is logistic-regression method in which the logistic-loss is minimized iteratively using the gradient descent method. The other method used is the Bayes-classifier which classifies the song to certain category that gives the maximum posterior probability with respect to label i. Both methods are described below in detail. In addition we studied the effect of feature extraction and for that purpose we used principal component analysis method to exclude features with little impact.

1. Logistic-regression

2. Principal component analysis

TABLE I: Confusion matrix corresponding to classification obtained using logistic regression. The column direction indicates the true value and the row direction is the predicted value. The labels 1 . . . 10 are the ten music genres specified in section II A.

	1	2	3	4	5	6	7	8	9	10
1	652	35	7	9	4	10	1	3	2	3
2	57	130	9	4	2	1	0	2	2	0
3	14	9	82	4	2	1	0	0	1	0
4	25	3	0	43	0	2	0	1	0	2
5	38	4	1	5	11	1	1	0	3	0
6	37	6	12	8	4	25	0	0	0	0
7	34	6	1	2	2	4	3	1	0	0
8	50	0	0	1	2	1	0	9	0	0
9	2	5	0	2	1	0	0	8	0	27
10	21	0	0	6	1	2	0	1	0	3

III. CONCLUSIONS

In this work we used logistic-regression and Bayes-classifier to classify songs to different genres based on the music signal's characteristics. For logistic regression the obtained accuracy for test set was 0.67 and logistic-loss 0.27. For the external data set used the obtained accuracy and logistic-loss were 0.65 and 0.178 respectively in the case of logistic-regression. For the Bayes-classifier the obtained accuracy and logistic-loss were 0.53 and 0.33 for the test-data and for external data set 0.32 and 1.17 respectively. According to obtained results both classifiers performed clearly better than random guess, but remained far from perfect classification. From the two classifiers used the logistic-regression classifier performed clearly better. The logistic classifier also generalized much better to completely new data giving nearly equal performance for test data set and external data set.