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Advances in Knowledge-Based Technologies

Proceedings of the Master and PhD Seminar Winter term 2009/10, part 1

Softwarepark Hagenberg
SCCH, Room 0/2
4 November 2009

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Program

13:00–15:00 Session 1 ***(Chair: Roland Richter)***

13:00 Henrike Stephani:
Evaluation of Feature Selection Methods for Terahertz Spectra on the example of a Wavelet Based Method

13:30 Wolfgang Heidl:
Men Take Higher Risks: Test Design and Pilot Study Results for a Visual Inspection Task

14:00 Jean-Luc Bouchot:
The Fast Discrepancy Norm - An Introduction

14:30 Johannes Himmelbauer:
Correlation of Time Series based on H. Weyl's Discrepancy Norm with Applications to Computational Finance

Evaluation of Feature Selection Methods for Terahertz Spectra on the Example of a Wavelet Based Method

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Abstract

In security control Terahertz (THz) technology is used to detect chemicals or weapons on people with as little physical contact as possible. This is possible due to the fact that chemicals have characteristic peaks in this wavelength while metals are absorbing and cloth are non absorbing. THz measurements in this area result in so called hyperspectral images that contain a whole spectrum of hundreds of values in each pixel. To make interpretation possible most researchers use classification techniques [1], [2], [3] and by that include informational content from all measured channels.

Both for reasons of computational efficiency as well as to improve the result, it is advisable to perform feature selection before applying a classification algorithm [4], [5]. Automatic feature extraction is usually done on the basis of statistical entropy values. To calculate them all data has to be known beforehand. Incrementally acquiring and comparing data is therefore difficult.

We propose a feature selection method that is applicable on arbitrary THz spectra. It takes the typical shape of the characteristic information into account by using wavelet basis function as filters to gain a reduced set of coefficients that can be used for succeding processing. furthermore propose a simulation scheme for spectra that have the same kind of basic shape, noise, and characteristic peaks as THz spectra. By controlling the position and depth of the characteristic peaks we can compare any set of features calculated from the full spectrum with the ground truth of the simulation. We are thereby able to evaluate proposed feature selection methods by calculating a detection rate for the characteristic peaks contained in a spectrum.

We prove our proposed wavelet based feature selection method to have as high a peak detection rate as one would gaind by using the whole spectrum. The features are reduced from 512 down to 32 coefficients. The computational costs for hyperspectral classification are thus improved and further channel-wise image processing is made feasible. These theoretical results are furthermore applied to a set of hyperspectral THz measurements of 6 different chemical compounds. The feature seletion method is applied to them and an hierarchical clustering performed on the basis of these reduced features as well as on the basis of the full spectra. The clustering result from both feature sets are comparably good.

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Men Take Higher Risks: Test Design and Pilot Study Results for a Visual Inspection Task

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Abstract

Among manufacturing companies there is a widespread consensus that women are better suited to perform visual quality inspection, having higher endurance and making decisions with better reproducibility. We will analyze these gender-related differences by modeling operator decisions with machine learning classifiers. The analysis will be based on data gathered during tests with 100 subjects asked to rate synthetic images based on a predefined set of rules.

We have conducted a pilot study to establish the test setup. Design and analysis of the tests has been based on the decision boundary modeled by the ground truth rule set. We show how the test images have been sampled to achieve reasonable coverage of the relevant area around the decision boundary. We present pilot study results that demonstrate the soundness of our approach along with a simple measure for risk propensity of subjects. On the 17 subjects participating in the pilot study this measure displayed a very significant gender difference of $d = 2.01$.

1. Introduction

Quality control typically involves the visual inspection of products at the end of a production line. This task is quite often done exclusively by women. Their job is to make a quick good/bad decision and to sort out the bad products. Manufacturing companies often argue that women have more endurance in performing this task and also make decisions with better reproducibility.

Our work aims at a mathematical description of decision-making processes in men and women during quality inspection tasks. It is focused on highlighting and quantifying the differences of male and female decision-making processes. The major goals are to:

1. Provide an answer to the question whether the gender-related differences in decision-making can be reproduced mathematically for visual inspection tasks.

2. Analyze the quantitative and structural nature of those variations in human decision-making.

The analysis will be based on data gathered during thoroughly designed and controlled tests with approximately 100 subjects, equally split between women and men. Each subject is asked to rate a large number of synthetic images according to a predefined set of rules.

To make the test a meaningfull instrument for analyzing differences between participants, controlling the level of difficulty plays a crucial role. The difficulty of the test is assessed by the number of errors made by the subjects. If the level of difficulty is too low, subjects will make a very small number of errors and little can be learned about their individual decision behavior, since they essentially reproduce the ground truth rules. Conversly, if the level of difficulty is chosen too high, decisions degrade into pure guessing, preventing identification of systematic differences.

In order to gain detailed insight into the decision behaviour not only overall difficulty but the distribution of test images over the decision space needs to be controlled. We utilize the notion of decision boundary established in the field of machine learing (e.g. (Hastie et al., 2008)) and propose to assess the level of difficulty of test images by their distance to the decision boundary. From this point of view images with reasonable difficulty lie within a *tube of interest* around the decision boundary.

For the pilot study we model the decision space and the decsion boundary based on the ground truth rules. We show how test images have been sampled to cover the tube of interest and analyze the results of pilot study

runs in this framework. The results provide strong evidence for the soundness of our setup.

Finally we present a measure related to risk propensity that is based on the confusion statistics between subject and ground truth ratings. On the 17 subjects participating in the pilot study the effect size (Cohen, 1988) of gender difference concerning this measure is $d = 2.01$, where

$$d = \frac{\mu_M - \mu_F}{\sigma'} \tag{1}$$

$$\sigma' = \sqrt{(\sigma_M^2 + \sigma_F^2)/2} \tag{2}$$

and μ, σ are the mean value and standard deviation of male and female scores, respectively.

2. Study Setup

Since our analysis will be of exploratory nature and the expected effect size is unknown, the well-established tool of statistical power analysis (Cohen, 1988) is of little utility for determing the required number of participants. We have therefore resorted to litrature surveying sex difference studies (Maccoby & Jacklin, 1974; Hyde, 2005). The number of participants has been chosen to $N = 100$, which is close to the median of the surveyed studies.

The main recruitment channel for subjects have been advertisements on the blackboards of several adult education centers. In a tradoff between homogenety and availabiltiy of subjects, acceptence has been limited to people aged 20 to 45, having no tertiary education and no experience with visual quality inspection.

The test will be run in a dedicated room with four to six subjects in parallel (Figure 1). Human computer interaction is kept as simple as possible and has been limited to TFT-Screens and a simple input device with two push buttons for rating parts good or bad.

Subject briefing has been video-taped and is played back synchronously on each screen to provide for identicall viewing conditions. The briefing includes remarks on the overall procedure and detailed instructions on how tho rate the parts. After the video briefing reference cards summarizing the rules are handed out and questions can be asked by the participants.

Then the visual inspection task is started. Figure 2 shows the GUI presented during this task. While there is no time limit on individual images, a certain overall throughput has to be reached. Within the test duration of 30 minutes, 600 images have to be rated. The throughput of 3 seconds per image has been determined during initial pilot runs.

Figure 1. Booths are used during participant tests to minimize distractions. The user interface is limited to a TFT-Screen and a dedicated input device with two push buttons.

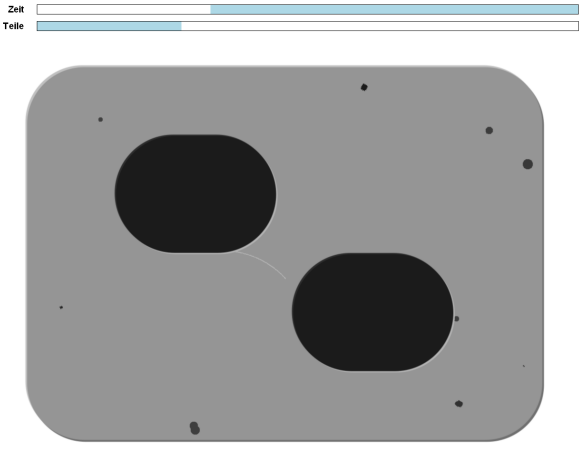

Figure 2. User interface presented during the experiments. Progress bars are displayed on top of the images to be classified. The upper bar indicates the remaining time while the lower bar shows the amount of completed images. Participants are urged to keep the completed parts up with the remaining time.

3. Inspection Task

4. Pilot Study Analysis

5. Results

6. Conclusion

Acknowledgments

This work has been supported by Austrian FFG grant No. 318113. It reflects only the authors' views.

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Technical Report
SCCH–TR–0950

Correlation of Time Series based on H. Weyl's Discrepancy Norm with Applications to Computational Finance

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Abstract — In finance most approaches for portfolio management are based on the concept of risk minimization by diversification, i.e. the aim is to select assets or asset classes that show possibly no (most of all positive) dependencies among each other. Pearson's correlation is the most popular similarity measure that is used to measure these dependencies among different assets. However, this measure is based on the assumption that the time series follow a normal distribution, whereas in practice asset returns tend to be negatively skewed and with an excess kurtosis. As a consequence extreme events are not handled in a proper way. Moreover Pearson's correlation applied to time series of asset returns show instabilities with respect to time as well as time-shifts. The paper focuses on the development of a novel dependency measure for time series based on Hermann Weyl's discrepancy concept which relies on the evaluation of partial sums. Most of all the fact that due to its monotonic behavior the discrepancy norm behaves very well with respect to horizontal shifts (i.e. time delays) was the motivation to introduce a dependency measure for time series based on the discrepancy norm. After the deduction of the proper similarity measure first experiments with artificial time series are presented and the statistical behavior of the discrepancy correlation is analyzed.

The Fast Discrepancy Norm: An Introduction

Jean-Luc Bouchot

November, 4^{th} 2009

In the field of computer vision, many problems are related to a problem of distance. For instance, when we want to do image registration, we often need to match keypoints. While many keypoints detector have been proposed for image registration and recognition [1] [2], we still have to match them the best way we can. Many registration problem have been proposed with pixel based method [[3], [4]], or histogram based method. Those methods have shown sometimes really bad results; alignment, scaling, rotation are the most common problems encountered. We want to introduce a novel method for image registration based on Herman Weyl's discrepancy norm. The idea comes from [5]. We have shown that this norm has several interesting properties. In particular we have proven that this norm is monotonic. We wan write the original discrepancy norm, in a discrete space:

$$\text{with } F(a) = \sum_{i=-\infty}^{a} f_i$$
$$||f||_D = \max_a F(a) - \min_a F(a) \tag{1}$$

Unfortunately the discrepancy norm is somehow slow and hard to solve. Therefore we want to introduce a new version which we call the fast discrepancy norm, based on p-norm, and with the same properties but faster:

$$||f||_{\underset{D_p}{fast}} = \frac{1}{p} \ln \left(\left(\sum_{a=-\infty}^{+\infty} \exp^{pF(a)} \right) \cdot \left(\sum_{a=-\infty}^{+\infty} \exp^{-pF(a)} \right) \right) \tag{2}$$

The introduction of the exponential is something important to gain speed for two main reasons:

1. Image registration can be done with a convolution (exponential transforms products into sums)

2. The power, coming from the p-norm idea, can be replaced by a product

In terms of complexity we have proven that the fast discrepancy norm is better. It needs only $O(n\log(n))$ to compute whereas the traditional discrepancy norm would compute in $O(n^2)$.

Our new definition holds. Indeed for bigger p we get closer to the original version of the discrepancy norm.

In order to prove all we have said here, we will provide several mathematical proofs as well as examples. These examples will also show how the fast discrepancy norm is better suited to face noise. Other numerics will be provided to show the time we gained using this new idea.

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