Gottfried Wilhelm Leibniz Universität
Hannover, Germany

Studienarbeit

Statistical Monitoring of Image Data

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Mentor: M. Sc.
Examiner: Prof. Dr.
Examiner: Prof. Dr.

June 17, 2021

The name of your protocol

Here write the background of your research.

Here write your research question.

Objectives
Here write your objectives in this master thesis.

Tasks and Timetable

- The first and the second months: literature review
- The second to the forth months: empirical study
- In the third month: mid-term reflection
- The forth and the fifth month: tuning the model(s)
- The sixth month: writing and presenting thesis
- The end: evaluation of performance (including thesis and presentation)

Tools
Algorithm:
Programming language: e.g., Python
Framework: e.g., Tensorflow
Datasets: e.g., Stanford drone datasets

PLEASE KEEP THIS PROTOCOL WITHIN ONE PAGE!

Statutory Declaration

I, YOUR NAME, declare that this master's thesis, and the work indicated herein have been composed by myself, and any sources have not been used other than those specified. All the consulted published or unpublished work of others have been clearly cited. I additionally declare that the work and master's thesis have not been submitted for any other previous degree examinations.

Xilin Huang Hannover, June 17, 2021

Eidesstattliche Erklärung

Ich, YOUR NAME, erkläre hiermit, die Arbeit selbstständig verfasst zu haben und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt zu haben. Alle Stellen der Arbeit, die wörtlich oder sinngemäß aus anderen Quellen übernommen wurden, habe ich als solche kenntlich gemacht. Die Arbeit wurde in gleicher oder ähnlicher Form noch keiner Prüfungsbehörde vorgelegt.

Xilin Huang Hannover, June 17, 2021

Acknowledgements

Here you can write your acknowledgements.

Abstract

Here write your abstract for your thesis. Please keep it accurate and clear within one page.

Contents

List of Acronyms

AI	Artificial Intelligence
CNNs	Conventional Neural Networks
DL	Deep Learning
FNNs	Feedforward Neural Networks
GPU	Graphics Processing Unit
GRUs	Gated Recurrent Units
IDE	Integrated Development Environment
KLD	Kullback-Leibler divergence
LIDAR	Light Detection and Ranging
LSTM	Long Short-Term Memory
ML	Machine Learning
NLP	Natural Language Processing
RNNs	Recurrent Neural Networks
SGD	Stochastic Gradient Descent
SDD	Stanford Drone Dataset

List of Figures

List of Tables

1 Introduction

Here is the introduction. You need to write the following key points for your work. Keep each part concise and short. In total, this chapter should not be more than four pages.

The remainder of this paper is organized as follows. The real-time contrasts framework for image monitoring is introduced in Section 2. Section 3 evaluates the performance of the proposed method using simulations. Section 4 provides an experiment to apply the proposed method in an industrial environment. Finally, the conclusions and directions of future research are presented.

- Background
- Motivation
- Research gap
- Objectives
- Approach (in introduction chapter you do not necessarily need to write the results for your work)
- The structure of your thesis

2 Related Work

Here you need to write your related work and cite properly. For example, one of the most influential researchers in Deep Learning (DL) is Yann LeCun with the Nature Article *Deep learning* [LeCun et al., 2015]. In total, you should refer to preferably approximately 50 papers (not less than 40 papers).

Here, it is highly recommended to start writing this part as soon as you start reading any papers. It will take you a lot of time to do so and can also help you track the papers that you have been reading.

3 Background

Please write down the basic background for your research, e.g., the fundamental concepts of the approaches that you use in the thesis, so that other people (who do not have the background) can understand your work.

Here is one example for sigmoid function:

The sigmoid function is defined by formula 3.1. It can compress the input into the interval $(0, 1)$. The drawback of the sigmoid activation function is the so-called “kill gradients”: if the input values locate in the tail of 0 or 1, the gradient at these regions tend to be zero. If the sigmoid function is used multiple times in a neural network, the gradients may be very small or even disappear.

$$f(x) = \frac{1}{1 + e^{-x}}. \tag{3.1}$$

4 Methodology

The proposed framework uses a bottom-up pipeline to gradually infer a high-level representation of the scratches and stains from low-level features in a back cover of mobile phone image. Firstly by mean of the wavelet transform, the surface texture properties such as scratch and stain are decomposed into so-called wavelet characteristics. Then multivariate statistical approach, i.e. Hotelling T^2 control chart is utilized to monitor the mean vector of a multivariate process, which can be used to judge the existence of scratch defects in the sample image.

4.1 Maximal variance of moving windows

For the surface of the back cover of handy, we assume that the pixels of the back cover are homogeneous. Therefore, we thought of using the variance of the pixel value to extract some features to represent the surface state.

The control charts are used spatially by moving a mask (or window) across the image and then calculating and plotting a statistic each time the mask is moved. The size of the mask depends on the expected size of the defects to be detected, with smaller defective regions requiring smaller mask sizes. [Megahed et al., 2011]Inspired by this view, we move a 10 by 10 window across the image and calculate the variance of the pixel value each time the window is moved. Then value with the largest variance in this image is taken as the desired statistic describing this image.

4.2 Discrete Wavelet transform decomposition

The continuous wavelet transform was computed by changing the scale of the analysis window, shifting the window in time, multiplying by the signal, and integrating over all times. In the discrete case, filters of different cutoff frequencies are used to analyze the signal at different scales. The signal is passed through a series of high pass filters to analyze the high frequencies, and it is passed through a series of low pass filters to analyze the low frequencies.
The DWT [Fig. 4.1] analyzes the signal at different frequency bands with different resolutions by decomposing the signal into a coarse approximation and detail information, which are associated with low pass and highpass filters, respectively. In our case, we use Haar discrete wavelet transform as the basic function to perform signal decomposition, thus an original image is decomposed into four coefficients: one low-pass filtering coefficients (approximation coefficients) and three high-pass filtering coefficients (detail coefficients, containing the horizontal, vertical, and diagonal detail coefficients) at each level.

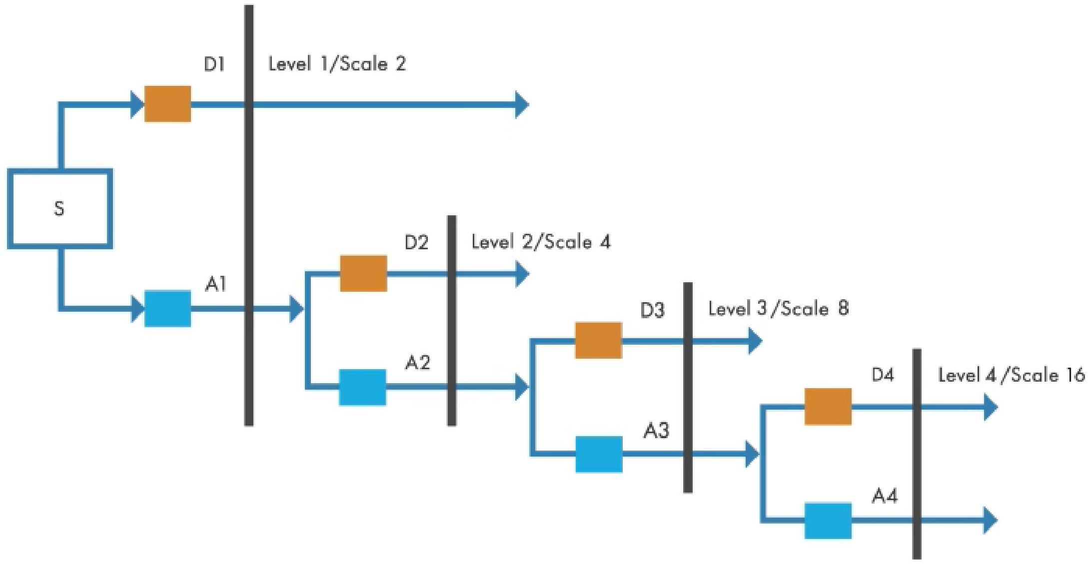

Figure 4.1: A general structure of CWT, the orange cube represent high-pass filter, the blue cube represent low-pass filter. Figure is adapted from MATLAB Tech Talks.

The number of coefficients of approximation coefficients and detail coefficients are halved when the level increase, the Haar transform is obtained down to level

$$\log_2(min(row'sdimension, column'sdimension)) \tag{4.1}$$

If the row or column dimension of data is even, but not a power of two, the Haar transform is obtained down to level

$$\lfloor \log_2(\frac{min(row'sdimension, column'sdimension)}{2}) \rfloor \tag{4.2}$$

In our case, we have sample data of size 100 * 100, the largest level of Haar transform is then 5 by using Equation 4.2.

4.3 Multivariate Control Chart

There are two distinct phases of the control chart [Bersimis et al., 2007].

- Phase I: charts are used for retrospectively testing whether the process was in control when the first subgroups were being drawn. In this phase, the charts are used as aids to the practitioner, in bringing a process into a state where it is statistically in control.
- Phase II: control charts are used for testing whether the process remains in control when future subgroups are drawn. In this phase, the charts are used as aids to the practitioner in monitoring the process for any change from an in-control state.

Multivariate Control Chart can be utilized to simultaneous monitor more than one quality characteristic.

5 Dataset

Here you need to describe the dataset(s) that you use for your experiments. If you use some open–source data, please cite them properly.

Here is an example of the Stanford drone datasets (SDD) [Robicquet et al., 2016]. SDD provides a bird's-eye-view in various intersections on Stanford University campus.

frame Nr.	user ID	x	y	user type
834	0	819.5	29.5	2
835	0	819.5	29.5	2

Table 5.1: An example of the real data for SDD [Robicquet et al., 2016]. The first, second, third, fourth, and fifth column present the frame ID, user ID, x coordinates, y coordinates, and user type, respectively. The x and y coordinates are in pixels.

6 Experiments

Please wire the experiments you have been doing for your research problems in detail and in an understandable way. This is the part that will largely reflect the work you have been doing for your thesis and will also mainly decide whether you can pass the examination or not.

Please keep in mind that you backup your code properly and regularly to avoid any risks by accident. It is recommended to use some open–source platform such as GitHub[1], which is also very convenient for code sharing.

[1] `https://github.com`

7 Results and Discussion

Please write down the findings for the experiments that you have been doing. It is also better to describe the results in figures or tables than only plain text. But again, you also need to have adequate text to explain the underlying meaning for the results.

8 Summary and Outlook

8.1 Summary

Here you need to wrap up the thesis in very concise and short paragraph(s). This is normally a very frequent part that your readers take a first look.

You can also change this sub-chapter to conclusion if you can draw a conclusion based on the results you have found. However, please pay attention to the difference between conclusion and summary.

8.2 Outlook

Here you can point out some potential aspects or interesting directions for future work and improvement.

Bibliography

[Bersimis et al., 2007] Bersimis, S., Psarakis, S., and Panaretos, J. (2007). Multivariate statistical process control charts: an overview. *Quality and Reliability engineering international*, 23(5):517–543.

[LeCun et al., 2015] LeCun, Y., Bengio, Y., and Hinton, G. (2015). Deep learning. *nature*, 521(7553):436.

[Megahed et al., 2011] Megahed, F. M., Woodall, W. H., and Camelio, J. A. (2011). A review and perspective on control charting with image data. *Journal of Quality Technology*, 43(2):83–98.

[Robicquet et al., 2016] Robicquet, A., Sadeghian, A., Alahi, A., and Savarese, S. (2016). Learning social etiquette: Human trajectory understanding in crowded scenes. In *European conference on computer vision*, pages 549–565. Springer.

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