APPLYING KERNEL CHANGE POINT DETECTION TO FINANCIAL MARKETS

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Abstract

Applying Kernel Change Point Detection to Financial Markets

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Text of abstract.

Acknowledgments

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Introduction

1.1 Motivation

In the first half of the twentieth century, Walter Shewart pioneered the use of statistical control charts for detecting real-time changes in variation. Shewart was interested in reducing the unexpected causes of variation in the manufacturing processes that produced faulty manufacturing equipment [?]. Shewart's method involved charting the process measurements over time and detecting when a statistical process was no longer exhibiting an expected level of variation. Once this detection occurred, the process was stopped and was not restarted until the cause of the variation was fixed. Shewart's control charts were one of the first formal methods to solve the problem of detecting changes in a distribution of a sequence of random variables. This problem is now known more generally as the *change point detection problem.* Many industries make use of change point techniques for real-time decision support systems. The following are a few motivating examples.

1.1.1 Health Care

Health care is an important area for quickly detecting signal changes. Some recent studies include applications to heart rate monitoring [?] [?], epilepsy signal segmentation [?], and multi-modal MRI lesion detection [?] to name a few. Quickly detecting changes to a patient's health is absolutely necessary for any system to be of practical use. However, this quick detection must be balanced with high accuracy as false positives or missed detections could have life-threatening consequences. Therefore, balancing missed change points with falsely identified change points is a central theme to online change point detection.

1.1.2 Financial Applications

The application of accurate and timely change point detection is popular in the finance sector where shifts in asset prices can suddenly happen. Change point detection is particularly hard in financial applications because of the non-stationary data typically observed in asset price time series. A common goal is detecting key, historical moments in the market such as stock market crashes [?] or the sub-prime mortgage crisis [?]. Note, in the financial literature, change points are also referred to as structural breaks, but for this thesis we will use the broader term change points.

An online, quick detection technique is proposed in [?], where a modified Shiryaev - Roberts procedure is used to detect a change point in a single stock's daily returns. They compare their non-parametric method with other classic control chart methods using speed of detection and false alarm rate as measures of performance.

Detecting changes in variance is explored in [?]. The authors propose an offline change point algorithm that minimizes a global cost function by using an adaptive regularization function. The algorithm is applied to the absolute returns of the FTSE 100 stock index and the US dollar-Japanese Yen foreign intra-day exchange rate to detect changes in asset price volatility. The change points identified in the FTSE 100 coincided with key market events such as the stock market crash that occurred on October 14^{th}, 1987 and breaking the 5000 price barrier in August 1997.

For more applications to options markets and arbitrage opportunities, see section 1.3.6 of [?].

1.2 Characteristics of the change point problem

A number of surveys of the literature already exist [?] [?], therefore we will not cover all existing methods but rather touch upon several, important factors to consider when approaching a change point detection problem. Across the literature, these factors determine what methods are available to practitioners.

The first factor is selecting between *parametric* and *non-parametric* techniques. Deciding between these two broad techniques is dependent on the prior knowledge