Quickest Detection and applications

Rationale

This is a comprehensive course on the topic of quickest detection that has been offered at the Graduate Center since the Fall of 2008. It covers the fundamental theory of quickest detection, the algorithms associated with it and the applications of quickest detection in a variety of fields, namely finance, signal processing and 3D Computer Vision. The basic financial notions of asset pricing and risk are also discussed. There is a great commitment in research and a huge commercial interest in all of the application areas on this field. A number of graduate students in the PhD program are currently using such algorithms in their research.

Description

The problem of detecting abrupt changes in the statistical behavior of observation arises in a variety of fields including signal processing, computer vision and finance. Using the mathematical methods of statistical sequential techniques and stochastic optimization, this course describes the fundamentals underpinning the field providing the background necessary to design analyze and understand quickest detection algorithms and stopping times. In this course we will provide a unified treatment of several different approaches to the quickest detection problem and draw examples from the field of signal processing, finance and computer vision. The course also covers models used in finance and signal processing, brownian motion, Ito calculus, markov processes and the fundamental theory of asset pricing. The notion of stopping time and its association with detection algorithms is further examined. Moreover, connections between detection algorithms and drawdown measures are drawn. The course finally examines the use of detection algorithms in online trading and the detection and classification of objects in point clouds of urban scenes.

Topic List

1. Statistical and sequential hypothesis testing.
2. The sequential probability ratio test and the cumulative sum algorithms as stopping times.
3. Applications to computer vision, algorithmic trading and signal processing.
4. Modeling in finance and signal processing, brownian motion.
5. Itô calculus, martingales, markov processes and the fundamental theory of asset pricing.
6. Drawdowns measures of risk and connections to detection.

Learning Goals

1. A general understanding of the importance of quickest detection in various fields.

2. Understanding of the notion of stopping time and online detection.

3. Ability to formulate research questions and to write research reports.

4. Ability to present technical talks.

5. Understanding of selected detection algorithms and how they can be applied in various fields.

6. Knowledge of basic models and stochastic processes used in signal processing and finance.

7. Knowledge of the fundamental theory of asset pricing, the notion of risk andhow it relates to drawdowns and detection.

Assessment

The course requires a midterm exam, a project and a final. Each student will prepare a research report either related to the theoretical study of detection algorithms or to adjusting and applying detection algortihms in a topic of their choice. The report will also be supported by a student presentation in class. Grading will be based on the attendance, student presentation, midterm, final and the final research report and project. Students can work in groups if they desire so for the final project, upon the consent of the instructor. I will provide a list of possible topics that would be appropriate for the final project and report. Student can pick a topic from this list or can also work on any other related topic of their choice subject to instructor approval.

Learning goals 1,2,6 and 7 will be assessed in the midterm (25%) and the final (35%), while learning goal 4 will be assessed in the student presentation (15%). Learning goals 3 and 5 will be assessed in the research report (20%). Student attendance and in-class participation will be worth 5% of the final grade.