College of ENGINEERING
UNIVERSITY OF HAWAI'I AT MĀNOA

Department of Electrical Engineering

Lecture Series on Bregman Divergences

Bregman divergences are used to quantify how much one probability measure deviates from another probability measure. Bregman divergences was defined already in 1967 but for many years the importance of this class of divergences was not recognized. Recently it has found a number of applications in apparently separated research areas, and new results pinpoint how and why certain concepts and methods appear in both information theory, statistics, physics and finance.

Lecture 1: **January 21, 2016 (Thursday)**
Bregman Divergences and Their Basic Properties **1030am-1130am Holmes Hall 389**

In this lecture we shall see how problems in decision theory and convex optimization naturally lead to the study of Bregman divergences. The basic properties of Bregman divergences will be explored. We shall see that a Bregman divergence that satisfies a certain sufficiency condition must be proportional to information divergence (Kullback-Leibler divergence).

Lecture 2: **January 28, 2016 (Thursday)**
Bregman Divergences in Statistics **1030am-1130am Holmes Hall 389**

The notion of proper scoring rules formalize the idea that we want to encourage people to be honest. It turns out that this is essentially only possible by using logarithmic score. This is closely related to the properties of Bregman divergences. Bregman divergences can also be used to characterize exponential families. For 1 dimensional exponential families the Bregman divergences can also be used to give much more precise bounds on tail probabilities than approximations by normal distributions via the central limit theorem.

Lecture 3: **February 11, 2016 (Thursday)**
Sufficiency in Thermodynamics **1030am-1130am Holmes Hall 389**

In thermodynamics and statistical physics a major goal is to extract as much energy from a system. This leads to the use of Bregman divergences. The sufficiency condition is related to reversibility of the system and if this condition is fulfilled the amount of energy that can be extrected is proportional to the number of bits we know about the system not being in equilibrium. The absolute temperature tells how much energy one bit of information is worth. The basic sufficiency result for Bregman divergences will be extended to quantum state spaces.

Lecture 4: **February 18, 2016 (Thursday)**
Sufficiency in Finance **1030am-1130am Holmes Hall 389**

It has been noted that certain quantities that appear in portfolio theory are closely related to quantities in information theory. We can describe portfolio theory in terms of convex optimization and Bregman divergences. The sufficiency condition is only fullfilled if the "stock market" is essentially equivalent to gambling where one either get a reward or lose the money.

Biography

Peter Harremoës is Associate Professor at Copenhagen Business College, Denmark since 2009. His main research interests are related to the use of information theory in statistics, probability theory and physics. In particular he has contributed to the use of information theoretic method for deriving inequalities and convergence theorems in probability. Other active research areas are Bayesian networks, lattice theory, and quantum information theory.

Peter Harremoës(M'00) received the B.Sc. degree in mathematics in 1984, the Exam. Art. degree in archaeology in 1985, and the M.Sc. degree in mathematics in 1988, all from the University of Copenhagen, Copenhagen, Denmark, and the Ph.D. degree in natural sciences in 1993 from Roskilde University, Denmark. From 1993 to 1998, he worked as a mountaineer. From 1998 to 2000, he held various teaching positions in mathematics. From 2001 to 2006, he was Postdoctoral Fellow with the University of Copenhagen, with a longer visit at Zentrum für Interdisziplinäre Forschung, Bielefeld, Germany, 2003. From 2006 to 2009, he was affiliated with the Centrum Wiskunde & Informatica, Amsterdam, The Netherlands, under the European Pascal Network of Excellence. Dr. Harremoës was Editor-in-Chief of the journal Entropy 2007-2011.