Second-Order Asymptotics in Information Theory

Vincent Y. F. Tan

Assistant Professor,
Dept. of Electrical and Computer Engineering, and
Dept. of Mathematics,
National University of Singapore

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Abstract

In this tutorial, we present a unified treatment problems in Shannon's information theory where we depart from the requirement that the error probability decays asymptotically in the blocklength. Instead, the error probabilities for various problems are bounded above by non-vanishing constants and the spotlight is shone on achievable coding rates as functions of the growing blocklengths. This represents the study of asymptotic estimates with non-vanishing error probabilities. In particular, we focus on the so-called second-order coding rates which approximately quantify the backoff from the first-order fundamental limit at finite blocklengths.

We first discuss Strassen's seminal result for binary hypothesis testing where the type-I error probability is non-vanishing and the rate of decay of the type-II error probability with growing number of independent observations is characterized. We subsequently use this basic hypothesis testing result to develop second-order asymptotic expansions for fixed-length lossless source and channel coding. Finally, we consider some network information theory problems such as the Slepian-Wolf problem.

This tutorial is designed to be relatively self-contained. The student is expected to have some background in information theory at the level of Cover and Thomas to appreciate the material.

Biography

Vincent Y. F. Tan is an Assistant Professor in the Department of Electrical and Computer Engineering (ECE) and the Department of Mathematics at the National University of Singapore (NUS). He received the B.A. and M.Eng. degrees in Electrical and Information Sciences from Cambridge University in 2005. He received the Ph.D. degree in Electrical Engineering and Computer Science (EECS) from the Massachusetts Institute of Technology in 2011. He was a postdoctoral researcher in the Department of ECE at the University of Wisconsin-Madison and following that, a research scientist at the Institute for Infocomm (I2R) Research, A*STAR, Singapore. His research interests include information theory, machine learning as well as statistical signal processing.

Dr. Tan received the MIT EECS Jin-Au Kong outstanding doctoral thesis prize in 2011 and the NUS Young Investigator Award in 2014. He has authored a research monograph on Asymptotic Estimates in Information Theory with Non-Vanishing Error Probabilities in the Foundations and Trends in Communications and Information Theory Series (NOW Publishers). He is currently serving as an Associate Editor for the IEEE Transactions on Communications.