SyMoCADS

GUEST LECTURE

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November 14., 2025, 4 pm CET

SR 00.030, Konrad-Zuse-Str. 3/5, Erlangen

Optimal Single-Letter Codes, Kelly Bets, and Biological Information Processing

ABSTRACT

It is widely believed in the biophysics community that information theory can be used to study biological communication - but how can this be, when there are no error-correcting codes in nature? To address this important puzzle, we consider Kelly betting: in an information-processing investment game, such as the growth of a population of organisms in a changing environment, Kelly betting is a method that uses received information to maximize the expected log rate of growth. In this talk, we discuss how Kelly bets are closely related to optimal single-letter codes, so that natural information processing systems can achieve information-theoretically optimal performance with trivial computational resources. Expressing such systems in terms of rate-distortion theory, we show that the rate-distortion tradeoff for an investment game has a simple linear bound, and that the bound is achievable at the point where the corresponding single-letter code is optimal. This interpretation has two interesting consequences. First, we show that increasing the fidelity of an organism's sensing can lead to optimal performance over a continuous range of channels, even if the strategy portfolio is fixed. Second, we show that increasing an organism's number of phenotypes (i.e., its number of possible behaviours in response to the environment) can lead to higher growth rates, and we give conditions under which this occurs. Examples illustrating the results in simplified biological scenarios are presented.

ANDREW ECKFORD is an Associate Professor in the Department of Electrical Engineering and Computer Science at York University, Toronto, Ontario. His research interests include the application of information theory to biology, and the design of communication systems using molecular and biological techniques. His research has been covered in media including The Economist, The Wall Street Journal, and IEEE Spectrum. His research received the 2015 IET Communications Innovation Award, and was a finalist for the 2014 Bell Labs Prize. He is also a co-author of the textbook Molecular Communication, published by Cambridge University Press. Andrew received the B.Eng. degree from the Royal Military College of Canada in 1996, and the M.A.Sc. and Ph.D. degrees from the University of Toronto in 1999 and 2004, respectively, all in Electrical Engineering. Andrew held postdoctoral fellowships at the University of Notre Dame and the University of Toronto, prior to taking up a faculty position at York in 2006. He has held courtesy appointments at the University of Toronto and Case Western Reserve University. In 2018, he was named a Senior Fellow of Massey College, Toronto.