
Computer Science Colloquium

Information Entropy of Humpback Whale Songs

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Olsen 311

Refreshments at 2:30, Talk from 3:00-4:00

Humpback whales produce songs consisting of more than a dozen sounds repeated in a complicated pattern. Many researchers have analyzed this song structure using manual classification and visual inspection of the sequence of sounds. Payne and McVay (1971) proposed a hierarchical syntax, which is currently the dominant hypothesis among marine mammal researchers. This hypothesis raises the question of whether the whales organize their songs using a hierarchical syntax, or if this structure is a bias of the human observers.

We applied information theory techniques to these songs to analyze the structure in an objective, quantitative manner. We converted the songs into discrete symbol sequences using both neural nets and human observers. The entropy of these symbol sequences estimated using an independent identically distributed model, a first-order Markov model and the nonparametric sliding window match length (SWML) estimator (Wyner & Ziv, 1989). A comparison of these entropy estimates indicates that the production of the songs is governed by strong syntactic constraints. Also, the entropy estimates from parametric models were significantly higher than that from the non-parametric estimator, indicating that both the memoryless and first order Markov models are too simple to model the syntax of humpback whale songs. Correlation functions of units in the songs demonstrate repetitive structure with two different periods of approximately 8 and 200 units. A simple hierarchical syntax will produce this phenomenon, while any nonhierarchical model consistent with the correlation behavior requires a huge number of parameters. This result is consistent with the Payne and McVay (1971) syntax.

Bio: John R. Buck received his Ph.D. from the MIT/WHOI Joint Program in Ocean and Electrical Engineering in 1996. He is currently an associate professor at the University of Massachusetts Dartmouth, jointly appointed in the Department of Electrical and Computer Engineering and the School for Marine Science and Technology. His research interests include signal processing, underwater acoustics, information theory and animal bioacoustics. Dr. Buck is the co-author of two textbooks, and the recipient an NSF CAREER award (1998), an ONR Young Investigator Award (2000), and the IEEE Education Society's Mac Van Valkenburg Early Career Teaching Award (2005). During 2003-2004, he was a Fulbright Senior Scholar in Australia, hosted by DSTO Sydney and the University of Sydney.