



# Permutation Complexity and Coupling Measures in Hidden Markov Models

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In [Haruna, T. and Nakajima, K., 2011. Physica D 240, 1370-1377], the authors introduced the duality between values (words) and orderings (permutations) as a basis to discuss the relationship between information theoretic measures for finite-alphabet stationary stochastic processes and their permutation versions. It has been used to give a simple proof of the equality between the entropy rate and the permutation entropy rate for any finite-alphabet stationary stochastic process and show some results on the excess entropy and the transfer entropy for finite-alphabet stationary ergodic Markov processes. In this paper, we generalize our previous framework and show the equalities between various information theoretic complexity and coupling measures and their permutation versions. In particular, we prove the following two results within the realm of hidden Markov models with ergodic internal processes: the two permutation versions of the transfer entropy, the symbolic transfer entropy and the transfer entropy on rank vectors, are both equivalent to the transfer entropy if they are considered as the rates, and the directed information theory can be captured by the permutation entropy approach.

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