離散力学系と符号化*

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1　Introduction

This papaer describes an application of discrete dynamical system[1] to coding. Discrete Dynamical System can generate any message as its itinerary given just an initial value. In other words, any message can be expressed as information of just a point which is the initial value of a dynamical system. This notion suggests the possibility of applying discrete dynamical systems to data compression, that is, using the initial value of a discrete dynamical system which is equivalent to the itinerary, instead of the message (or the message's codewords) when saving or transmitting it. To decode message, we just need to give the codewords to the dynamical system as its initial value. Then, the message will be decoded mechanically (automatically) by generating the itinerary according to rules of the dynamical system.

2　Geometric Features of Discrete Dynamical Systems and Models

Geometric features of discrete dynamical Systems imply models. Figure 1 shows the discrete dynamical system for encoding the source in which
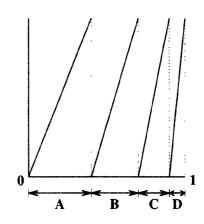

$A : B : C : D = 4 : 3 : 2 : 1.$

図 1:　A Discrete Dynamical System for the Multi-Symbol Alphabet

Besides, expressing one symbol with more than two lines as in Figure 2, it is adaptable to m-order Markov Model, too.

3　Chaos Coding

The idea of applying discrete dynamical systems to coding and the idea of arithmetic coding [2] are very similar. To extremes, the difference is only whether the method is conscious of (feeling, or seeing) graphs showing discrete dynamic systems above the horizontal axis or not. It is possible, however, to form Chaos Coding which is a different coding algorithm more natural from the viewpoint of discrete dynamical systems.
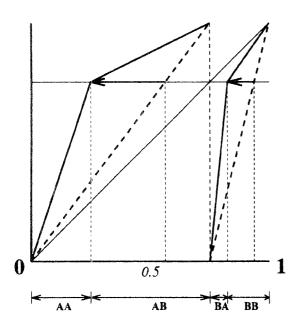
図 2: A Discrete Dynamical System for Markov Model

The difference between Chaos Coding and arithmetic coding is:

- from the viewpoint of discrete dynamical system, the initial value (input) comes first, and then corresponding itinerary (output) is decided.

- from the viewpoint of arithmetic coding, the message (input) to be encoded comes first, and then corresponding codewords (output) are decided.

This difference results in another difference:

- in the former case, encoder is defined as its reverse process, and

- in the latter case, decoder is defined as its reverse process.

So Chaos Coding does the reverse of usual coding:

- considering decoder as a kind of generator, and

- considering encoder as a kind of interpreter.

4 Future Work

First of all, I would like to optimize Chaos Coding whose possibility is described in the previous section. Then, to compare Chaos Coding with other methods both practically and theoretically, I would like to compare them quantatively.

It may be profitable to discuss deeper on Chaos Coding from the viewpoint of discrete dynamical systems. For example, when coding by Chaos Coding, as it settles into entropy, the orbit of the discrete dynamical systems forms a self-affine structure. It might be very interesting to visualize this process.

Acknowledgment

References

[1] Satoshi Hayama, Foundation of Chaotic Dynamics, 1993.

[2] I.H.Witten, R.M.Neal, and J.G.Cleary, "Arithmetic Coding for Data Compression", Comm. ACM vol.30 (June 1987), pp.520-540.

[3] Masanobu Ohkawa, "Chaos Coding — Application of Discrete Dynamical Systems to Data Compression —", Master's thesis, Keio University, Jan., 1997.