Scientific Research Publishing

Applied Mathematics, 2024, 15, 829-833
https://www.scirp.org/journal/am
ISSN Online: 2152-7393
ISSN Print: 2152-7385

Sea-Control Algorithm in Lake Wave Case

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How to cite this paper: Uemura, Y., Kita, K. and Matsumoto, K. (2024) Sea-Control Algorithm in Lake Wave Case. *Applied Mathematics*, **15**, 829-833.
https://doi.org/10.4236/am.2024.1512046

Received: September 9, 2024
Accepted: December 2, 2024
Published: December 5, 2024

Abstract

In previous studies, an isosceles triangular-type possibility distribution was employed to represent the analog waves of a Gaussian Process. The model was then projected onto actual waves using Zadeh's extension principle of mapping (Hori *et al.*, 2019). Furthermore, by applying Vague Set and Systems theory, it was shown that the actual waves followed a Gaussian process, and that the system could be efficiently controlled via Monte Carlo simulation. However, due to the use of fuzzy OR logic in the extension principle of mapping and wave synthesis, the resulting ambiguity increased significantly. To address this issue, a Possibility Markov Chain was proposed, incorporating possibility theory to mitigate the explosion of ambiguity. In this study, we propose a novel modeling approach that utilizes a possibility transition matrix without relying on fuzzy OR logic. Additionally, we introduce the Sea-Control Algorithm, which artificially introduces system error into the system function, thereby enabling modification of the possibility transition matrix through the deliberate manipulation of possibility information within the fuzzy system.

Keywords

Lake Wave Modeling, Lake Wave Control, Possibility Markov Chain, Analog Gaussian Process, Vague Event

1. Introduction

Visible waves are Type 2 Vague Events on Another World, mapped and transformed twice by an artificially set system function from Fuzzy Events (waves) determined by a priori possibility distribution on This World. In this paper, we focus on a state of calm regulated by the differential system of a uniform distribution, namely, an isosceles triangular possibility distribution. In initial modeling [1], the use of Zadeh's extension principle for mapping and Fuzzy OR logic in a fuzzy composite-type algorithm led to a rapid increase in ambiguity. As a countermeasure, representative values of fuzzy numbers and α-level cut techniques were employed. However, these methods significantly reduced the information quantity of possibilities within the fuzzy system. In response, a new algorithm that does not use Fuzzy OR logic was proposed [2]. The issue with this algorithm lies in the additional requirement of ergodicity in the possibility Markov chain. To circumvent this ergodic condition, attempts have been made to introduce a priori impartial states and posterior indistinguishable states as possibility buffers [3]. This paper proposes the Sea-Control Algorithm by artificially introducing system errors into the Type 1 Bays-Vague system function, constructing a Type 2 Bays-Vague interval-type system function, and varying the possibility transition by artificially manipulating the informational content of possibilities within the fuzzy system. It is worth noting that even when using the initial fuzzy composite algorithm, modeling of rough or gentle waves can be achieved by adjusting the width of the isosceles triangular-shaped system function. This note can be applied to the only lake wave case. As we had already proposed the possibility principal (oblique) factor rotation, we consider that the lake wave case is applied to possibility principal factor rotation.

2. Lake Wave Modeling

The Type 1 Bayes-Vague System is illustrated in **Figure 1**. When the triangular distribution representing a system's possibilities is vertically bisected at its vertex, identical right-angled triangular distributions emerge. Notably, since the centroids (Bayes) of these two areas are identical, reassembly after decomposition is permissible. Furthermore, it has been demonstrated that when Gaussian waveforms are mapped using a linear system function, the resultant waves also conform to Gaussian distributions [4]. Additionally, two actual waveforms can be modeled as Gaussian processes, and when employing fuzzy OR logic, the synthesized waveform similarly constitutes a Gaussian process. However, if Zadeh's extension principle for mappings and fuzzy OR logic are employed, an explosion of ambiguity occurs. Previously, the system function's width was artificially adjusted to address this issue, although this does not serve as a fundamental solution. In this study, instead of relying on fuzzy OR logic, we focus on the possibility state transitions of waves rather than their fuzzy synthesis. By leveraging Possibility Theory [5], we can derive both the possibility transition matrix from wave M to wave N (**Figure 2**) and the possibility state transition diagram (**Figure 3**). Here, the equality and order relations of fuzzy numbers are described by the following equations [5]. Moreover, $\mu_M(s), \mu_N(s)$ represent the possibility distributions over the natural state s for the actual analog waves M and N, respectively. If we picked up the measure of possibility and necessity (ref. [5]), our method was able to avoid the biggest variance factor. It is logic.

$$POS(M = N) \triangleq \sup_{u \in R^1} \min\left(\mu_M(u), \mu_N(u)\right) \tag{1}$$

$$POS(M \geq N) \triangleq \sup_{U \geq V} \min\left(\mu_M(U), \mu_N(V)\right) \tag{2}$$

$$POS(M > N) \triangleq \sup_{U} \inf_{V \geq U} \min\left(\mu_M(U), \mu_N(V)\right) \tag{3}$$

$$NES(M \geq N) \triangleq \inf_{U} \underset{V \leq U}{SUP} \max\left(1-\mu_M(U), \mu_N(V)\right) \tag{4}$$

$$NES(M > N) \triangleq 1-\sup_{U \geq V} \min\left(\mu_M(U), \mu_N(V)\right) \tag{5}$$

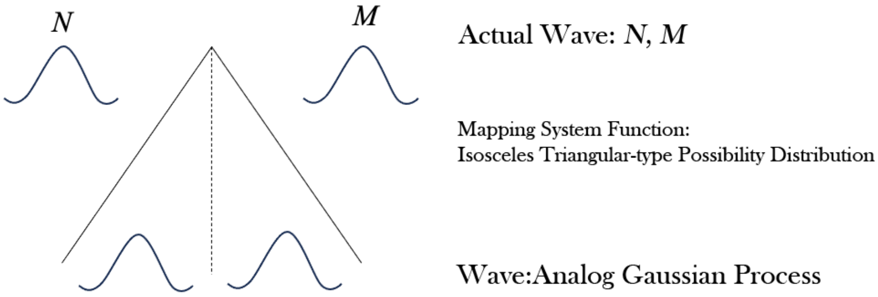

Figure 1. Type 1 bays-vague system.

$$\begin{pmatrix} \mathrm{Pos}(M = N) & \mathrm{Nes}(N > M) \\ \mathrm{Nes}(M > N) & \mathrm{Pos}(M = N) \end{pmatrix}$$

Figure 2. The probabilistic transition matrix from vague event M to vague event N.

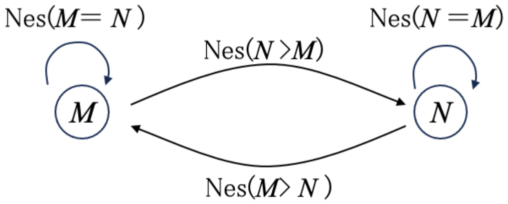

Figure 3. Probabilistic state transition diagram.

3. Lake Wave Control

The Type 2 Bays-Vague System is strictly defined by a two-dimensional isosceles triangular system function that spans the upper and lower bounds. However, to simplify the problem, this paper focuses on an interval-type linear system function with these bounds, as depicted in Figure 4. Within this interval, the system function fluctuates, which introduces system errors into the Type 2 Bayes-Vague System. To control these fluctuations, a possibility transition matrix is derived using the weighted average sum of the weighted possibility information quantities $[I_1, I_2]$ over the upper interval $[M_1, M_2]$ and lower interval $[N_1, N_2]$ of the two mapped and transformed waves M and N. Therefore, by artificially manipulating the possibility information quantity, the system can be adjusted (as shown in **Figure 5**). Here, the possibility information quantity is given by the following equation. Actual lake wave has two dimensional variable factors. We try to extend type 1 vague forward to type 2 vague in the sense of two errors (system and observation). Of cause, as type 2 vague system is the diplex one, we proposed the simplex system by α-cut technic. However, the system functions (*i.e.* membership functions) are defined by the decision makers. By our moving the system functions, we can sea-control in lake wave.

$$\mathrm{I}_{1i} = \underset{S}{\max}\ \mu_{Mi}(S)\times\log\mu_{Mi}(S) \quad (i=1,2) \tag{6}$$

$$\mathrm{I}_{2i} = \underset{S}{\max}\ \mu_{Ni}(S)\times\log\mu_{Ni}(S) \quad (i=1,2) \tag{7}$$

Here, I_1 and I_2 denote the averages of Equations (6) and (7), respectively.

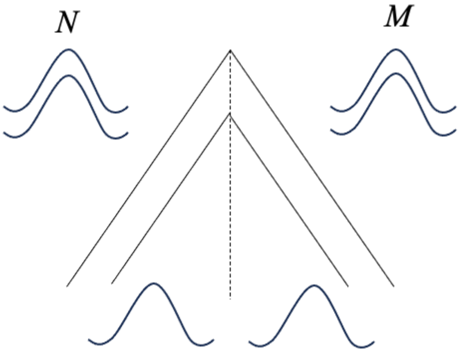

Figure 4. Type 2 bays-vague system.

$$\mathrm{I}_1 \begin{pmatrix} \mathrm{Pos}(M_1=N_1) & \mathrm{Nes}({}_1N>M_1) \\ \mathrm{Nes}(M_1>N_1) & \mathrm{Pos}(M_1=N_1) \end{pmatrix}$$

$$+\mathrm{I}_2 \begin{pmatrix} \mathrm{Pos}(M_2=N_2) & \mathrm{Nes}(N_2>M_2) \\ \mathrm{Nes}(M_2>N_2) & \mathrm{Pos}(M_2=N_2) \end{pmatrix}$$

Figure 5. Weighted average sum of weighted possibility information quantity.

4. Conclusion

In this paper, we proposed an exceedingly simple algorithm with a focus on Lake Wave Control. One of the challenges that need to be addressed in future research is determining whether waves existed prior to analysis or were rendered indiscernible afterward when the ergodic condition is dismissed. Since calm states are present in all marine environments excluding straits (Rever Wave Case), this study is expected to make a significant contribution to the field of Sea-Control. However, further research is necessary to advance our understanding of this domain.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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