Claims

1. A computer-implemented method for processing time-series data in a computing system to solve a prediction problem, the method comprising:

decomposing, by a computer system comprising at least one processor, a target sequence associated with the prediction problem into a binary sequence group which includes at least one binary sequence, wherein each binary sequence in the binary sequence group is generated based on a corresponding multiplier value;

generating, by the computer system, a plurality of elementary sequences based on each composite sequence in the binary sequence group;

determining, by the computer system, initial weights of each composite sequence in the binary sequence group based on average of weights of the corresponding elementary sequences;

determining, by the computer system, a binary prediction value for each binary sequence in the binary sequence group, wherein the binary prediction value for each composite sequence in the binary sequence group is determined by modelling each composite sequence using RNN based on the determined initial weights;

determining, by the computer system, a real prediction value for the target sequence based on a product of the binary prediction value for each binary sequence in the binary sequence group and the corresponding multiplier value; and

outputting, by the at least one processor, the real prediction value to a downstream system for optimizing operation of the computing system;

wherein the decomposition of the target sequence into the binary sequence group enables reduction in computational complexity and improved prediction accuracy for the computing system.

2. The method according to claim 1, wherein the decomposing the target sequence into a binary sequence group comprises:

decomposing, by the computer system, the target sequence into a binary sequence group including a plurality of binary sequences,

wherein the determining a real prediction value for the target sequence comprises:

calculating, by the computer system, a product of the binary prediction value for each binary sequence in the binary sequence group and the corresponding multiplier value; and

determining the real prediction value as an addition of the products corresponding to all of the binary sequences in the binary sequence group.

3. The method according to claim 1 or claim 2, wherein the decomposing the target sequence into a binary sequence group comprises:

Step 1: generating a current binary sequence based on a current sourc sequence and a current multiplier value corresponding to the current source sequence, wherein the current multiplier value is determined based on a minimum value in the current source sequence, wherein an initial sequence of the current source sequence is the target sequence;

Step 2: updating the current source sequence by subtracting the current multiplier value from each element of the current source sequence;

repeating the Steps 1 and 2 until each element of the current source sequence is zero.

4. The method according to claim 3, wherein the generating a current binary sequence based on a current source sequence and a current multiplier value comprises:

if an element of the current source sequence is greater than or equal to the current multiplier value, determining the corresponding element of the current binary sequence as 1; if the element of the current source sequence is 0, determining the corresponding element of the current binary sequence as 0.

5. The method according to claim 3 or claim 4, wherein the decomposing the target sequence into a binary sequence group further comprises:

swapping at least one element between two rows of a generated binary sequence group, wherein the two rows of the generated binary sequence group have a same multiplier value.

6. The method according to any proceeding claim, wherein the generating a plurality of elementary sequences based on each composite sequence in the binary sequence group comprises:

generating a plurality of elementary sequences based on each composite sequence in the binary sequence group, wherein each of the elementary sequences

starts with 1 and repeats a base sequence from a corresponding composite sequence and contains at least two and half repetitions of the base sequence.

7. The method according to any preceding claim, wherein the determining initial weights of each composite sequence based on average of weights of the corresponding elementary sequences, comprises:

retrieving weights of at least one elementary sequence corresponding to a first composite sequence from a pre-stored table which is stored in a memory and includes a plurality of mappings wherein each mapping associates a set of weights to an elementary sequence; and

calculating the initial weights of the first composite sequence based on the retrieved weights of the at least one elementary sequence.

8. The method according to any preceding claim, wherein the determining initial weights of each composite sequence based on average of weights of the corresponding elementary sequences comprises:

modelling at least one elementary sequence corresponding to a second composite sequence using RNN to obtain weights of the at least one elementary sequence; and

calculating the initial weights of the second composite sequence based on the obtained weights of the at least one elementary sequence.

9. The method according to claim 8, wherein the modelling at least one elementary sequence corresponding to a second composite sequence using RNN comprises:

modelling a plurality of elementary sequences corresponding to the second composite sequence using RNN in parallel.

10. The method according to any preceding claim, further comprising:

determining initial learning rate of each composite sequence in the binary sequence group based on average of initial learning rates of the corresponding elementary sequences.

11. The method according to any preceding claim, further comprising:

determining an error threshold value for each composite sequence in the binary sequence group based on average of error threshold values of the corresponding elementary sequences.

12. The method according to any preceding claim, wherein the determining a binary prediction value for each binary sequence in the binary sequence group comprises:

modelling each composite sequence in the binary sequence group using RNN based on the determined initial weights in parallel to determine the binary prediction value for each composite sequence.

13. A system for solving a prediction problem in a computing system, the system comprising at least one processor and a memory communicably coupled to the at least one processor, wherein the memory is configured to store instructions to be executed by the at least one processor, wherein the at least one processor is configured to

decompose a target sequence associated with the prediction problem into a binary sequence group which includes at least one binary sequence, wherein each binary sequence in the binary sequence group is generated based on a corresponding multiplier value;

generate a plurality of elementary sequences based on each composite sequence in the binary sequence group;

determine initial weights of each composite sequence in the binary sequence group based on average of weights of the corresponding elementary sequences;

determine a binary prediction value for each binary sequence in the binary sequence group, wherein the binary prediction value for each composite sequence is determined by modelling each composite sequence using RNN based on the determined initial weights;

determine a real prediction value for the target sequence based on a product of the binary prediction value for each binary sequence in the binary sequence group and the corresponding multiplier value; and

output the real prediction value to a downstream system for optimizing operation of the computing system;

wherein the decomposition of the target sequence into the binary sequence group enables reduction in computational complexity and improved prediction accuracy for the computing system.

14. The system according to claim 13, wherein the at least one processor is further configured to decompose the target sequence into a binary sequence group including a plurality of binary sequences, and

calculate a product of the binary prediction value for each binary sequence in the binary sequence group and the corresponding multiplier value; and determine the real prediction value for the target sequence as an addition of the products corresponding to all of the binary sequences in the binary sequence group.

15. The system according to claim 13 or claim 14, wherein the at least one processor is further configured to decompose the target sequence into a binary sequence group by

Step 1: generating a current binary sequence based on a current source sequence and a current multiplier value corresponding to the current binary sequence, wherein the current multiplier value is determined based on a minimum value in the current source sequence, wherein the initial sequence of the current source sequence is the target sequence;

Step 2: updating the current source sequence by subtracting the current multiplier value from each element of the current source sequence;

repeating the Steps 1 and 2 until each element of the current source sequence is zero.

16. The system according to claim 15, wherein the at least one processor is further configured to determine the corresponding element of the current binary sequence as 1

if an element of the current source sequence is greater than or equal to the current multiplier value; determine the corresponding element of the current binary sequence as 0 if the element of the current source sequence is 0.

17. The system according to claim 15 or claim 16, wherein the at least one processor is further configured to decompose the target sequence into a binary sequence group by swapping at least one element between two rows of a generated binary sequence group, wherein the two rows of the generated binary sequence group have a same multiplier value.

18. The system according to any one of claim 13 to claim 17, wherein the at least one processor is configured to generate a plurality of elementary sequences based on each composite sequence in the binary sequence group, wherein each of the elementary sequences starts with 1 and repeats a base sequence from a corresponding composite sequence and contains at least two and half repetitions of the base sequence.

19. The system according to any one of claim 13 to claim 18, wherein the at least one processor is further configured to retrieve weights of at least one elementary sequence corresponding to a first composite sequence from a pre-stored table which is stored in a memory and includes a plurality of mappings wherein each mapping associates a set of weights to an elementary sequence; and

calculate the initial weights of the first composite sequence based on the retrieved weights of the at least one elementary sequence.

20. The system according to any one of claim 13 to claim 19, wherein the at least one processor is further configured to model at least one elementary sequence corresponding to a second composite sequence using RNN to obtain weights of the at least one elementary sequence; and

calculate the initial weights of the second composite sequence based on the obtained weights of the at least one elementary sequence.

21. The system according to claim 20, wherein the system comprises a plurality of processor which are configured to model a plurality of elementary sequences corresponding to the second composite sequence using RNN in parallel.

22. The system according to any one of claim 13 to claim 21, wherein the at least one processor is further configured to determine initial learning rate of each composite sequence in the binary sequence group based on average of initial learning rates of the corresponding elementary sequences.

23. The system according to any one of claim 13 to claim 22, wherein the at least one processor is further configured to determine an error threshold value for each composite sequence in the binary sequence group based on average of error threshold values of the corresponding elementary sequences.

24. The system according to any one of claim 13 to claim 23, wherein the system comprises a plurality of processors which are configured to model each composite sequence in the binary sequence group using RNN based on the determined initial weights in parallel to determine the binary prediction value for each composite sequence.

25. A non-transitory computer readable medium comprising computer program code for solving a prediction problem, wherein the computer program code, when executed, is configured to cause at least one processor in a computer system to perform a method according to any one of claim 1 to claim 12.