

NEURAL NETWORK RADAR-AIDED CHANNEL ESTIMATION ENHANCEMENT  
METHOD AND DEVICE BASED ON HONEY BADGER ALGORITHM

**Field of the Invention**

5       **[01]**       The present application relates to the field of wireless communication, and in particular to a neural network radar-aided channel estimation enhancement method and device based on a honey badger algorithm.

**Background to the Invention**

10       **[02]**       With rapid development of a wireless communication and sensing technology, Radar-Communication Integration (RCI) has become a research hotspot in recent years. This technology aims to realize collaborative optimization of radar detection and wireless communication functions, so as to improve a system efficiency, reduce a device complexity, and alleviate an increasingly tense spectrum congestion problem. The RCI technology  
15       exhibits a broad application prospect in the fields of military, intelligent transportation, unmanned aerial vehicle (UAV) coordination, 5G communication and Internet of Things (IoT).

**[03]**       In some cases, a radar system and a communication system usually work independently, and adopt different hardware architectures and frequency bands, leading to  
20       low spectrum utilization, device redundancy and electromagnetic interference. The RCI technology, by designing joint waveforms and optimizing signal processing algorithms, enables a single system to not only complete radar functions such as target detection, tracking and imaging, but also realize high-speed and reliable data transmission. For example, in a vehicle system, the RCI technology can allow the vehicle to implement  
25       environmental sensing and Internet of Vehicles (IoV) communication at the same time, and improve autonomous driving safety and efficiency. The implementation mode of the RCI mainly includes two major aspects, i.e. waveform sharing and resource allocation optimization. The waveform sharing solution can embed communication information and radar detection function in the same signal, while the resource allocation optimization

balances radar performance by dynamically allocating time slots, frequency bands or power. Based on this, introduction of artificial intelligence and machine learning technologies further improves the adaptive capacity and intelligence level of the system.

5 [04] However, on the RCI level, a machine learning model has a low estimation accuracy and a poor robustness, and a data proportion of the radar system and the communication system in a transmission process cannot be allocated accurately, so that the overall data transmission capacity is relatively poor.

### **Statement of Invention**

10 [05] An objective of the present application is to provide a neural network radar-aided channel estimation enhancement method and device based on a honey badger algorithm, which can enhance a prediction accuracy of the neural network model on the fusion channel, so that a working frame structure of radar and communication can be adjusted dynamically, a data proportion can be allocated accurately, and a data  
15 transmission capacity can be improved on the premise of meeting basic performance requirements of radar positioning.

[06] In order to realize the above objective, the present application adopts the following solutions.

20 [07] In a first aspect, the present application discloses a neural network radar-aided channel estimation enhancement method based on a honey badger algorithm, including: acquiring a historical radar data reconstruction channel and a historical communication data estimation channel in different TDD running cycles, and performing inter-channel fusion on those channels to obtain a historical fusion channel; dividing a training set and a testing set by taking the historical radar data reconstruction channel and  
25 the historical communication data estimation channel as an input of a neural network model, and the historical fusion channel as an output of the neural network model; optimizing hyperparameters of the neural network model based on a honey badger algorithm using the training set, to obtain an optimized neural network model; evaluating the optimized neural network model based on the testing set; acquiring a current radar

data reconstruction channel and a current communication data estimation channel in different TDD running cycles, and inputting the optimized neural network model to obtain a current fusion channel; constructing constraints in combination with the current communication data estimation channel and the current fusion channel, selecting primary performance indicators and designing optimization problems, and obtaining and updating an optimal time and power allocation strategy by solving the designed problems; and allocating and sending the optimal time and power allocation strategy to a user, and communicating with the user through the optimal time and power allocation strategy in next TDD running cycle after the user adjusts a working mode.

10 **[08]** In a second aspect, the present application provides a computer device, comprising: a memory, a processor and a computer program stored in the memory and runnable on the processor, wherein the processor executes the computer program to implement the neural network radar-aided channel estimation enhancement method based on a honey badger algorithm described above.

15 **[09]** According to the specific embodiments provided by the present application, the present application has the following technical effects:

**[10]** The hyperparameters of the neural network model are optimized based on the honey badger algorithm using the training set, to obtain an optimized neural network model, and the optimized neural network model is evaluated based on the testing set, so that the prediction accuracy of the neural network model on the fusion channel is enhanced. The constraints are constructed in combination with the current communication data estimation channel and the current fusion channel, primary performance indicators are selected and optimization problems are designed, and an optimal time and power allocation strategy is obtained and updated by solving the designed problems; the optimal time and power allocation strategy is allocated and sent to a user, and the user is communicated with through the optimal time and power allocation strategy, so that a working frame structure of radar and communication can be adjusted dynamically, a data proportion can be allocated accurately, and a data transmission capacity can be improved on the premise of meeting basic performance requirements of radar positioning.

### **Brief Description of the Drawings**

[11] In order to explain the technical solution in embodiments of the present application or in the prior art more clearly, the drawings to be used in the embodiments will be introduced briefly below. Obviously, the drawings described below are only some  
5 embodiments of the present application. For those of ordinary skill in the art, other drawings may be obtained based on these drawings without making creative efforts.

[12] FIG. 1 is a flowchart of a neural network radar-aided channel estimation enhancement method based on a honey badger algorithm provided by an embodiment of the present application.

10 [13] FIG. 2 is a structural diagram of a computer device provided by an embodiment of the present application.

### **Detailed Description**

[14] The technical solutions in embodiments of the present application will be  
15 clearly and completely described below in combination with the drawings in embodiments of the present application. It is obvious that the described embodiments are only a part of, rather than all of, the embodiments of the present application. On the basis of the embodiments in the present application, all other embodiments obtained by those of ordinary skill in the art without making creative efforts will fall within the protection scope of  
20 the present application.

[15] To make the aforesaid objectives, features and advantages of the present application clearer and more understandable, the present application will be further explained below in detail in combination with the drawings and embodiments.

[16] Embodiment 1. As shown in FIG. 1, the present application provides a neural  
25 network radar-aided channel estimation enhancement method based on a honey badger algorithm, including the following steps.

[17] S1. A historical radar data reconstruction channel and a historical communication data estimation channel in different TDD running cycles are acquired, and inter-channel fusion is performed on those channels to obtain a historical fusion channel.

[18] In practical applications, radar and communication functions share the same frequency band in a TDD manner, and each TDD cycle may be divided into three parts: radar working time  $t_1$ , communication estimation time  $t_2$ , and data transmission time  $t_3$ . These three quantities are initialized as  $t_{10}$ ,  $t_{20}$  and  $t_{30}$ .

5 [19] When beginning to work, a radar system searches in a "Scan" mode whether new detection targets are discovered around, and then tracks the main detection targets in a "Track" mode, including main path reflectors in space and communication users. After completing sensing tasks, the radar system shares the acquired environmental information to a local communication system.

10 [20] The communication data estimation channel may be obtained by traditional channel estimation methods. The traditional channel estimation algorithms may be divided into two major categories by input data types, i.e. time-domain and frequency-domain methods. The frequency-domain methods mainly apply to multi-carrier systems; the time-domain methods are applicable to all single-carrier and multi-carrier systems, and  
15 estimate fading coefficients of multipath components in fading channels by means of reference signals or statistical characteristics of the sent data. The channel estimation algorithms may fall into three categories by prior information.

[21] 1) Reference signal-based estimation. This algorithm determines parameters to be estimated according to a certain estimation criteria, or tracks or adjusts estimated  
20 values of parameters to be estimated step by step according to certain criteria. This algorithm is characterized by requiring reference signals, i.e. pilot or training sequences. Training sequence and pilot sequence-based estimation algorithms are collectively called reference signal-based estimation algorithms.

[22] The training sequence-based channel estimation algorithms apply to systems  
25 of a burst transmission mode. Initial channel estimation is performed on a receiving end by sending a known training sequence; when useful information data are sent, initial channel estimation results are used for one decision update to complete real-time channel estimation. The pilot symbol-based channel estimation algorithms apply to systems of a continuous transmission mode. Channel estimation results of a pilot position may be

obtained by inserting a known pilot symbol into the useful data sent; next, channel estimation results of a useful data position may be obtained through interpolation using the channel estimation results of the pilot position, to complete the channel estimation.

[23] 2) Blind estimation. This is a method in which channel estimation is performed using some characteristics inherent in modulation signals and independent of specific carried information bits.

[24] 3) Semi-blind estimation. This is a channel estimation method which combines the blind estimation method and the training sequence-based estimation method.

[25] Generally, the common method is to estimate a channel by designing training sequences or inserting pilot symbols periodically into data. Whereas, the blind estimation and semi-blind estimation algorithms require no or short training sequences, showing a high spectrum efficiency. However, the blind estimation and semi-blind estimation algorithms have a relatively high computation complexity, and require long observation data; some problems may occur, such as phase ambiguity (subspace-based methods), error propagation (decision feedback methods), slow convergence and falling into local minimum.

[26] S2. A training set and a testing set are divided by taking the historical radar data reconstruction channel and the historical communication data estimation channel as an input of a neural network model, and the historical fusion channel as an output of the neural network model.

[27] S3. Hyperparameters of the neural network model are optimized based on a honey badger algorithm using the training set, to obtain an optimized neural network model; the optimized neural network model is evaluated based on the testing set.

[28] Further, the process that hyperparameters of the neural network model are optimized based on a honey badger algorithm specifically includes the following steps.

[29] The population quantity and maximum iterations of the honey badger algorithm are set, and a honey badger hunting method is modeled; the modeling process

specifically includes: initializing population, defining odor intensity, updating density factor and updating individual position.

[30] Non-Gaussian mixture noise is added to a label value of the training set, and optimal parameters are sought from the hyperparameters of the neural network model under the non-Gaussian mixture noise.

[31] S4. A current radar data reconstruction channel and a current communication data estimation channel in different TDD running cycles are acquired, and the optimized neural network model is inputted to obtain a current fusion channel.

[32] S5. Constraints are constructed in combination with the current communication data estimation channel and the current fusion channel, primary performance indicators are selected and optimization problems are designed, and an optimal time and power allocation strategy is obtained and updated by solving the designed problems.

[33] In practical applications, the output of the neural network exhibits smaller errors than Channel State Information (CSI) of the original channel estimation, which indicates that the CSI in the channel estimation step has learned environment-related information from radar detection data and more accurate CSI is successfully generated. A base station may, as needed, select whether to send the calculated CSI back to the user and adjust the own beam forming solution based on this.

[34] S6. The optimal time and power allocation strategy is allocated and sent to a user, and the user is communicated with through the optimal time and power allocation strategy in next TDD running cycle after the user adjusts a working mode.

[35] In practical applications, when the base station and the user finish the adjustment and complete data transmission in the current cycle, it may be considered that one cycle of the communication-sensing integration system ends. After that, the above steps are repeated.

[36] According to the specific embodiments provided by the present application, the present application discloses the following technical effects:

[37] The hyperparameters of the neural network model are optimized based on the honey badger algorithm using the training set, to obtain an optimized neural network model, and the optimized neural network model is evaluated based on the testing set, so that the prediction accuracy of the neural network model on the fusion channel is enhanced. The constraints are constructed in combination with the current communication data estimation channel and the current fusion channel, primary performance indicators are selected and optimization problems are designed, and an optimal time and power allocation strategy is obtained and updated by solving the designed problems; the optimal time and power allocation strategy is allocated and sent to a user, and the user is communicated with through the optimal time and power allocation strategy, so that a working frame structure of radar and communication can be adjusted dynamically, a data proportion can be allocated accurately, and a data transmission capacity can be improved on the premise of meeting basic performance requirements of radar positioning.

[38] Embodiment 2. The present application further provides a computer device, which may be a server or a terminal, and has an internal structure as shown in FIG. 2. The computer device includes a processor, a memory, an input/output (I/O) interface and a communication interface. Among those units, the processor, the memory and the I/O interface are connected via a system bus, and the communication interface is connected to the system bus via the I/O interface. The processor of the computer device is configured to provide computing and control capacities. The memory of the computer device includes a non-volatile storage medium and an internal memory. The non-volatile storage medium stores an operating system, a computer program and a database. The internal memory provides an environment for running of the operating system and the computer program stored in the non-volatile storage medium. The database of the computer device is configured to store processing data. The I/O interface of the computer device is configured to exchange information between the processor and external devices. The communication interface is configured to communicate with external terminals via network connection. The computer program, when executed by the processor, implements the above methods.

[39] Those skilled in the art may understand that the structure as shown in FIG. 2 is just part of the structure relevant to the solution of the present application, rather than

limiting the computer device to which the solution of the present application is applied. A specific computer device may include more or fewer components than those shown in the figure, combine certain components, or have a different arrangement of components.

**[40]** Those skilled in the art may understand that all or part of the processes in the methods of the above embodiments may be implemented by relevant hardware instructed by the computer program. The computer program may be stored in one non-volatile computer readable storage medium, and may include the processes of the embodiments in the above methods when executed. Any reference to the memory, database or other media used in various embodiments of the present application may include at least one of the non-volatile and volatile memories. The non-volatile memory may include a Read-Only Memory (ROM), a magnetic tape, a floppy, a flash memory, an optical memory, a high-density embedded non-volatile memory, a resistive random access memory (ReRAM), a Magnetoresistive Random Access Memory (MRAM), a Ferroelectric Random Access Memory (FRAM), a Phase Change Memory (PCM), and a graphene memory. The volatile memory may include a Random Access Memory (RAM) or an external cache memory. By way of illustration but not limitation, the RAM may be in various forms, such as Static Random Access Memory (SRAM) or Dynamic Random Access Memory (DRAM).

**[41]** Various technical features of the above embodiments may be combined in any manner. In order to simplify the description, not all possible combinations of the various features of the above embodiments are described. However, any combination of these technical features should be considered to fall within the scope of the specification, provided that such combinations do not contradict each other.

**[42]** Specific examples are applied in explaining the principle and implementation mode of the present application, and the above embodiments are only used for helping understand the methods and core idea of the present application; meanwhile, for those of ordinary skill in the art, alterations may be made to the specific implementation mode and the application scope based on the ideas of the present application. In summary, the contents of the specification should not be understood as a limitation on the present application.