CLAIMS

1. An action decision-making method for a virtual character, performed by a computer device, the method comprising:

obtaining character status information of a first virtual character, and obtaining environment perception information of the first virtual character with respect to a virtual environment in which the first virtual character is currently located, the environment perception information comprising perception information of a plurality of modalities, and the plurality of modalities each representing one information dimension;

fusing a coding result corresponding to the character status information and a coding result corresponding to the environment perception information into a fused feature, the coding result being a result obtained by separately performing feature coding on the character status information and a plurality of pieces of perception information by using different coding schemes;

determining a character action for the first virtual character based on the fused feature; and

controlling the first virtual character to execute the character action.

2. The method according to claim 1, wherein the environment perception information comprises first-modality perception information, second-modality perception information, and third-modality perception information; and

the obtaining environment perception information of the first virtual character with respect to a virtual environment in which the first virtual character is currently located comprises:

obtaining the first-modality perception information through ray detection based on a character location of the first virtual character in the virtual environment, the first-modality perception information being a one-dimensional vector, and the first-modality perception information being configured for representing a depth status of an obstacle at a same horizontal height around the first virtual character;

obtaining the second-modality perception information through ray detection based on the character location of the first virtual character in the virtual environment and an orientation of the first virtual character, the second-modality perception information being a two-dimensional depth map in an orientation direction of the first virtual character, and the second-modality perception information being configured for representing a depth status of an obstacle in the orientation direction of the first virtual character; and

obtaining the third-modality perception information of the virtual environment within a preset range of the first virtual character through ray detection based on the character location of the first virtual character in the virtual environment, the third-modality perception information being a three-dimensional occupancy grid map, and the third-modality perception information being configured for representing a spatial distribution status of obstacles within the preset range.

3. The method according to claim 1 or 2, wherein the obtaining the first-modality perception information through ray detection based on a character location of the first virtual character in the virtual environment comprises:

transmitting environment perception rays in a plurality of directions by using at least two heights of the character location of the first virtual character as starting points, the environment perception rays being reflected along normal directions of the environment perception rays when the environment perception rays collide with a surface of an obstacle, and transmitting directions of environment perception rays transmitted at a same height are at a same horizontal height; and

generating the first-modality perception information based on reflection statuses of the environment perception rays.

4. The method according to any one of claims 1 to 3, wherein the obtaining the second-modality perception information through ray detection based on the character location of the first virtual character in the virtual environment and an orientation of the first virtual character comprises:

transmitting an environment perception ray toward the orientation direction of the first virtual character by using the first virtual character as a starting point, the environment perception ray being reflected along a normal direction of the environment perception ray when the environment perception ray collides with a surface of an obstacle; and

generating the second-modality perception information based on a reflection status of the environment perception ray.

5. The method according to any one of claims 1 to 4, wherein the obtaining the third-modality perception information of the virtual environment within a preset range of the first virtual character through ray detection based on the character location of the first virtual character in the virtual environment comprises:

dividing the virtual environment within the preset range of the first virtual character by using an occupancy grid, the occupancy grid comprising a plurality of cubes with a same volume; and

transmitting environment perception rays from starting points of at least two directions in the virtual environment to the occupancy grid, and generating the third-modality perception information based on reflection statuses of the environment perception rays.

6. The method according to any one of claims 1 to 5, wherein character action for the first virtual character is determined by using an action decision-making model, and the action decision-making model comprises a coding network and a decision-making network; and

the fusing a coding result corresponding to the character status information and a coding result corresponding to the environment perception information, to obtain a fused feature comprises:

inputting the character status information and the environment perception information to the action decision-making model, and coding the character status information and the environment perception information by using the coding network, to obtain a status information coding result corresponding to the character status information and a perception information coding result corresponding to the environment perception information;

concatenating the status information coding result and the perception information coding result to obtain a concatenated feature code; and

performing feature extraction on the concatenated feature code by using the coding network, to obtain the fused feature.

7. The method according to any one of claims 1 to 6, wherein the character status information comprises absolute status information, and the absolute status information is configured for representing status information, irrelevant to another virtual character or an obstacle, of the first virtual character in the virtual environment; and

after the obtaining character status information of a first virtual character, the method further comprises:

generalizing the absolute status information comprised in the character status information, to obtain relative status information, the relative status information being status information of the first virtual character relative to another virtual character or an obstacle.

8. The method according to any one of claims 1 to 7, wherein the decision-making network comprises n action output heads, the n action output heads are configured to serially output n object sub-actions, different action output heads correspond to different action types, the n action output heads are serially connected based on a dependency relationship between the action types, the dependency relationship is configured for representing a dependency limitation status between sub-

actions of different action types, the n object sub-actions constitute the character action, and n is a positive integer greater than 2; and

the performing action decision-making on the first virtual character based on the fused feature to obtain a character action comprises:

inputting the fused feature to a first action output head in the decision-making network, and determining a first object sub-action from sub-actions of a first action type by using the first action output head in the decision-making network; and

inputting, to an ith action output head, the fused feature and embedded coding vectors corresponding to the first object sub-action to an $(i–1)^{th}$ object sub-action that are determined, and determining an ith object sub-action from sub-actions of an ith action type by using the ith action output head, i being a positive integer greater than 1.

9. The method according to any one of claims 1 to 8, wherein at least two of the n action output heads correspond to a same action type, the ith action output head among the n action output heads corresponds to a coarse-grained sub-action, a jth action output head among the n action output heads corresponds to a fine-grained sub-action, i is less than j, and j is a positive integer greater than 2;

the determining an ith object sub-action from sub-actions of an ith action type by using the ith action output head comprises:

determining the ith object sub-action from the coarse-grained sub-action by using the ith action output head in the decision-making network; and

the method further comprises:

determining a jth object sub-action from the fine-grained sub-action by using the jth action output head based on a fusion vector and an embedded coding vector corresponding to the ith object sub-action, an action range indicated by the jth object sub-action being less than an action range indicated by an ith character action.

10. The method according to any one of claims 1 to 9, wherein before the determining an ith object sub-action from sub-actions of an ith action type by using the ith action output head, the method further comprises:

performing, based on the first object sub-action to the $(i–1)^{th}$ object sub-action that are determined and a dependency limitation status between different sub-actions of different action types, action masking on a sub-action of the ith action type corresponding to the ith action output

head, at least two sub-actions that have a dependency limitation relationship and that are indicated by the dependency limitation status being unable to be simultaneously executed, and the action masking being configured for masking an inappropriate sub-action or an invalid sub-action; and

the determining an ith object sub-action from sub-actions of an ith action type by using the ith action output head comprises:

determining the ith object sub-action from unmasked sub-actions of the ith action type by using the ith action output head.

11. The method according to any one of claims 1 to 10, wherein before the obtaining character status information of a first virtual character, the method further comprises:

obtaining sample character status information of the first virtual character and sample environment perception information of the first virtual character with respect to the virtual environment in which the first virtual character is currently located, the sample environment perception information comprising sample perception information of a plurality of modalities, and the plurality of modalities each representing one information dimension;

fusing, by using the coding network in the action decision-making model, a sample coding result corresponding to the sample character status information and a sample coding result corresponding to the sample environment perception information, to obtain a sample fused feature, the coding network performing feature coding on the sample character status information and sample environment perception information of different modalities by using different coding schemes; and

training the action decision-making model based on the sample fused feature through reinforcement learning.

12. The method according to any one of claims 1 to 11, wherein the training the action decision-making model based on the sample fused feature through reinforcement learning comprises:

inputting the sample fused feature to the decision-making network in the action decision-making model, to obtain an estimated character action;

controlling the first virtual character to execute the estimated character action, to obtain an estimated action execution result of the first virtual character;

determining an estimated action execution reward based on the estimated action execution result of the first virtual character; and

updating a model parameter of the action decision-making model based on the estimated action execution reward.

13. A computer device, the computer device comprising a processor and a memory, the memory having at least one program stored therein, the at least one program being loaded and executed by the processor to implement the action decision-making method for a virtual character according to any one of claims 1 to 12.

14. A computer-readable storage medium, the readable storage medium having at least one program stored therein, and the at least one program being loaded and executed by a processor to implement the action decision-making method for a virtual character according to any one of claims 1 to 12.

15. A computer program product, the computer program product comprising computer instructions, the computer instructions being stored in a computer-readable storage medium, a processor of a computer device reading the computer instructions from the computer-readable storage medium, and the processor executing the computer instructions, to enable the computer device to perform the action decision-making method for a virtual character according to any one of claims 1 to 12.