CLAIMS

What is claimed is:

1. A storage device comprising:

at least one nonvolatile memory including a single-level cell area and a multi-level cell area; and

a storage controller configured to dynamically resize the single-level cell area through reinforcement learning,

wherein the storage controller includes a memory storing a queue table which comprises a plurality of entries, and stores a plurality of states respectively mapped to a plurality of pieces of environmental information, and reward history corresponding to each of the plurality of states.

2. The storage device of claim 1, wherein the storage controller performs the reinforcement learning whenever a total amount of write data received from a host reaches a threshold sector count value.

3. The storage device of claim 2, wherein the reinforcement learning determines a selected state among the plurality of states using the environmental information of the storage device, calculates a current reward from the selected state and the environmental information, determines a reward direction based on the current reward and the reward history of an entry indicating the selected state, and adjusts the threshold sector count value according to the calculated reward direction.

4. An operating method of a storage device, the method comprising:

dividing a nonvolatile memory into a single-level cell area and a multi-level cell area based on a threshold sector count value;

performing reinforcement learning on environmental information to determine a reward direction when a total amount of write data from a host for writing to the storage device reaches the threshold sector count value; and

dynamically adjusting the threshold sector count value according to the reward direction,

wherein the method further comprises storing a queue table which stores a plurality of states respectively mapped to a plurality of pieces of the environmental information, and reward history corresponding to each of the plurality of states.

5. The method of claim 4, further comprising adjusting a size of the single-level cell area according to the adjusted threshold sector count value.

6. The method of claim 4 or claim 5, wherein the performing of the reinforcement learning comprises:

collecting the environmental information from the nonvolatile memory and the host during a current cycle;

determining a state among the plurality of states based on the environmental information;

determining the reward history associated with the determined state;

calculating a current reward from the determined state and the environmental information; and

determining the reward direction based on the reward history and the current reward.

7. The method of claim 6, wherein the environmental information includes space utilization information, valid page count information, invalid page count information, and valid/invalid page count ratio information about the nonvolatile memory in the current cycle.

8. The method of claim 6 or claim 7, wherein the environmental information includes an average write sector count value for the host.

9. The method of any one of claims 6 to 8, wherein the environmental information includes historical information about an adjustment to the size of the single-level cell area in a previous cycle.

10. A storage device comprising:

a nonvolatile memory including a single-level cell area and a multi-level cell area; and

a storage controller comprising a processing unit configured to perform reinforcement learning on environmental information of the storage device to determine an optimal ratio of the single-level cell area to the multi-level area, and

wherein the storage controller dynamically adjusts a size of the single-level cell area according to the determined optimal ratio, and

wherein the storage controller includes a memory storing a queue table which stores a plurality of states respectively mapped to a plurality of pieces of the environmental information, and reward history corresponding to each of the plurality of states.

11. The storage device of claim 10, wherein the processing unit performs the reinforcement learning when write data of a host to be written to the single-level cell area is predicted to completely fill the single-level cell area.

12. The storage device of claim 10 or claim 11, wherein the processing unit resizes the single-level cell area in a current state and collects the environmental information of the storage device during a current cycle.

13. The storage device of claim 12, wherein the storage controller includes a register configured to store the size of the single-level cell area in the current state and the environmental information.

14. The storage device of claim 12, wherein the processing unit determines the current state of the nonvolatile memory based on the environmental information.

15. The storage device of claim 14, wherein the processing unit determines a reward from the determined current state and the environmental information.

16. The storage device of claim 15, wherein the reward is determined based on a migration cost in the current cycle and a valid/invalid page count ratio in the current cycle.

17. The storage device of claim 16, wherein when a migration cost of a previous cycle is greater than or equal to an average migration cost, the reward is determined as a negative reward for resizing the single-level cell area when a valid/invalid page count ratio of the single-level cell area in the current cycle is smaller than a valid/invalid page count ratio of the single-level cell area in the previous cycle, and the reward is determined as a positive reward when the valid/invalid page count ratio of the single-level cell area in the current cycle is not smaller than the valid/invalid page count ratio of the single-level cell area in the previous cycle.

18. The storage device of claim 15 or claim 16, wherein when a migration cost of a previous cycle is smaller than an average migration cost, the reward is determined as a negative reward for resizing the single-level cell area.

19. The storage device of claim 18, wherein when the migration cost of the previous cycle is smaller than the average migration cost, the negative reward for resizing the single-level cell area is increased when a valid/invalid page count ratio of the multi-level cell area in the current cycle is smaller than a valid/invalid page count ratio of the multi-level cell area in the previous cycle.