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APPARATUS AND METHOD FOR RECORDING, APPARATUS AND METHOD FOR REPRODUCTION, APPARATUS AND METHOD FOR RECORDING/REPRODUCING, AND DISTRIBUTION MEDIUM

Technical Field

This invention relates to data recording and/or reproducing apparatus and data storage mediums, and more particularly, to manipulating the recording/reproducing/storage of data to account for defects in a storage medium.

Background of the Invention

The data recorded in or reproduced from a hard disk drive (referred to as an HDD hereinafter) is managed by the file management function of a built-in operating system (referred to as an OS hereinafter) of a host computer. For example, an HDD itself is not involved in specification of data recording area or free area in the disk, but the data is recorded in an area which is specified by the host computer. Further, when data is reproduced, the data is read out from an area specified by the host computer.

In operation of the "MS-DOS" or "UNIX" (both are brand names) operating systems, the recording area is divided into fixed size data blocks (512 bytes or 1024 bytes) when a disk is initialized (or "formatted"), and data is recorded in units of the data blocks. This method is called fixed size division.

In fixed size division, the number which is specific to a sector (referred to as sector ID hereinafter) is written at the

head of each sector when the disk is initialized. A sector ID indicates a physical position on the disk. For example, a sector ID consists of an 8 bit sector number, a 16 bit track number, a 9 bit plane number, and a 16 bit error checking code (referred to as CRC (Cyclic Redundancy Check code hereinafter).

The host computer manages the sector ID by use of a series of logical block numbers (referred to as LBA (Logical Block Address) hereinafter). The physical position on the disk at which data is to be recorded is specified by the host computer as LBAs.

Fig. 15 shows an exemplary structure of a conventional HDD system. In this exemplary structure, "MS-DOS" is used as an OS.

In the system of Fig. 15, a microprocessor unit (referred to as MPU hereinafter) 11 controls the functions of HDD 1. A servo circuit 12 generates a driving signal for controlling a voice coil motor 13 (referred to as VCM hereinafter), and the VCM accordingly directs a magnetic head (not shown in the drawing) to a prescribed track position on a disk 18. A buffer 16 accumulates data supplied from the outside to HDD 1 and data to be supplied to the outside from HDD 1. A R/W (read/write) channel processing unit 17 generates a signal to be recorded on the disk 18 and a signal read out from the disk 18. A hard disk controller (referred to as HDC hereinafter) 15 controls the writing/reading of data in/from buffer 16 and transfers data

between the buffer and RW channel processing unit 17 based on control by the MPU 11. An MPU bus 14 couples MPU 11, servo circuit 12, HDC 15, and R/W channel processing unit 17.

An error correcting code (referred to as ECC hereinafter) is added to the data to be recorded in the disk 18. When the ECC indicates that an error is present in reproduced data, the MPU 11 again tries to reproduce the data from disk 18. This operation is called retry processing. In a typical HDD, retry processing is repeated several times as an internal process.

The MPU 11 regards a sector from which recorded data can not be read out as a defective sector when the data can not be read out in spite of retry processing. The MPU "notes" that the sector is defective so that the next time data is recorded on the disk, the defective sector is not used, but rather, a replacement sector located on a normally unused portion of the disk is substituted for the defective sector. This processing is called replacing sector processing.

The HDD 1 is connected to a host computer 2 by way of a bus such as a SCSI (Small Computer System Interface) bus or an IDE (Integrated Drive Electronics) bus.

"MS-DOS" is used as an OS 21 in the host computer 2, and a device driver 22 is a program for accessing the disk 18 as a block device. A logical format program 23 is a program for writing the initialization information (for example, sector ID

and file managing table) required when the disk 18 is initialized. A BIOS (Basic Input Output System) is connected to the device driver 22 and the logical format program 23, and is a program for serving I/O (Input/Output) between host computer 2 and HDD 1.

When image and audio data (referred to as AV data hereinafter) of a high data rate is recorded in the above-mentioned HDD 1 in logical block units, then a continuous stream of data is broken up and recorded on the disk in the form of small fragments. Such a state is called fragmentation. As a result of fragmentation, when the data is to be read out from the disk frequent head seek operations and attendant disk rotation waiting periods occur, thereby adversely affecting the continuity of the reproduced data.

To avoid this problem, the data is recorded not in logical block units but in cluster units, each cluster consists of a multiple of logical blocks (for example, a unit of 1024 sectors). The size of a cluster is determined so that data continuity is maintained even though fragmentation may occur in cluster units.

The cluster is of the same fixed size regardless of data type to allow for easy control (including data writing). For widely different AV data rates, the data is recorded according to a cluster size that is based on the maximum data rate. Thus, the AV data having a rate lower than the maximum

rate is nevertheless recorded in a cluster size determined on the basis of the maximum rate.

As a result, data having a low rate (for example, data including only audio information and AV data having a low rate) or data having a small size (for example, system management data) is recorded in a single cluster size unit (maximum rate), thereby giving rise to unused cluster portions and reducing the utilization rate of the recording area of the disk.

Disk defects are accounted for during logical-to-physical address conversion processing in the HDD 1. A defect which is formed in the stage before the disk is used by user (for example, the defect formed during fabrication or transportation) is called an initial defect. A defect formed after initial usage is called a secondary defect.

When an initial defect is detected by entire surface verification during fabrication and initialization, slip replacing processing is performed. The slip replacing processing involves skipping the physical address of a defective sector during the logical-to-physical address conversion process. The physical address of the normal (non-defective) sector positioned subsequent to the defective sector is used instead of the physical address of the defective sector. The slip replacing processing is realized by skipping the physical address of a defective sector when consecutive logical addresses are translated to their respective physical addresses.

On the other hand, a secondary defect is subjected to replacing sector processing. The replacing sector processing involves the use of a replacement sector which has been secured previously in a separate area of the disk. The replacement sector is used instead of the defective sector. More specifically, a physical address in the replacement sector is allocated to the logical address which indicates the defective sector during logical-to-physical address conversion processing. The replacing sector processing is classified into replacing processing and automatic replacing processing, to be described hereinafter.

A method for detecting a secondary defect in a disk and processing subsequent to such detection will now be described. When recorded data is reproduced, retry processing is performed if an error is detected in the reproduced data. In retry processing, reproduction is repeated while changing various parameters. If the data can not be read out in spite of a predetermined number of repetitions, the address is regarded as a secondary defective address. When data is thereafter recorded on the disk, the defective address is subjected to replacing processing.

If the data can be read out before the predetermined number of repeated retries, the address is regarded as an address which is likely deteriorated, and the data is recorded automatically in the replacing sector area in the HDD 1 after the

data which has been read out is transferred to the host computer 2. This processing is called automatic replacing processing.

In any case in which replacing processing or automatic replacing processing is performed, the host computer 2 may access data according to consecutive LBAs. In other words, even if the physical address becomes discontinuous as the result of replacing processing or automatic replacing processing, the LBA is continuous.

When the data is reproduced from a disk in which replacing processing or automatic replacing processing has been performed, the overall data accessing time is increased due to the additional time needed for performing a seek for moving the magnetic head to the replacing area, a disk rotation after the seek, a seek for returning the magnetic head to the original area to reproduce the subsequent sector, and a disk rotation after the seek. The waiting time due to such mechanical operation (null running time in which data transfer is not performed) could be a critical problem.

In the case that the secondary defect is handled by the host computer 2, because the data is managed in cluster units, an entire cluster area becomes null when one sector in the cluster is defective. As the result, the continuity of data and utilization rate of the recording area are sacrificed.

As the number of secondary defects increases due to increased wear, the above-mentioned cluster replacement operation

occurs frequently, the null recording area increases and the apparatus becomes disabled as an apparatus for recording/reproducing continuous data such as image and audio signals.

Objects and Summary of the Invention

The object of the present invention is to solve the above-mentioned problems.

The object of the invention is realized by providing a recording system, reproduction system and storage medium wherein the data unit recording sized is determined according to a particular one of multiple recording modes, and/or wherein defective storage medium areas are managed by exchanging one or more continuous data type storage areas with one or more dispersive type data storage areas.

Brief Description of the Drawings

The following detailed description, given by way of example and not intended to limit the present invention solely thereto, will best be appreciated in conjunction with the accompanying drawings, wherein like reference numerals denote like elements and parts, in which:

FIG. 1 is a block diagram illustrating the structure of a recording/reproducing apparatus in accordance with the present invention;

FIG. 2 is a diagram illustrating an exemplary format of recording areas for a hard disk drive;

FIG. 3 is a diagram illustrating AV data recorded in cluster units, the size of which vary according to the recording mode;

FIG. 4 is a diagram for describing the TOC management area shown in FIG. 2;

FIG. 5 is a diagram for describing the part descriptor area shown in FIG. 4;

FIG. 6 is a flow chart describing processes performed when a host computer is initialized in accordance with the present invention;

FIG. 7 is a flow chart for describing processes performed when a host computer is shut down in accordance with the present invention;

FIG. 8 is a flow chart for describing processes performed when AV data is recorded;

FIGS. 9A-9D are diagrams useful for describing processes performed when AV data is recorded;

FIGS. 10A-10C are diagrams for describing TOC information operations performed when AV data is recorded;

FIG. 11 is a flow chart for describing processes performed when AV data is reproduced;

FIGS. 12A-12C are diagrams useful for describing TOC information operations performed when AV data is reproduced;

FIG. 13 is a flow chart for describing processes performed when editing TOC information;

FIGS. 14A-14D are diagrams for describing the recording area and TOC information after performing the processes of FIG. 13; and

FIG. 15 is a block diagram illustrating the structure of a conventional recording/reproducing apparatus.

Detailed Description of Certain Preferred Embodiments

FIG. 1 shows an exemplary structure of a host computer 2 for implementing the present invention. The data to be recorded or reproduced is assumed to be MPEG (Moving Picture Experts Group) AV data.

MPU 31 controls operation of the host computer, including management of user data files. The MPU 31 has a built-in RAM (Random Access Memory) 40, and data which is used temporarily such as required file management information and tables for new defects is stored in built-in RAM 40. In a host RAM 32, file management tables, which include defect list 41 used for defect processing, are written.

A memory controller 33 controls AV data supplied from an MPEG encoder 35 and AV data sent out to an MPEG decoder 36 to realize simultaneous recording/reproduction. The memory controller also performs interface processing together with an ATA (AT Attachment) I/F 38, the components being connected to each other by way of a data bus 37. Further, the memory controller controls temporary storage of host computer input/output data.

The MPEG encoder 35 receives an AV signal from an external device (not shown in the drawing, for example, a television receiver), MPEG-encodes the image signal and audio signal separately, multiplexes the encoded signals and supplies the multiplexed signal to memory controller 33. The MPEG decoder 38 separates multiplexed data supplied from the memory controller 33 by use of a demultiplexer (not shown in the drawing) into image data and audio data, decodes the respective image data and audio data and transmits the decoded data to an external device. The MPU 31, host RAM 32, memory controller 33, and ATA I/F 38 are coupled via data bus 37.

ATA I/F 38 performs interface processing between an HDD 1 and host computer 2 by way of the data bus 37. The HDD 1 has the same structure as shown in FIG. 15 and therefore will not be described again.

Next, the operation of the host computer 2 is described. An AV signal from an external device not shown in the drawing (for example, a television receiver) is supplied to the MPEG encoder 35. The MPEG encoder 35 encodes the image signal and audio signal separately, multiplexes them by use of a built-in multiplexer (not shown in the drawing), and then supplies them to the memory controller 33. The memory controller 33 forwards the input AV data to the buffer 34 for temporary storage. The MPU 31 controls the memory controller 33 to read out the AV data

stored in the buffer 34 in predetermined amounts, and supplies the read out AV data to the HDD 1 for recording.

The MPU 31 commands the HDD 1 to read out the AV data so that a predetermined amount of AV data is stored in the buffer 34 for reproduction operation. The AV data read out from the HDD 1 according to the MPU's commands is temporarily stored in the buffer 34 by way of the memory controller 33. The AV data read out by way of the memory controller 33 is supplied to the MPEG decoder 36. The MPEG decoder 36 demultiplexes the input AV data into image data and audio data and decodes the image data and audio data separately. The decoded data is then transmitted as an AV signal.

FIG. 2 shows an exemplary data format of the recording area of the HDD 1. The entire recording area of the disk 18 of the HDD 1 consists of a multiple of logical blocks, addressed according to a series of consecutive logical block addresses (from LBA 0 to LBA N).

The area from LBA 0 to LBA M-1 is the recording area for AV data, and the residual area from LBA M to LBA N is an IT (Information Technology) recording area. The IT recording area consists of an audio data area, TOC (Table of Content) area, and secondary defect list area. The area where the user data can be recorded is the AV data recording area and the audio data area. The TOC area and the secondary defect list area belong to the system management area.

The AV data is recorded in cluster units, wherein the cluster size may be different for any two given recording modes. Each recording mode is associated with a distinct bit rate. For example, the recording modes can include an edit mode (8 Mbps) for recording the data which can be edited, an SP mode (4 Mbps) for recording the image at a relatively high quality, though the quality is not so high as that in the edit mode, or an LP mode (2 Mbps) for recording data during a relatively long period of time, though the quality is not as high as that in the former two modes.

A cluster is a group of logical blocks and is the minimum unit arranged on a disk when the data is recorded. As mentioned above, the size of a cluster varies depending on the recording mode, for example, the size is maximum for edit mode, minimum for LP mode, and between maximum and minimum for Sp mode.

FIG. 3 shows an exemplary arrangement of data files to be recorded. User data files (AV data and audio data) are recorded in cluster units having respective sizes in accordance with the recording mode of the user file in question. The data recorded in the system management area is recorded in logical block units. Each file of AV data is denoted by a title.

The structure of the TOC area is shown in FIG. 4. The TOC area consists of a TOC management area, title number area, and part descriptor area. The data in the TOC area is used to manage the title information, free area, and defect area.

In the TOC management area 2 byte unit pointers are stored for indicating the part descriptor (defect area part descriptor, free area descriptor, and free part descriptor) which describes the position of the recorded data on the disk. "1ST TNo" is a pointer which indicates the number of the first title and "LAST TNo" is a pointer which indicates the number of the last title. "P-DFA (Part-Defect Area)" is a pointer which indicates the defect area.

"P-Empty" is a pointer which indicates the area having no part descriptor, in the example shown in FIG. 4, the "P-Empty" pointer indicates 4, therefore the fourth part descriptor of the part descriptor area is an empty data where no content is described. "P-FRA" is a pointer which indicates the empty area (Free Recordable Area), and in the example shown in FIG. 4, "P-FRA" pointer indicates 2, therefore the free area information is described in the second part descriptor of the part descriptor area.

A title number area has a size for 247 titles, and 1 byte unit pointers for indicating a part descriptor of each title is stored therein. In the example shown in FIG. 4, the pointer of title 1 indicates 1, therefore the information of title 1 is described in the first part descriptor of the part descriptor area.

The structure of a part descriptor is shown in FIG. 5. A part descriptor is 16 byte information consisting of the head

address of the recorded data on the disk, end address, pointer for the subsequent part descriptor, and title attribute information (e.g. recording mode of title). In the example shown in FIG. 5, the first part descriptor of the part descriptor area is the information of title 1, the head address of the data of title 1 of the user data area is described as the head address, and the end address of title 1 of the user data area is described as the end address, further the third part descriptor is specified as the pointer information (the pointer indicates 3) to the part descriptor which is subsequent to title 1. If there is no pointer information specified to the subsequent part descriptor (the value of the pointer is zero), then the zero pointer value indicates that there is no chaining to the subsequent part descriptor. The address of unused area and the pointer information specified to the subsequent descriptor are described in the free part descriptor.

The host computer 2 manages the AV data recording area in units of LP mode cluster size, and the address number given based on this unit is called the HBA (Host Block Address). For example, assuming that the cluster size in the LP mode is 256 logical blocks, then the actual LBA is HBA x 256.

For example, for obtaining the TOC information of title 1, a pointer which indicates the part descriptor of title 1 is obtained from the first and second bytes of the title number area. Based on the address which the pointer indicates (in the

example shown in FIG. 5, the value of the pointer is 1), the part descriptor of title 1 (the address of the first part descriptor of the part descriptor area) is accessed, and the address on the user data area where the data is actually recorded is obtained. In the case that the data is recorded dispersedly in the user data area, the address of the chaining part descriptor (in the example shown in FIG. 5, the pointer value is 3) is obtained from the chaining information (the pointer to the subsequent part descriptor), and the chaining part descriptor is accessed. Such chained access is repeated until there is no longer a pointer to the subsequent part descriptor, indicating that there is no more data associated with the title being read out. In the example shown in FIG. 5, the data of title 1 is recorded dispersedly in the second and fourth clusters in the user data area. The free area information and defect area information are each managed as a single continuous information stream by chaining their respective part descriptors as the title information's part descriptors are chained.

Referring to the flow chart shown in FIG. 6, the reproduction processing of the system management area data which is performed when the host computer 2 is started is described. In step S1, the MPU 31 reads out the TOC area information (the TOC information written In the HDD 1 is referred to as dTOC information hereinafter) from the system management area recorded in the HDD 1.

In step S2, the MPU 31 writes the TOC area information read in step S1 and generates oTOC (TOC area information written in the host RAM 32 is referred to as oTOC information hereinafter) information. In step S3, the MPU 31 writes the secondary defect list area information read in step S1 on the predetermined address in the host RAM 32, and generates a new defect table. After completion of step S3, the host computer 2 waits for the next command.

Updating of the system management area information which is performed when recording or reproduction in the host computer 2 is completed or when a power is turned off is described referring to a flow chart shown in FIG. 7. In step S11, the MPU 31 calculates the difference between oTOC information written in the host RAM 32 and the dTOC information written in the HDD 1 and records the difference as a new dTOC information of the HDD 1.

In step S12, the MPU 31 determines whether the power of the host computer is turned off. If the power is determined not to be turned off, then the host computer 2 enters a wait state. If the power is determined to be turned off, then the sequence proceeds to step S13, and the MPU 31 determines whether a new defect information is to be added to the oTOC information of the host RAM 32. If the MPU 31 determines that new defect information is to be added to the oTOC information, the sequence proceeds to step S14. At step S14 the defect information of the

oTOC information is overwritten in the secondary defect list area of the HDD 1, and the processing of the host computer 2 is brought to an end. If the MPU 31 determines that new defect information is not to be added to the oTOC, the processing of the host computer 2 is simply brought to an end.

Updating of the system management area information which is performed when the host computer 2 records the AV data is described with reference to the flow chart shown in FIG. 8. In step S21, the MPU 31 acquires the title and recording mode of the image data to be recorded from the user interface unit (not shown in the drawing). In step S22, the MPU 31 selects the free area TOC information (part descriptor information of the free area) from among the oTOC information (generated from the dTOC information of the HDD 1 in step S2 shown in FIG. 6) of the host RAM 32.

In step S23, the MPU 31 determines whether there is a new defect in the free area indicated by the free area part descriptor information selected in step S22. The determination is carried out based on the new defect table generated in the host RAM 32 in step S3 shown in FIG. 6. If there is a new defect, the sequence proceeds to step S24, and in step S24, the MPU 31 determines the address of the cluster which includes the new defect, excludes it from the chain of the free area, and proceeds to step S25. If the MPU 31 determines that there is no new defect in step S23, then the sequence proceeds directly to

step S25. In step S25, the MPU 31 writes the data of the free area part descriptor on the predetermined address in the built-in RAM 40, and generates iWTOC information (TOC information in the built-in RAM 40 is referred to as iTOC information, iTOC information for recording is referred to as iWTOC information, and iTOC information for reproduction is referred to as IRTOC information).

In step S26, the MPU 31 issues a retry count limiting command to the HDD 1. That is, the HDD 1 to which the present invention is applied receives a number of retry limitation from the host computer 2 as a command. This command is defined as a new special command by, for example, the ATA. When data cannot be correctly written/read to/from the HDD 1 despite a number of retries equal to the limitation, the HDD 1 sends an indication of the address of the sector to/from which the write/read failed to the host computer and sets the error status to interrupt the host computer 2. The host computer 2 detects the defective address when interrupted.

In step S27, the MPU 31 determines the count N of the number of recording command issues corresponding to the recording mode (for example, for edit mode N=3) of the title to be recorded. More specifically, N is equal to the number of record operations that the hard drive must perform in order to record a cluster in accordance with a given recording mode. For example, if a given cluster has a size of 1024 sectors and the hard drive

records in units of 256 sectors, a count of N=4 is needed to record 1 cluster. In step S28, the MPU 31 sets the count N determined in step S27 to the recording command issue count counter.

In step S29, the MPU 31 converts HBA which is the address for managing the AV data recording area by use of the host computer 2 to an LBA. In step S30, the MPU 31 issues a command to indicate the HDD 1 to record the title (acquired from the user interface unit in step S21) by way of the data bus 37 and the ATA I/F 38. The recording command is issued based on the iWTOC information of the built-in RAM 40. At that time, a recordable cluster is selected based on the TOC information chain of free area of the iWTOC information as the recording position.

In step S31, the MPU 31 determines whether the count value of the recording command issue count counter is zero. If the MPU 31 determines that the count value of the recording command issue count counter is not zero in step S31, then the sequence proceeds to step S32, and 1 is added to the count value (the value set in step S28) of the recording command issue count counter. The sequence thereafter returns to step S30 and a recording command is issued again.

If the MPU 31 determines the count value to be zero (the number of recording command issues is N+1) in step S31, then the sequence proceeds to step S33. In step S33, the MPU 31 determines whether recording of the title acquired in step S21 is

to be ended. If the MPU 31 determines the current title recording is not to be ended, the sequence returns to step S28, and the MPU 31 sets the number of the counter to N for the subsequent cluster, and repeats steps S29-S33.

If the MPU 31 determines the recording to be ended in step S33, the starting address of the recorded title, ending address of the recorded title, recording mode (title attribute information), and chain information (information on the pointer to the subsequent part descriptor) are recorded in the oTOC information of the host RAM 32. In step S35, the MPU 31 deletes the data indicating the new defect area from the new defect table and adds the addresses denoting the extent containing the new defect area to the secondary defect list area of the oTOC information of the host RAM 32, and the host computer 2 enters a wait state.

The processing performed in step S22 to step S25 shown in FIG. 8 is described further referring to FIG. 9. FIG. 9(A) shows the free area information which the MPU 31 has selected from the oTOC information of the host RAM 32 and FIG. 9(B) shows the oTOC information. FIG. 9(C) shows the iWTOC information which the MPU 31 generates in the built-in RAM 40, and FIG. 9(D) shows the new defect table obtained as the result of a new defect detected by the MPU 31.

FIG. 9(A) shows the content of the part descriptor in the free area. The free area consists of three areas, the first

area has the start address of 0 and last address of 9, the second free area has the start address of 24 and last address of 31, and the third free area has the start address of 40 and the last address of n.

FIG. 9(B) shows the part descriptor information of the oTOC information of the host RAM 32. In the content of the part descriptor of the title 2, 16 in the first row represents the head address of the first extent (continuous HBA area on the HDD 1), and 23 represents the last address of the first extent. 32 in the second row represents the head address of the subsequent extent, and 39 represents the last address of the subsequent extent. h'FF..FF in the third row represents that there is no data in the following areas (cleared). In other words, the data of title 2 is recorded in two extents dividedly. The content of the part descriptor of the free area and the part descriptor of the defect area is h'FF..FF, and represents that there is no free area description and no defect area description because there is no data.

FIG. 9(C) shows the content of the iWTOC information which has been generated in the built-in RAM 40 of the MPU 31 by the MPU 31 during step S25 after the processing in steps S23 and S24 performed by the MPU 31. The area denoted by address 2 out of the extent (having the head address of 0 and the last address of 7) in the first row in the free area in FIG. 9(A) is determined to be in a new defect area, and the first area is

excluded (processing in step S24 shown in FIG. 8) from the chain of the free area. Therefore, the free area consists of two areas, the first free area has the start address of 24 and the end address of 31, and the second free area has the start address of 40 and the end address of n. The iRTOC information is h'FF..FF because no data is written.

The new defect table shown in FIG. 9(D) represents the area where the MPU 31 detects an error in step S23 shown in FIG. 8. In this case, the new defect table represents that the area at address 2 of the free area is newly detected secondary defect. The MPU 31 has detected the new defect and the defect has been recorded in the new defect table in the built-in RAM 40.

FIG. 10 shows the oTOC information, iTOC information and information of the new defect table in the built-in RAM 40 after recording of title 2 has been ended as shown in FIG. 9 and steps S34 and S35 shown in FIG. 8 have been completed. FIG. 10(A) shows the oTOC information of the host RAM 32, one extent (having the head address of 0 and last address of 7) is added to the part descriptor in the defect area in comparison with FIG. 9(B) where one extent is not added. This extent is generated as a result of the MPU 31 adding the addresses denoting the extent containing the new defect area to the secondary defect area list of the oTOC information in step S35 shown in FIG. 8. FIG. 10(B) is the same as FIG. 9(C), and description is omitted. The new defect table of the built-in RAM 40 of the MPU 31 shown in FIG.

10(C) represents the result of deletion of the information of the address 2 from the information shown in FIG. 9(D) (deleted based on recording of the extent including the address 2 in the part descriptor of the defect area of the oTOC information) through the processing of step 35 shown in FIG. 8.

Updating of the system management area information involved when the host computer 2 reproduces the AV data is described with reference to the flow chart shown in FIG. 11. In step S41, the MPU 31 acquires a title of the image data to be reproduced form a user interface unit (not shown in the drawing). In step S42, the MPU 31 selects the TOC area information corresponding to the title from among the oTOC information (generated from the dTOC information of the HDD 1 in step S2 shown in FIG. 6) of the host RAM 32. In step 43, the MPU 31 writes the oTOC information selected in step S42 in the predetermined address of the built-in RAM 40 in the MPU 31, and generates the iRTOC information.

In step S44, the MPU 31 issues a retry count limiting command to the HDD 1. In step S45, the MPU 31 determines the count N of the number of reproduction commands limitations in accordance with the recording mode (for example, edit mode) of the title to be reproduced. In step S46, the MPU 31 sets the number of reproduction commands counter to N.

In step S47, the MPU 31 converts HBA which is the address used when the host computer 2 manages the AV data

recording area to an LBA. In step S48, the MPU 31 issues a command which indicates reproduction of the title (acquired form the user interface in step S41) to the HDD 1 by way of the data bus 37 and ATA I/F 38.

In step S48, the MPU 31 determines whether there is any error in the reproduced AV data supplied from the HDD 1 by way of the ATA I/F 38. If the reproduced AV data is determined to be erroneous, the sequence proceeds to step S50 where the MPU 31 recognizes that the host address corresponding to the reproduced AV data detected in step S49 is a new defect area, and the host address of the new error area is recorded in the new defect table of the built-in RAM 40. The sequence then proceeds to step S51. If the MPU 31 determines in step S49 that the AV is not erroneous, step S50 is skipped and the sequence proceeds directly to step S51.

In step S51, the MPU 31 determines whether the count value (the value set in step S46) of the number of reproduction commands counter is 0. If the MPU 31 determines the count value not to be 0, the sequence proceeds to step S52, and 1 is subtracted from the count value of the number of reproduction commands counter. Thereafter, the sequence returns to step S48, and the MPU 31 again issues a reproduction command.

If the MPU 31 determines the count value to be 0 (the number of reproduction commands issued has reached N+1), then the MPU 31 determines in step S53 whether reproduction of the title

acquired in step S41 is ended. If the MPU 31 determines that reproduction has not ended, the sequence returns to step S46, the number of counter is set to N for the subsequent cluster, and steps S47-S53 repeated. If the MPU 31 determines in step S53 that reproduction has ended, the host computer 2 enters a wait state.

The processing performed in step S42, step S43, and step S50 shown in FIG. 11 is further described herein with reference to FIG. 12. FIG. 12(A) shows the oTOC information which the MPU 31 selects from the host RAM 32 in step S42, FIG. 12(B) shows the iRTOC information which the MPU 31 generates in the built-in RAM 40, and FIG. 12(C) shows the information formed by recording the new defect detected by the MPU 31 in step S49 in the new defect table of the built-in RAM 40.

In FIG. 12(A), the first block represents the part descriptor of the title information, the second block represents the part descriptor of the free area, and the third block represents the part descriptor of the defect area. In the case of FIG. 12(a), the part descriptor of the title information consists of two titles, namely title 1 and title 2.

In FIG. 12(A), for the part descriptors of title 1, 0 in the first row represents the head address of the first extent, and 3 represents the last address of the first extent. 8 in the second row ropresents the head address of the subsequent extent, and 15 represents the last address of the subsequent extent. In

other words, the data of title 1 is recorded in two extents dividedly. h'FF..FF in the third row represents that there is no data in the following areas. The information of title 2 is formatted in the same manner as that of title 1, and therefore description of the title 2 information is omitted.

For the part descriptors of the free area shown in FIG. 12(A), 3 in the first row represents the start address of the first free area and 7 in the first row represents the last address of the first free area. 24 in the second row represents the head address of the subsequent free area and 31 in the second row represents the end address of the subsequent area. 40 in the third row represents the start address of the free area and n in the third row represents the end address of the third free area. In other words, the free area consists of three areas.

h'FF..FF of the part descriptor of the defect area shown in FIG. 12(A) represents that there is no defect area.

FIG. 12(B) shows the content of the iRTOC information which is written in the built-in RAM 40 of the MPU 31 in step S43 shown in FIG. 11 after the MPU 31 selects the part descriptor of title 1 (selected in step S42 shown in FIG. 11) of the oTOC information shown in FIG. 12(A).

FIG. 12(C) shows the new defect table of the built-in RAM 40, namely, the disk address at which the MPU 31 has detected an error in step S50 shown in FIG. 11. In this case, the address 2 is determined to be the address of a secondary defect detected

during reproduction of the data of title 1, and thus the address 2 is recorded in the new defect table in the built-in RAM 40 by the MPU 31.

When the MPU 31 detects a new defect during recording of the title (processing in step S23 shown in FIG. 8) or during reproduction of the title (processing in step 49 shown in FIG. 11), the address of the new defect area is recorded in the dTOC information of the HDD 1. However, the area is considered defective during recording or reproduction, the area is not necessarily regarded as defective when IT information is recorded. In the present embodiment, the defect area is used for recording IT information and a cluster in the IT data recording area having the same size as that of the defect area is used to record AV data. That is, when a defect is detected in the AV area, the cluster containing the defect is used for recording IT data while a corresponding area in the IT area is used to record the displaced AV data.

The replacing of the recording area is realized through use of the P-FRA pointer which indicates the free area in the TOC management area. The process is described in detail with reference to the flow chart shown in FIG. 13.

In step S61, the MPU 31 determines the size of the defect cluster D in the secondary defect area list of the oTOC information of the host RAM 32. In step S62, the MPU 31 determines whether there is a consecutive free area having a size

equal to or larger than that of the defect cluster D determined in step S61 in the IT recording area. If the MPU 31 determines that a free area of a size equal to or larger than cluster D does exist, the sequence proceeds to step S63, and in step S63 the MPU 31 adds the address of the defect cluster D (the head address and last address) to the P-FRA of the TOC management area for IT information (adds to the chain of the part descriptor of the last free area of IT information).

If the MPU 31 determines that there is no consecutive free area having the size equal to or larger than that of the defect cluster D in step S62, then the sequence proceeds to step S64. In step S64, the MPU 31 issues a retry count unlimiting command to the HDD 1. In step S65, the MPU 31 reads out the IT information of the consecutive area having a size equivalent to that of the defect cluster D of the IT area. In step S66, the MPU 31 writes the IT information read out in step S65 in the area of the amount equivalent to that of the defect cluster D in the AV data recording area. In step S67, the MPU 31 rewrites the TOC information of the IT area of the amount equivalent to that of the defect cluster D read out in step S65 to the address of the AV area of the defect cluster D.

In step S68, the MPU 31 adds the TOC information (the head address and last address) of the consecutive area (equivalent to the size of the defect cluster D) of the IT information read in step S65 to the P-FRA of the TOC management

area for AV data (adds to the chain of the part descriptor of the last free area of the TOC information of the AV data). In step S69, the MPU 31 deletes the information of the defect cluster D described in the oTOC information of the host RAM 32, and the host computer 2 enters a wait state.

The recording area of the AV data and IT data and the TOC information of the AV data and IT data, to which processing shown in FIG. 13 has been performed, are described further with reference to FIG. 14. FIG. 14(A) shows the entire recording area before the processing shown in FIG. 13, and FIG. 14(B) shows the entire recording area after the processing shown in FIG. 13. The shaded areas represents used areas. FIG. 14(C) shows the TOC information of the AV data after the processing shown in FIG. 13, and FIG. 14(D) shows the TOC information of the IT data after the processing shown in FIG. 13.

In FIG. 14(A), the AV data is continuously recorded in the AV area with the exception of the defect cluster D area (addresses B to C-1). In FIG. 14(B), the area (addresses B to C-1) of the defect cluster D is changed to the IT recording area through the processing in step S63 shown in FIG. 13, and the area (addresses G to Z-1) having a size equivalent to that of the defect cluster D of the IT recording area is changed to the AV data recording area. According to this processing, the area (addresses B to C-1) of the defect cluster D is used as the recording area of the IT information, and the area (addresses G

to Z-1) which had been the recording area of the IT information is used as the recording area of the AV data.

FIG. 14(C) shows the TOC information of the AV data (only free area), the pointer of "P-FRA" indicates M, the part descriptor of the free area of the pointer M represents that addresses D to D-1 are free area, and the chain to the subsequent part descriptor (pointer value N) represents addresses G to Z-1 (the area added to the AV data recording area in the processing shown in FIG. 13).

FIG. 14(D) shows the TOC information of the IT information (only free area), the pointer of "P-FRA" indicates 0, the part descriptor of the free area of the pointer 0 represents that addresses F to G-1 is free area, and the chain to the subsequent part descriptor (pointer value P) represents addresses B to C-1 (the area added to the IT recording area in the processing shown in FIG. 13).

Recording or reproduction of the data in the IT area is performed in LBA units including the system management area, and the HDD 1 accepts access without the number of retry limitation. The usual defect processing which is implemented in the HDD 1 is performed.

In an alternative embodiment, defect areas may be processed as follows. A save area is provided previously, the save area is allocated to the AV data recording are temporarily without checking whether the IT recording area is free, and the

AV data is recorded. Then, the IT data having a size equivalent to that of the defect cluster is written in the defect cluster, the AV data in the save area is transferred to the free IT recording area to thereby empty the save area.

As another option, an alternative area may be provided for defective AV clusters and the computer can perform replacement of defective cluster areas with the alternative area instead of performing skip processing.

In the above-mentioned embodiments, the host computer detects the secondary defect by means of the error status. However, as an alternative the MPU 31 collects erroneous LBAs from the HDD at completion of the reproduction command so that checking error status during reproduction is unnecessary.

In the present invention, the distribution medium for distributing the computer program to execute the above-mentioned processing to users includes, but is not limited to, the information recording medium such as a magnetic disk and CD-ROM and other network transmission medium such as the internet and digital satellite.

As described hereinbefore, because the size of a group consisting of consecutive logical blocks is controlled correspondingly to the data recording mode, it is therefore possible to record the data efficiently on a recording medium without sacrificing recording rate of the data. Further, because a partial area of the first data recording area containing a

defect is changed to a partial area of the second recording area, it is possible to use the recording area efficiently. Also, because the data is reproduced from the area of the predetermined range containing a defect during a period of time for recording the position of the defect in the recording area of a recording medium, it is possible to reproduce the data as much as possible even through a defect is generated.

While the present invention has been particularly shown and described in conjunction with preferred embodiments thereof, it will be readily appreciated by those of ordinary skill in the art that various changes may be made without departing from the spirit and scope of the invention. Therefore, it is intended that the appended claims be interpreted as including the embodiments described herein, the alternatives mentioned above, and all equivalents thereto.



CLAIMS

What is claimed is:

1. An apparatus for recording data as recording units on a recording medium, comprising:

means for designating one of plural recording modes;

means for setting the size of recording units according to said designated recording mode; and

means for recording the data on the recording medium on a recording unit - by - recording unit basis.

2. The apparatus according to claim 1, further comprising means for setting a number of recording processes for each recording mode, said number of recording processes for each of said modes being indicative of the number of recording processes that are performed when recording a unit according to said mode.

3. The apparatus according to claim 1, wherein the data includes audio data, video data and system management data.

4. The apparatus according to claim 1, wherein said recording medium is partitioned into an audio/video data recording area and an information technology recording area.

5. The apparatus according to claim 4, wherein the data includes audio data, video data and system management data, said

video data is recorded only in said audio/video data recording area and said system management data is recorded only in said information technology recording area.

6. The apparatus according to claim 4, wherein when a defect area is detected in said audio/video area of the recording medium at least a portion of said system management data is recorded in said defect area.

7. The apparatus according to claim 4, wherein when a defect area is detected in said audio/video area of the recording medium at least a portion of said video data is recorded in said information technology area.

8. An apparatus for reproducing data from a recording medium, comprising:

means for recognizing one of plural recording modes according to which the data is to be reproduced; and

means for reproducing data on a recording unit - by - recording unit basis, wherein the size of each said recording unit is determined on the basis of the recording mode associated with said unit.

9. The apparatus according to claim 8, further comprising means for setting a number of reproducing processes for each recording

mode, said number of reproducing processes for each of said modes being indicative of the number of reproducing processes that are performed when reproducing a unit according to said mode.

10. The apparatus according to claim 8, wherein the data includes audio data, video data and system management data.

11. The apparatus according to claim 8, wherein said recording medium is partitioned into an audio/video data recording area and an information technology recording area.

12. The apparatus according to claim 11, wherein the data includes audio data, video data and system management data, said video data is recorded only in said audio/video data recording area and said system management data is recorded only in said information technology recording area.

13. The apparatus according to claim 11, wherein when a defect area is detected in the recording medium during reproduction, an indication of said defect is stored in the apparatus.

14. A method of recording data as recording units on a recording medium, comprising the steps of:

designating one of plural recording modes;

setting the size of recording units according to said designated recording mode; and

recording the data on the recording medium on a recording unit - by - recording unit basis.

15. The method according to claim 14, further comprising the step of setting a number of recording processes for each recording mode, wherein said number of recording processes for each of said modes is indicative of the number of recording processes that are performed when recording a unit according to said mode.

16. The method according to claim 14, wherein the data includes audio data, video data and system management data.

17. The method according to claim 14, wherein said recording medium is partitioned into an audio/video data recording area and an information technology recording area.

18. The method according to claim 17, wherein the data includes audio data, video data and system management data, said video data is recorded only in said audio/video data recording area and said system management data is recorded only in said information technology recording area.

19. The method according to claim 17, wherein when a defect area is detected in said audio/video area of the recording medium at least a portion of said system management data is recorded in said defect area.

20. The method according to claim 17, wherein when a defect area is detected in said audio/video area of the recording medium at least a portion of said video data is recorded in said information technology area.

21. A method of reproducing data from a recording medium, comprising the steps of:

recognizing one of plural recording modes according to which the data is to be reproduced; and

reproducing data on a recording unit - by - recording unit basis, wherein the size of each said recording units is determined on the basis of the recording mode associated with said unit.

22. The method according to claim 21, further comprising the step of setting a number of reproducing processes for each recording mode, wherein said number of reproducing processes for each of said modes is indicative of the number of reproducing processes that are performed when reproducing a unit according to said mode.



23. The method according to claim 21, wherein the data includes audio data, video data and system management data.

24. The method according to claim 21, wherein said recording medium is partitioned into an audio/video data recording area and an information technology recording area.

25. The method according to claim 24, wherein the data includes audio data, video data and system management data, said video data is recorded only in said audio/video data recording area and said system management data is recorded only in said information technology recording area.

26. The method according to claim 24, wherein when a defect area is detected in the recording medium during reproduction, an indication of said defect is stored in the apparatus.

27. A recording medium for storing data, comprising:

an audio/video data recording area for storing video data, said video data being recorded in said audio/video data recording area on a recording unit - by - recording unit basis according to one of a plurality of recording modes, the size of each said recording unit being determined on the basis of the recording mode associated with said unit; and

an information technology data area for storing system management data.

28. The recording medium according to claim 27, wherein the data includes audio data, video data and system management data.

29. The recording medium according to claim 28, wherein when a defect area is present in said audio/video area at least a portion of said system management data is recorded in said defect area.

30. The recording medium according to claim 29, wherein when a defect area is present in said audio/video area at least a portion of said video data is recorded in said information technology area.

31. An apparatus for recording data on a recording medium having a continuous data region and a dispersive data region, comprising:

means for detecting a defective region within said continuous data region;

means for recording continuous data and dispersive data onto said recording medium; and

means for controlling said means for recording to record said dispersive data in said dispersive data region and in said defective region.

32. The apparatus according to claim 31, wherein said means for detecting further comprises means for detecting in said dispersive data region a region that has a size equal to or larger than the size of said defective region.

33. The apparatus according to claim 32, wherein at least a portion of said continuous data is recorded in said region having a size equal to or larger than the size of said defect region.

34. The apparatus according to claim 31, wherein said continuous data includes audio data and video data and said dispersive data includes system management data.

35. The apparatus according to claim 31, wherein said means for controlling controls said means for recording to record at least a portion of said continuous data in said dispersive data region.

36. An apparatus for reproducing data from a recording medium having a continuous data region and a dispersive data region, comprising:



means for providing a location within said recording medium of said continuous data region and said dispersive data region;

means for reproducing continuous data and dispersive data from said recording medium; and

means for controlling said means for reproducing to reproduce as dispersive data at least a portion of said dispersive data which has been recorded in said continuous data region.

37. The apparatus according to claim 36, wherein said means for controlling is operable to reproduce as continuous type data at least a portion of said continuous data which has been recorded in said dispersive data region.

38. The apparatus according to claim 36, wherein said continuous data includes audio data and video data and said dispersive data includes system management data.

39. A method of recording data on a recording medium having a continuous data region and a dispersive data region, comprising the steps of:

detecting a defective region within said continuous data region;

recording continuous data and dispersive data onto said recording medium via a means for recording; and

controlling said means for recording to record said dispersive data in said dispersive data region and in said defective region.

40. The method according to claim 39, wherein said step of detecting further comprises the step of detecting in said dispersive data region a region that has a size equal to or larger than the size of said defective region.

41. The method according to claim 39, wherein at least a portion of said continuous data is recorded in said region having a size equal to or larger than the size of said defect region.

42. The method according to claim 39, wherein said continuous data includes audio data and video data and said dispersive data includes system management data.

43. The method according to claim 39, further comprising the step of controlling said means for recording to record at least a portion of said continuous data in said dispersive data region.

44. A method for reproducing data from a recording medium having a continuous data region and a dispersive data region, comprising the steps of:

providing a location within said recording medium of said continuous data region and said dispersive data region;

reproducing continuous data and dispersive data from said recording medium via a means for reproducing; and

controlling said means for reproducing to reproduce as dispersive type data at least a portion of said dispersive data which has been recorded in said continuous data region.

45. The method according to claim 44, further comprising the step of controlling said means for reproducing to reproduce as continuous type data at least a portion of said continuous data which has been recorded in said dispersive data region.

46. The method according to claim 44, wherein said continuous data includes audio data and video data and said dispersive data includes system management data.

47. A recording medium for storing continuous data and dispersive data, comprising:

a continuous data region for storing said continuous data;

a dispersive data region for storing said dispersive data; and

a defect region included in said continuous data region;

wherein said defect region is managed as part of said dispersive data region such that dispersive data is stored in said defect region despite said defect region being included within said continuous data region.

48. The recording medium according to claim 47, wherein said continuous data includes video data, and said dispersive data includes system management data.

49. The recording medium according to claim 48, wherein at least a portion of said video data is recorded in said dispersive data region.