METHOD AND APPARATUS FOR RECORDING/REPRODUCING MESH PATTERN DATA

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a data recording/reproduction system for encoding binary data to record same as an image, and for reading a recorded image and decoding the read image into binary data.

2. Description of the Related Art

A bar code technique is known as a technique for reading an encoded image from a recording medium (recording sheet) to reproduce binary data.

For example, U.S. Pat. Nos. 4,422,361, 4,437,378, and 4,464,966 disclose this technique. However, it is difficult to increase a recording density of a bar code in terms of its structure, and the bar code is not suitable for handling a large volume of data.

Unexamined Japanese Patent Application Publication No. 53-73026 discloses a technique wherein an image in which some meshes of an $i \times j$ (e.g., 3×3) matrix are set to be black meshes, and the remaining meshes are set to be white meshes, is read to recognize a black-and-white mesh pattern. The use of the matrix encoded image can easily increase a data volume by increasing the number of meshes included in the matrix. Another technique using a similar matrix image is also described in Magazine I/O, May, 1988, pp. 121 to 125, "Damp List Read by Image Scanner".

U.S. patent application Ser. No. 7/389,287 (filing date: Aug. 3, 1989, inventors: Morikawa et al.), now U.S. Pat. No. 5,042,079, assigned to the present assignee proposes the following technique. That is, a mesh pattern obtained by encoding data by black-and-white meshes selectively formed on a mesh matrix consisting of a large number of meshes is used as a data body of an encoded image in place of a bar code, and such an encoded image is read and decoded.

According to the invention disclosed in this U.S. application Ser. No. 07/389,287, since data bits are expressed by a black-and-white pattern of meshes which are two-dimensionally arrayed at small intervals, a recording density can be greatly improved.

However, when an encoded image itself on a recording medium is stained, e.g., contaminated, and a scanning reference pattern is partially deformed, omitted, or damaged thereby, the above-mentioned decoding method may erroneously recognize the contamination as a segment of the scanning reference pattern, and position errors of meshes of the mesh pattern on image data which are determined on the basis of the recognition result occur, resulting in a wrong black-and-white recognition result. For example, if a certain white clock mesh (hereinafter referred to as a clock) of a synchronous pattern as a sub-scanning reference pattern is stained in black and becomes continuous with back clocks before and after this white clock, when clocks of the synchronous pattern are detected on image data, the white clock is not read (i.e., three, i.e., black, white, and black clocks are detected as one black clock), and this error causes a decoding error of all other clocks. In this state, even if an error is detected later in error correction processing using a checking code (redundant code included in a mesh pattern), correction is impossible to achieve since the error is considerably beyond a correction capability.

A position error of a guide line as a main scanning reference caused by contamination influences a position as a central position of meshes in the vertical direction thereof obtained by equally dividing a line connecting corresponding positions of two guide lines on a scanning line image. As a result, a noncorrectable sampling error occurs later.

A recognition error of image data may occur due to various other causes. For example, the causes include a defect (caused by poor printing precision, a variation in density, or the like) of an encoded image on a recording medium, problems of an image sensor (an image resolution of the image sensor, an image distortion in image processing by the image sensor (distortion of a lens, a change in scanning speed or direction), luminance stability of a light source, a threshold level for binarizing analog image data, and photoelectric conversion characteristics of an image sensor such as a CCD), and the like.

Most of such errors are caused by the fact that a mesh pattern is adopted to increase a recording density on a recording medium. In other words, most of errors are related to the fact that an encoded image on a recording medium is constituted by a two-dimensional array of image elements encoding information units in order to effectively use a two-dimensional space on the recording medium.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a data reading method and apparatus, which can detect correct positions of scanning reference patterns on image data even when scanning reference patterns of an encoded image having a mesh pattern as a data body are partially destroyed by, e.g., contamination on a recording medium.

It is another object of the present invention to provide a recording medium for recording an encoded image, which can effectively solve the above-mentioned error problems while maintaining a relatively high recording density, to provide a data recording method and apparatus for recording an encoded image on the recording medium, and to provide a data reproduction method and apparatus capable of reproducing desired data free from an error or at a low error rate from the encoded image.

According to one aspect of the present invention, image data representing an image is read from a recording medium which records the image including a mesh pattern and a main scanning reference pattern, and the read image data is divided into a plurality of partial image data segments. For each partial image data segment, a feature pixel group featuring a piece of the main scanning reference pattern included in each partial image data segment is searched from the partial image data piece. For the partial image data segment from which n feature pixel group is detected upon searching, the position of the piece of the main scanning reference pattern in that partial image data segment is determined from the position of a piece of the main scanning reference pattern represented by the feature pixel group detected upon searching of another partial image data segment. Thus, position data of pieces of the main scanning reference pattern in the image data are generated, and black and white meshes of the mesh pattern of the