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Spruyt

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[54] **METHOD FOR DETECTING ERASURES IN RECEIVED DIGITAL DATA**

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[51] **Int. Cl.**[6] **H03D 1/06**; H03D 11/04; H03K 5/01; H03K 6/04

[52] **U.S. Cl.** **375/348**; 329/304; 371/37.1

[58] **Field of Search** 375/317, 340, 375/261, 264, 348; 371/6, 31, 57.1, 43, 44, 37.1; 329/304, 306; 455/296

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[57] **ABSTRACT**

A method is described for detecting erasures in a stream of sets of digital signal values received at a receiver side after transmission from a transmission side. Subsets of these sets are modulated on distinct carrier signals, each transmitted and received thus modulated carrier signal corresponding to one of a number of predetermined subset related points and to a receipt point on a carrier dependent modulation representing map respectively. The method includes the steps of:

selecting for each receipt point the nearest of the predetermined subset related points;

calculating a distance between the receipt point and the nearest subset related point and multiplying this distance with a map dependent weight factor;

summing the thus obtained weighted distances for all subsets of a set; and

marking the latter set as an erasure when the thus obtained result exceeds a predetermined threshold.

7 Claims, 3 Drawing Sheets

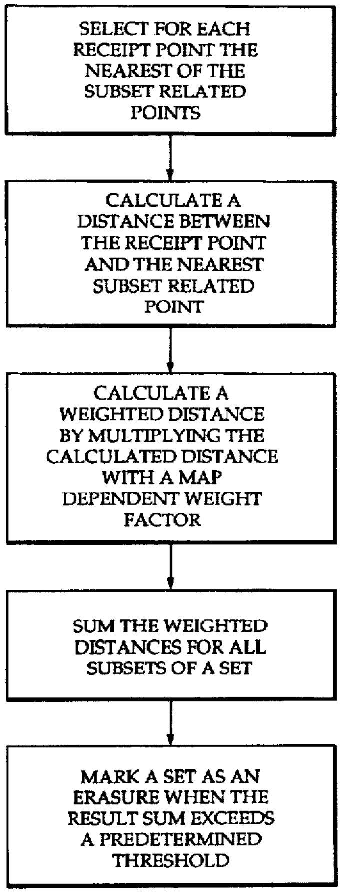

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FIG. 1
(PRIOR ART)

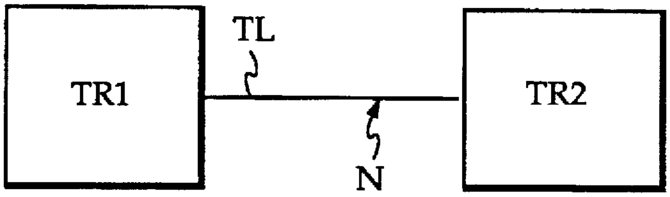


FIG. 3

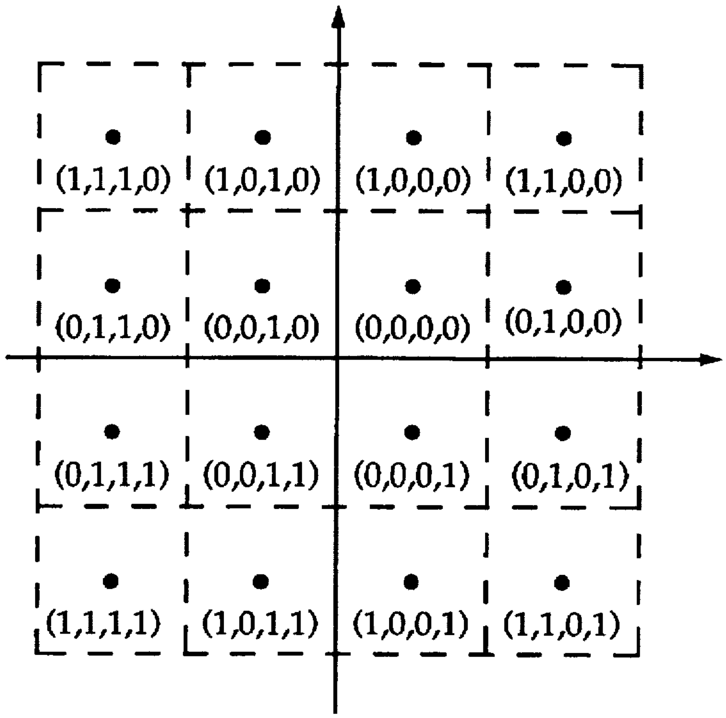
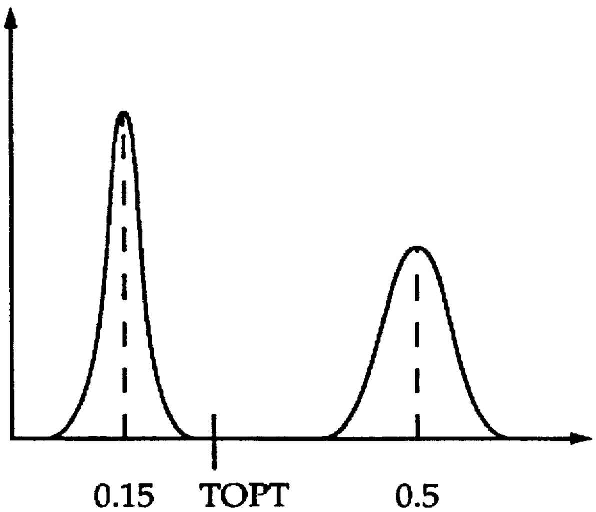


FIG. 4



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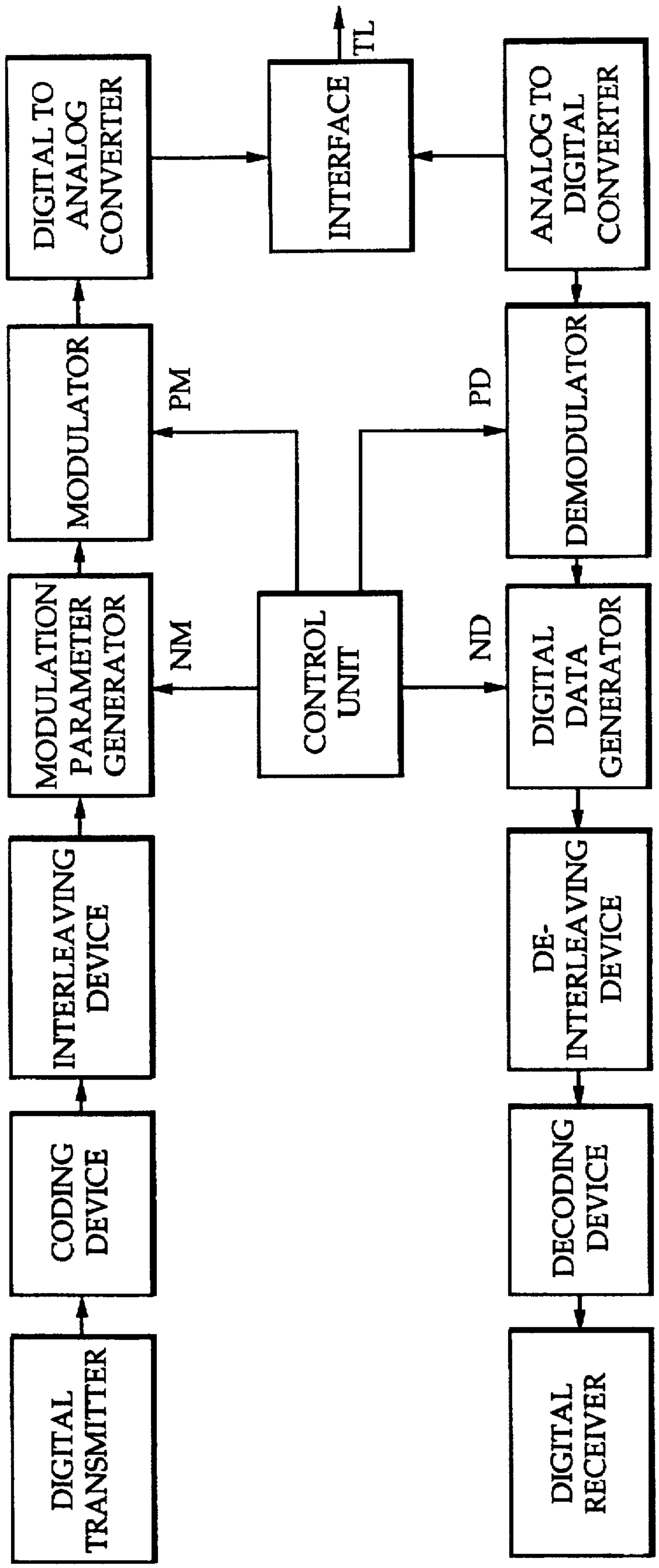

FIG. 2

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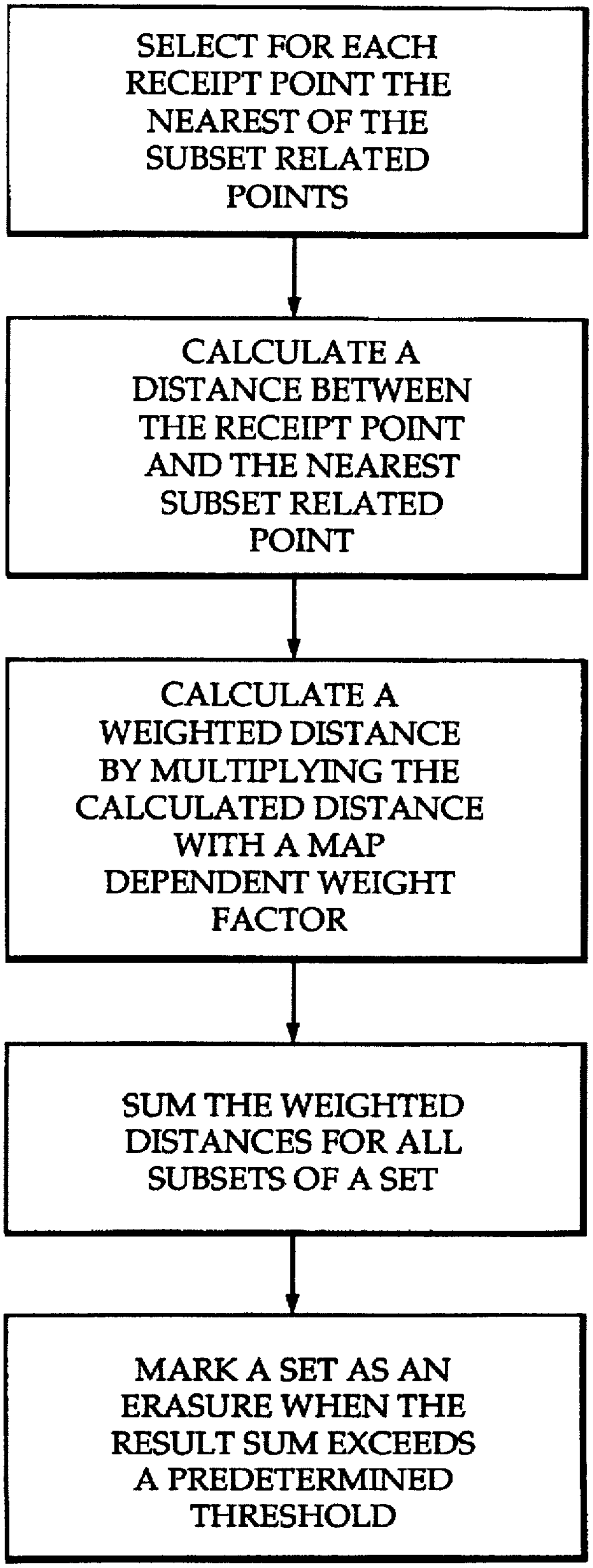

FIG. 5

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METHOD FOR DETECTING ERASURES IN RECEIVED DIGITAL DATA

TECHNICAL FIELD

The present invention relates to a method for detecting erasures in a stream of sets of digital signal values received at a receiver side after transmission from a transmission side.

BACKGROUND OF THE INVENTION

In this context, an erasure means a faulty set having a known position in the stream, and is thus different from an error which indicates a faulty set having an unknown position in the stream. Such a method is already known in the art, e.g. from the book 'Theory and practice of error control codes', by R. E. Blahut, published by Addison-Wesley Publishing Company, Reading, 1983, pp. 11 and 199. Therein, it is used in a receiver which processes the stream of sets of digital signal values and declares a set erased either when it is received ambiguously (p. 11), or when presence of interference or a transient malfunction is detected (p. 11), or when various internal validity checks fail (p. 199). However, from this book it is not clear at all which criterion should be used to decide when a set is received ambiguously, or when interference or a transient malfunction is present, or which internal validity checks should be performed.

The advantage of being able to detect whether a set is erased or not becomes apparent when the stream of digital signal values is encoded according to an error-correcting code having a so-called minimum distance d. Indeed, in that case, a number of R errors and E erasures in this bit stream may be corrected when $2\times R+E+1\leq d$. Thus, by detecting erasures the error correcting capability of the code is doubled for a given minimum distance d. This may be appreciated from the fact that half the error correcting work, specifically the work locating faulty digital signal values in the stream, is already performed when an erasure is detected.

DISCLOSURE OF INVENTION

An object of the present invention is to provide a method of the above known type, but which is fully elaborated.

According to the invention, this object is achieved due to the fact that subsets of said sets of digital signal values are modulated on distinct carrier signals, each transmitted and received thus modulated carrier signal corresponding to one of a number of predetermined subset related points and to a receipt point on a carrier dependent modulation representing map respectively, and that said method includes the steps

- selecting for each said receipt point the nearest of said predetermined subset related points;
- calculating a distance between said receipt point and said nearest subset related point and multiplying this distance with a map dependent weight factor;
- summing the thus obtained weighted distances for all subsets of a set; and
- marking the latter set as an erasure when the thus obtained result exceeds a predetermined threshold.

The invention is based on the insight that the transmitted stream is submitted to noise before being received at the receiver side, and that in general this noise is additive white gaussian noise corrupting only a limited number of digital signal values per set, whereas occasionally short bursts of so-called impulse noise may occur corrupting close to all digital signal values of a set. Thus, when during transmission of a set impulse noise occurs, this set had best be marked as

an erasure. The above method provides a criterion for deciding whether impulse noise occurs or not. It is to be noted that modulation parameters such as power allocated to the various carrier signals and the modulation representing map, and encoding techniques for encoding the stream of digital signal values are chosen to cope with the additive white gaussian noise but not with the impulse noise.

Indeed, when the transmitted stream is submitted to additive white gaussian noise before being received at the receiver side, the receipt point for each carrier is close to the one of the subset related points which corresponds to the respective transmitted modulated carrier signal. As a consequence, the nearest subset related point is most likely constituted by the latter subset related point. Thus, an interpretation of the receipt point as the nearest subset related point is most probably correct. Furthermore, the distance between the nearest subset related point and the receipt point, which is a measure of the noise to which the received stream has been submitted, is probably small. By weighing this distance or noise measure with the map dependent weight factor it is in fact normalized and has a probability distribution with a small mean distance. When the thus normalized distances or noise measures are then summed for all modulated carriers, an average normalized distance is obtained which has a gaussian probability distribution with a mean equal to the above small mean distance and a variance which is inversely proportional to N, N being the number of carriers over which the normalized distances are summed.

On the other hand, when the transmitted stream is submitted to impulse noise, this impulse noise having a relatively flat probability distribution characteristic compared to that of the additive white gaussian noise, the relation between the receipt point and the one of the subset related points which corresponds to the respective transmitted modulated carrier signal is fully corrupted for all carriers. As a consequence, an interpretation of the receipt point as the nearest subset related point is most probably wrong and each subset had best be marked as erased. Furthermore, the mean distance between the nearest subset related point and the receipt point is relatively large. By weighing this distance with the weight factor normalized distances are obtained which have a probability distribution with a relatively large mean distance. When these normalized distances are then summed for all modulated carriers, an average normalized distance is obtained which has a gaussian probability distribution with a mean equal to the above relatively large mean distance and a variance which is inversely proportional to N, N being the number of carriers over which the normalized distances are summed.

To be noted that both the additive white gaussian noise and the impulse noise have a relatively flat power spectrum whereby all carrier frequencies are equally affected by them.

It may be appreciated from the above, and it will become apparent later, that the obtained sum has a gaussian probability distribution which in case of additive white gaussian noise has a lower mean value than in case of impulse noise, and that in both cases the variance on this value is low. Thus, by comparing the obtained sum with the predetermined threshold a criterion is provided for deciding whether the subsets of a set are only slightly corrupted (gaussian noise) or fully corrupted (impulse noise). This threshold is so chosen that the probability for an erroneous decision is minimized.

Another characteristic feature of the present invention is that for each said carrier the transmit power and said carrier dependent modulation representing map are chosen such

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