Title: Sequence detecting by multi-valued coding
Increasing the difference between dissimilar sequences

Author: Peter Lablans, Ternarylogic LLC

Patent Application: US 11/141,336

Date: May 25, 2006

The problem with comparing binary sequences

Comparing binary sequences is an essential technique in current applications such as wireless communications. In spread-spectrum technology a binary symbol will be translated into a sequence of bits at the transmitting side. On the receiving side a piece of equipment will try to detect the sequence, usually from a multitude of sequences.

The way how this is done is quite elaborate. A sequence identical to the expected sequence will be generated locally and will be compared with a received sequence. For each symbol of the received sequence and of the local sequence that are identical a number (say 1) is added to a sum. If the symbols are different a number (usually also a 1) is subtracted from a sum. When the sum is identical to the total of symbols in an expected sequence the sequence is assumed to be detected.

When the received sequence is the expected one, but out of sync with the local sequence the sum (or correlation) between the two sequences will be smaller than the maximum. How much smaller depends on the 'make-up' of the sequence.

In general one uses sequences with a single peak auto-correlation and with a low cross-correlation. Assuming an even statistical distribution of 0s and 1s in sequences, the autocorrelation peak of a sequence of p bits will p above the average cross-correlation of about 0. That is because in full alignment all bits will contribute to the correlation, while out of alignment there will on average be as many bits identical between two sequences as there will be bits different.

This makes it difficult to use other than pseudo-noise type sequences or related types like Gold sequences. Sequences with additional peaks in their auto-correlation, which are lower than the main peak in the correlation, certainly with transmission over channels with noise, may lead to faulty detection.

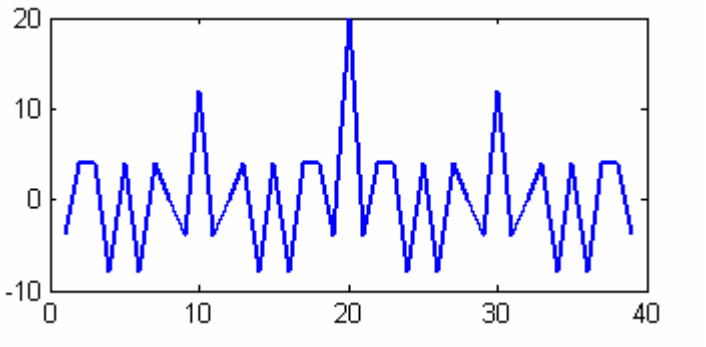
Multi-valued coding of the binary sequences can drastically increase the difference between sequences with a limited distance and remove unwanted peaks in auto-correlation.

Multi-valued coding

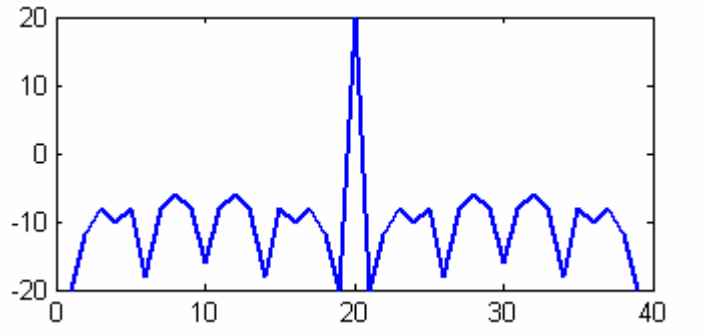
The problem with binary correlation techniques is that the statistics are working against large differences between sequences. There is a 50% chance that a 1 in one sequence will see a 1 in another sequence. One may try to change the order of bits, only to find that 'unwanted' peaks pop-up elsewhere in the correlation.

A way to change the statistics in our favor is to apply multi-valued coding to the sequence during detection. One still transmits a sequence in binary form. However at the receiving side the received sequence as well as the locally generated sequence will be coded according to a multi-valued coding rule.

For instance assume the binary sequence to be:
bin = [1 0 0 1 0 1 1 1 1 1 1 0 0 1 0 1 1 0 1 0].
The following figure shows the correlation graph of this sequence.



As simple multi-valued coding scheme is:
for 0s: code a first 0 as 0; code a second 0 as 2; code a third 0 again as 0; etc.
for 1s: code a first 1 as 1; code a second 1 as 3; code a third 1 again as 1; etc.
This will generate the following 4-valued sequence:
bin4 = [1 0 2 3 0 1 3 1 3 1 3 2 0 1 2 3 1 0 3 2].
The following figure shows the correlation graph of this sequence.



The result of multi-valued coding is improving differentiating between main peak and side-peaks in the correlation.

The reason for the improvement in correlation is again statistical. The chance for a 3 to see another 3 is .25*.25. The combined chance for a 0, 1, 2 or 3 to match at a symbol position is 25%, which is smaller than in the binary case. The peak value under the selected correlation scheme remains the same.

The graphs shown are the auto-correlation graphs. These are different from detection graphs, which in general are not symmetrical around the peak.

A 4 valued coding rule may not be sufficient to shave all side peaks, and one may have to use higher valued coding methods.

One should also keep in mind that errors may occur during transmission. The coding rule as presented here may lead to catastrophic errors. Consequently one should limit coding runs based on expected BERs.

An advantage of this coding method is that one can apply this to sequences that would normally not be considered for spread-spectrum purposes.

Patent Application

The method of sequence detection by multi-valued coding is an aspect of an invention that has been filed as a US Patent Application. The Patent Application is published in the USPTO Pregrant Patent Application database as number ***20050265463***.

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About Ternarylogic LLC: Ternarylogic LLC is a New Jersey based R&D company. Its mission is to create novel MVL technology. The company owns a portfolio of inventions related to scramblers/descramblers, sequence generators and sequence detectors, sequence correlators, gates and inverters based circuitry, non-binary multipliers, latches and other non-volatile memory elements, optical disk applications and MC-DSSS technology.

Intellectual Property Rights

Methods and apparatus disclosed herein are part of Ternarylogic's IP rights. Please review our portfolio.