**Differential Encoding**

Simple example of transform coding mentioned earlier and instance of this approach.

Here:

* The difference between the actual value of a sample and a prediction of that values is encoded.
* Also known as ***predictive encoding***.
* Example of technique include: differential pulse code modulation, delta modulation and adaptive pulse code modulation -- differ in prediction part.
* Suitable where successive signal samples do not differ much, but are not zero. ***E.g.*** Video -- difference between frames, some audio signals.
* ***Differential pulse code modulation*** (DPCM) simple prediction:

*fpredict*(*ti*) = *factual*(*ti*-1)

***i.e.*** a simple Markov model where current value is the predict next value.

So we simply need to encode:

\begin{displaymath}
\Delta f(t_i) = f_{actual}(t_{i}) - f_{actual}(t_{i-1})\end{displaymath}

If successive sample are close to each other we only need to encode first sample with a large number of bits:

Actual Data: 9 10 7 6

Predicted Data: 0 9 10 7

$\Delta f(t)$: +9, +1, -3, -1.

* ***Delta modulation*** is a special case of DPCM: Same predictor function, coding error is a single bit or digit that indicates the current sample should be increased or decreased by a step.

Not Suitable for rapidly changing signals.

* ***Adaptive pulse code modulation*** -- Fuller Markov model: data is extracted from a function of a series of previous values: ***E.g.*** Average of last *n* samples. Characteristics of sample better preserved.

**differential encoding:** Encoding in which [signal](https://www.its.bldrdoc.gov/fs-1037/dir-033/_4851.htm) significant conditions represent [binary](https://www.its.bldrdoc.gov/fs-1037/dir-005/_0602.htm) [data](https://www.its.bldrdoc.gov/fs-1037/dir-010/_1401.htm), such as "0" and "1", and are represented as changes to succeeding values rather than with respect to a given reference. *Note:* An example of differential encoding is [phase-shift keying](https://www.its.bldrdoc.gov/fs-1037/dir-027/_3945.htm) (PSK) in which the [information](https://www.its.bldrdoc.gov/fs-1037/dir-019/_2720.htm) is not conveyed by the absolute phase of the signal with respect to a reference, but by the difference between phases of successive symbols, thus eliminating the requirement for a phase reference at the receiver.

Hi

does anyone know why differential encoding of data is done

in GSM before modulation ?

( As I understand , this is not to enable noncoherent detection, but

is related to the connection between gmsk and msk which is an offset-PAM

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shankar

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Reply by **Chris Mason** ●September 20, 2004

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consecutive decision errors result in three bit errors. Three

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Differential decoding eliminates the extra bit error. In most cases

this means that one decision error results in one bit error. If the

errors are randomly distributed, this will result in an improvement by

a factor of 2 (approximately). If decision errors are consecutive,

the improvement is less. Note: Differential decoding reduces the net

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towards MSK. MSK has no ISI, whereas the filtering of the signal to

produce GMSK introduces ISI (in favor of a tighter spectrum).

Differential encoding/decoding works the same on both GMSK and MSK.

There is no connection between MSK/GMSK with respect to differential

encoding.

There may be other reasons for the differential encoder in addition to

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Chris Mason

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Reply by **Eric Jacobsen** ●September 21, 2004

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Reply by **Chris Mason** ●September 21, 2004

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This gives the generic phase trellis shown on page 523.

For our example, we start at a phase of zero radians.

k: 0 1 2 3 4 5 6

Bits: 1 0 0 0 1 0

Phase: 0 pi/2 0 -pi/2 -pi -pi/2 -pi

Assume at time k = 4, we make a detection error of zero instead of

-pi.

k: 0 1 2 3 4 5 6

PhaseRx: 0 pi/2 0 -pi/2 0 -pi/2 -pi

BitsRx: 1 0 0 1 0 0

Notice that we made one detection error and that results in two bits

in error (bit3,4 and bit4,5).

If differential encoding is used (initial state of '1'), and an error

is observed again at time k=4:

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PhaseTx: 0 -pi/2 0 -pi/2 -pi -pi/2 0

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Now only bit3,4 is in error after differential decoding.

Let me know if my analysis is flawed in anyway.

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Reply by **Eric Jacobsen** ●September 21, 2004

Very nice explanation, thanks.

On 21 Sep 2004 09:27:55 -0700, ckizlyk@hotmail.com (Chris Mason)

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Reply by ●September 22, 2004

"Chris Mason" <ckizlyk@hotmail.com> wrote in message

news:25b3fe9c.0409210827.42edc2b3@posting.google.com...

> eric.jacobsen@ieee.org (Eric Jacobsen) wrote in message

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> I'll use the MSK example in page 524 in A. Bruce Carlson

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<<<<<much material snipped>>>>>

All this is correct, but it should also be remembered that the method

being used for demodulation of MSK is not the optimum method

(which treats MSK as offset QPSK). With the offset QPSK

approach, bits b[2n] and b[2n+1] are demodulated at times

t = 2n and t = 2n+1 respectively in the I and Q branches respectively

of the receiver, and are then multiplexed to form a single bit stream.

More important is the point that bit b[2n] modulates the signal

from t = 2n-2 to t = 2n, while bit b[2n+1] modulates the signal from

t = 2n-1 to t = 2n+1. Therefore, each decision statistic is gathered over

(i.e., the I and Q correlators integrate over) over TWO (overlapping)

bit intervals: from t = 2n-2 to t = 2n for b[2n] in the I branch and from

t = 2n-1 to t = 2n+1 for b[2n+1] in the Q branch. Also, each

branch is demodulating an antipodal binary PSK signal.

The MSK demodulation method described by the OP uses the fact that

during the interval from t = 2n-1 to t = 2n, BOTH b[2n] and b[2n+1] are

modulating the signal (in fact, the "data" bit is effectively

b[2n].XOR.b[2n+1],

which the way it is in differential encoding). Indeed, the signal is an

orthogonal FSK signal at frequency f\_c + 1/4T or f\_c -1/4T depending

on the data bit. The decision statistic is gathered over just ONE bit

interval

(from t = 2n-1 to t = 2n). Thus, the raw BER is worse than with the

offset QPSK approach (less bit energy, and orthogonal instead of antipodal

signaling), and of course the differential decoding further exacerbates the

BER (as noted by the OP).

--Dilip Sarwate

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Reply by **kbc** ●September 23, 2004

I saw the replies just now.

Thanks chris and others.

shankar

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