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Title: MOTION COMPENSATED PREDICTION

For block based motion compensation using side information, there are three main different kind of strategies:

a) Integer pel displacement without filterring

b) Integer pel displacement with filterring

c) Fractional pel displacement

This paper is an effort to clarify the differences and similarities between the three.

Introduction

In all strategies, side information is used to indicate to the decoder which predictor to use for a block. Heuristically speaking, each predictor corresponds to a motion vector, or a certain amount of displacement (translational) for the block. However, in this paper I preffer to speak about "one predictor from a pre-defined set of predictors", which is equivalent to saying "one motion vector from a pre-defined set of motion vectors". It is not important, from a standardisation point of view, how the predictor (motion vector) is chosen in the coder. On the other hand, when the predictor is chosen, it is necessary that coder and decoder use the same predictor, and thus the set of predictors must be standardized.

a) Integer pel displacement without filterring

In this strategy the set of predictors contain a number of predictors, all using one pel in previously coded picture with the predictor coefficient = 1,0

$$x(i,j,t) = 1{,}0 * y(i-h, j-v, t-1)$$

where x is prediction and y is coded pel, (h,v) is usually denoted "motion vector" for obvious reasons.

b) Integer pel displacement with filterring

In this strategy the set of predictors only contain one predictor with one pel from previously coded picture. This predictor corresponds to "zero motion vector".

$$x(i,j,t) = 1{,}0 * y(i,j,t-1)$$

All other predictors, corresponding to "non-zero motion vectors" contain more than one pel from previous picture, each with a prediction coefficient ci. The sum of ci is usually 1,0.
In fact, the use of more than one pel in the predictor, is equivalent to filterring previous picture, hence the name of the strategy.
In Swedish simulations these predictors contain five pels (corresponding to a 5-tap FIR filter) with prediction coefficients c1 = 0,5 , c2-c5 = 0,125.

$$\begin{aligned} x(i,j,t) = \; & c1 * y(i-h, j-v, t-1) \\ + \; & c2 * y(i-h+1, j-v, t-1) \\ + \; & c3 * y(i-h-1, j-v, t-1) \\ + \; & c4 * y(i-h, j-v+1, t-1) \\ + \; & c5 * y(i-h, j-v-1, t-1) \end{aligned}$$

The denotion "(h,v) is motion vector" is convenient also for this case.

c) Fractional pel displacement
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In this strategy, the same set of predictors as for "Integer pel displacement without filterring" is used. However, the set is extended with even more predictors containing two or four pels. These new predictors correspond to fractional displacement. For example, if the motion vector is (3.5,1) the predictor is

$$x(i,j,t) = 0.5 * y(i-3,j-1,t-1) + 0.5 * y(i-4,j-1,t-1)$$

This predictor can also be viewed as horizontal filterring of previously coded picture. In a similar way, vertical filterring can be achieved by using fractional displacement in the vertical direction. Example: (h,v) = (0,-0.5) gives the predictor

$$x(i,j,t) = 0.5 * y(i,j,t-1) + 0.5 * y(i,j+1,t-1)$$

Of course it is possible to have fractional displacement in both horisontal and vertical direction at the same time. For example: (h,v) = (4.5,-3.5) gives the predictor

$$x(i,j,t) = 0.25 * y(i-4,j+3,t-1) + 0.25 * y(i-4,j+4,t-1) + 0.25 * y(i-5,j+3,t-1) + 0.25 * y(i-5,j+4,t-1)$$

If displacements other than half pels are introduced, the predictor coefficients become more complicated. For example: (h,v) = (0.25,0.75) gives a four pel predictor

$$x(i,j,t) = 0.25 * (0.75 * y(i,j,t-1) + 0.25 * y(i-1,j,t-1)) + 0.75 * (0.75 * y(i,j-1,t-1) + 0.25 * y(i-1,j-1,t-1))$$

It should be pointed out that it is up to the coder to decide which motion vector to use. If the coder finds an improvement by using a filter, the corresponding motion vector is transmitted. Thus, in fractional displacement, a larger freedom than in integer displacement with filterring is achieved, to the cost of increased complexity.