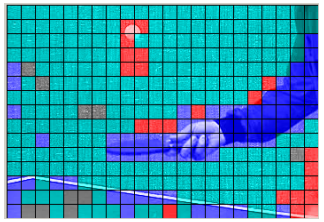
CS4405

MPEG Video

Coding Mode Decisions



Display of macroblock coding types within a frame

Depending on the picture coding type, different macroblock coding types are available, this is a choice made by the encoding application

MPEG-1 Macroblock Coding Mode

- MB of I-frame use INTRA mode only
- MB of B, P frames are coded in several modes depending on macroblock error (based on the Mean Squared Error)

$$\frac{1}{MN}\sum_{i=1}^{M}\sum_{j=1}^{N}(x_{ij}-y_{ij})^2$$

- Mode decision
  - If MSE(MB) < threshold$_1$ then code MV only
  - If threshold$_1$ < MSE(MB) < threshold$_2$ then code MV + DCT(DFD)
  - If MSE(MB) > threshold$_2$ code using INTRA mode

Displaced Frame Difference

INTRA Mode and INTER Mode

- INTRA mode the texture of the macroblock is coded via a DCT transformation, quantisation, and entropy coding
- No motion compensation is required in this mode

INTRA Mode and INTER Mode

- INTER mode uses motion compensation
  - A motion compensated difference block (residual block) is formed by subtracting the pixel values of the predicted block from that of the current block point by point
  - Texture coding is performed on the difference block
  - The coded motion vector and the coded texture information of the difference block are transmitted to the decoder

INTER Mode

- Because most of the blocks in the current frame are similar to a predicted block in reference frames, the residuals are usually very small
  - In this case a small amount of bits can encode the residual block (DFD) using the DCT
  - **Most of the time** coding the motion vector as well as coding the residue costs fewer bits than coding the texture of the block

INTER Mode

- In some cases (e.g., scene change, object occlusion), coding the difference block and the motion vector may require more bits than directly coding the texture of the current block
- Consequently there must be a way to decide when to choose INTRA mode and when to choose INTER mode

Making Coding Mode Decisions

- A solution of choosing INTRA/INTER mode for a block should compare

$$\#bits(VLC(Q(DCT(B_i))))$$

$$\#bits(VLC(Q(DCT(MC(B_i)))))+\#bits(MV_{B_i})$$

- When the distortion is the same
  - If the first term is smaller then INTRA mode is preferred
  - Otherwise INTER mode is preferred

Example Decision Algorithm

- It is computational intensive to calculate the bit counts and distortion
- To simplify the computation calculate

$$SAD = \min_{MV_x,MV_y} \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} |p(i+MV_x, j+MV_y) - c(i,j)|$$

$$mean = \frac{1}{N^2}\sum_{i=0}^{N-1}\sum_{j=0}^{N-1} c(i,j)$$

$$VAR = \sum_{i=0}^{N-1}\sum_{j=0}^{N-1} |c(i,j) - mean|$$

VAR is the sum of the absolute deviations from the mean – a measure of the spread of the data

$N = 16$

Example Decision Algorithm

- The INTRA mode is chosen if

$$VAR < SAD - 2 \times N^2$$

- SAD is reduced to favour selection of INTER mode when there is no significant difference in the energy of predictive residuals and the energy of original texture

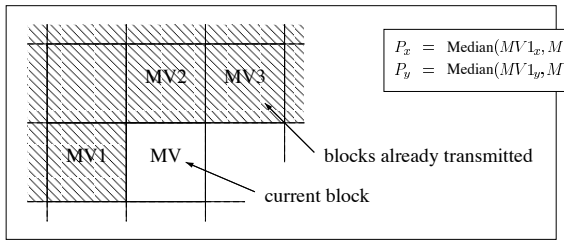
Limitations

- This approach is too simple to cover all cases
  - It does not take in account the bits required for coding motion vectors
  - In INTRA mode these "saved bits" can be used for texture coding

Coding Motion Vectors

- Motion vectors in a neighbourhood are usually similar
  - So they can be coded differentially
- A difference is calculated between the current motion vector and the prediction of current motion vector
  - For example use a spatial neighbourhood of three motion vectors already transmitted to predict the current motion vector

Coding Motion Vectors



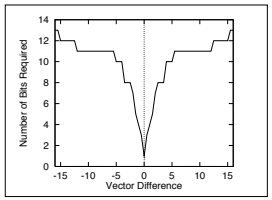
$$P_x = \text{Median}(MV1_x, MV2_x, MV3_x)$$
$$P_y = \text{Median}(MV1_y, MV2_y, MV3_y)$$

$$MVD_x = MV_x - P_x$$
$$MVD_y = MV_y - P_y$$

The median is the middle of the sorted values

Coding Motion Vectors

- Represent the difference between the actual motion vector and the predicted motion vector (VLC)
  - The smaller the difference the less the bits required
- The zero differential motion vector allows more bits to code the residual component



Coding Motion Vectors

- The SAD of the zero difference predicted MV is reduced as follows

$$SAD(P_x, P_y) - N^2/2 + 1$$

$$MVD_x = 0 \implies MV_x = P_x$$
$$MVD_y = 0 \implies MV_y = P_y$$

- To favour the zero difference vector when there is no significant difference in the SAD
- With this adjustment in place the displacement vector resulting in the lowest SAD is chosen as the motion vector

Problems

- The choice of coding modes gets more complicated when the motion vectors are coded differentially as

$$\#bits(VLC(Q(DCT(MC(B_i)))) + \#bits(MV_{B_i})$$

- not only depends on the texture of the block but also depends on the motion vectors which are already transmitted
- Also the next optimal motion vector also depends on the current decision