Notes for week 4 part 1 (MPEG Encoding)

Macroblock encoding

Macroblocks are encoded via forward prediction vectors, backward prediction vectors, bi-directional prediction vectors, or they are intracoded. Which type of encoding is used is dependent upon two factors: which type of frame is being encoded, and which type of encoding saves the most space (highest compression). Macroblocks within a B frame can be encoded by any of the encoding methods, P frames by either forward prediction or intracoding, and I frames can only be intracoded.

Determining which encoding method has the highest compression is done by calculating the mean square error. The mean square error is the average square difference between the macroblock being encoded and the 16x16 pixel region being used as the reference area. The formulas for the mean square error for each type of macroblock encoding are as follows (where $MB$ is the 16x16 pixel macroblock being encoded and $MR$ is the 16x16 pixel macro region being used as the reference):

- **Forward Predicted:**
  $$\frac{1}{256} \sum (MB - MR)^2$$

- **Backward Predicted:**
  $$\frac{1}{256} \sum (MB - MR)^2$$

- **Bi-directionally Predicted:**
  $$\frac{1}{256} \sum \left( MB - \frac{MR_{\text{Front}} + MR_{\text{Back}}}{2} \right)^2$$

- **Intracoded (no prediction):**
  $$\frac{1}{256} \sum MB^2$$

*Note that summations are over all pixels within the 16x16 macroblock/macro region

*In each case, the error value for each pixel is the equation inside the parenthesis (i.e. the error value for a pixel in a macroblock that is forward predicted is $MB-MR$)

Once the mean square errors for each valid encoding method (depends on whether this is an I frame, P frame or B frame) are computed, the minimum of the four selected as the encoding method for that macroblock. Notice that different macroblocks within the same frame can be encoded differently (i.e. one can be forward predicted, another bi-directionally predicted…etc.).

Also note that each prediction method is computed several times per macroblock, and only the minimum of those is kept for the final comparison between encoding methods. This is because the reference area can be any 16x16 area in the reference frame (but is usually restricted to an area within a certain range of the macroblock’s location). See below.
Example mean square error computation for forward prediction
After all mean square errors for forward prediction are computed, the minimum one is selected as the position and value for the forward motion vector.

Note that the size of the search area is NOT restricted to a 32x32 area. The size of the search area is left to the discretion of the MPEG encoder.