Interframe Compression

• The simple way is a frame-by-frame compression (JPEG-like): Limited compression ratio

• Interframe compression exploits temporal redundancies due to similarity between successive frames, (In addition to spatial, spectral and psychovisual redundancies in still image compression)

• No Random Access at all frames!
Possible Strategies

- 3-D Waveform coding (TC / Sub-Band)
- Object/Knowledge based coding
- Motion Compensation based coding
Motion Compensation Approach

• Segmenting each frame to “changed” and “unchanged” regions (Vs. previous frame)

• Pixels in changed region are DPCM encoded (between successive frames and following motion compensation)
Frame 2 Macro Block
Motion Compensation  (Cont’d)

• Amount of changed info. varies from frame to frame (VLC): a buffer needed

• A motion detection algorithm needed

• MC-DPCM is efficient if displacement vectors estimation is accurate
Motion Compensation (Cont’d)

• **ideally**: motion info for each pixel
  – too expensive

• **semantically**: motion data for each region or object
  – second generation coding techniques

• **simplified**: motion info for each 16x16 macroblock
Motion Model

• Affine motion:
  – translation, rotation, scale
  – 6 parameters in 2D
  – complex

• Simplified translational model:
  – motion vectors (MV, 2 parameters)
ME Options

• optimal motion vector?
  – investigate all positions within a search window
  – keep the one with minimum Mean Square Error
  – MV = corresponding translation
Motion Estimation Techniques

The choice of sending zero MV, is always available, with no cost…and worst results.

• **Backward prediction**
  – Predict where the pixels in a current frame were in a past frame

• **Forward prediction**
  – Predict where the pixels in a current frame will go to in a future frame
Motion Estimation

Block Matching Method

• Motion vector is estimated by pixel domain search procedure
• Most popular due to lesser h/w complexity
• Basic idea:
Matching Criteria

• Maximum cross-correlation
• Maximum pel matching count (MPC)
• Minimum mean squared error (MSE)
  Not popular in VLSI due to square operation
• Minimum mean absolute difference (MAD)
  Very popular but problematic due to several possible local minima
• SNR
Other Parameters

• Calculation and implementation
• Visual results ...
Full Search & Zero MV results
Search Procedure

- Full search (inside the search window)
- Three step
- Conjugate direction

3-Step

Conjugate direction

12 pixels
3 or 4 Step Search Results

SNR

Full search

No search
Conjugate Direction Search
## Search Algorithm results

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Ave. SNR(dB)</th>
<th>Calculations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full search</td>
<td>28.46</td>
<td>100% (~7M)</td>
</tr>
<tr>
<td>Zero Search</td>
<td>27.7</td>
<td>0</td>
</tr>
<tr>
<td>Conjugate</td>
<td>27.9</td>
<td>2%</td>
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<tr>
<td>Orthogonal</td>
<td>28.1</td>
<td>3.6%</td>
</tr>
<tr>
<td>Decimation</td>
<td>28.2</td>
<td>33%</td>
</tr>
<tr>
<td>Pyramid and more...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MC Transform Coding

• Temporal prediction error is 2-D transform coded by segmenting the displaced frame difference into blocks, and encoding the DCT coeff. of each block
  
• *Intra* and *Inter* modes

• *Field* and *frame* modes
Other MC Compression Techniques

• **Vector Quantization:**
  Prediction error signal encoded by VQ

• **Sub-Band Coding:**
  Frame prediction error (residual) is decomposed into 2-D subbands
Video Compression (Cont’d)

• **Complete process:**
  – Encode every N frame “JPEG style”
  – Between the “JPEG style” frames, predict the motion from frame to frame
  – Subtract the predicted frame from the original one and encode the difference

• **Compression ratio: about 100:1 and more**
Motion Compensation

- frame #0
- difference frame

- frame #1
- motion compensated difference frame
Prediction Technique

Bidirectional Interpolation