Outline

- Position and Research targets of System LSI application group

Activities for video processing SoC
- Content based ME for MPEG and H.264
- Video coding based on adaptive tree
- Selective video encryption
- Adaptive fast-forwarding
Faculties and research area

Application Area
Multimedia, Mobile, Ubiquitous

System LSI application group

High Level Design and Verification
Satoshi Goto
Takaaki Baba

On-chip Memory and CAM
Takeshi Ikenaga

Logic Design
Takeshi Yoshimura
Shinji Kimura

Partitioning and Layout
Takahiro Watanabe
Yasuaki Inoue

Integration of Digital / Analog, MEMS, Sensors and Micro Energy
Tsutomu Yoshihara
Yoshihara

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Research Target

Knowledge processing
- Recognition, Data mining, ..

Security processing
- Encryption, Virus detection, ..

Image processing
- Image coding, Computer graphics, ..

Network processing
- Error collection, Adaptive network, ..

Media Communication
Activity map of video processing SoC

3) Selective video encryption

Video security

4) Adaptive fast-forwarding

International standard

MPEG2/4, H.264

1) Content based ME algorithm

Non-international standard

2) Video coding based on adaptive tree
Content-based Motion Estimation with
Extended Spatial-Temporal Analysis

1. Video Contents Identification
Recognition of different video nature

2. Content-based Adaptive Algorithm
Dynamic optimization of M.E strategy

Temporal-Spatial analysis on motion vector distribution


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Evaluation Results

1. Computational Complexity in terms of No. Search points / block

<table>
<thead>
<tr>
<th></th>
<th>Akiyo</th>
<th>Carphone</th>
<th>Foreman</th>
<th>Stefan</th>
<th>Football</th>
</tr>
</thead>
<tbody>
<tr>
<td>FS</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
<td>961</td>
</tr>
<tr>
<td>TSS</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>Our Method</td>
<td>24.7</td>
<td>25.8</td>
<td>26.1</td>
<td>28.2</td>
<td>37.4</td>
</tr>
</tbody>
</table>

2. Visual quality in terms of PSNR

Max PSNR drop: 0.334db, while that of TSS: 1.984db

PSNR of Y plane, Stefan (CIF), 90 frames, 1024kbps.
Video Coding Algorithm Based on Adaptive Tree for Low Power Consumption

New Video Encoding for Low Power Consumption

- Encoding Rate Control
- Averaging Pixels’ Levels
- Quantization
- Variable Length Coding
- Coding Data

Video Image Input

- Segmentation Decision
- Block Segmentation
- Repeating till the pixels in the block can be regarded as same levels.

**Evaluation Results**

<table>
<thead>
<tr>
<th>Method</th>
<th>Encoding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPEG-4 TM5 (Microsoft Version)</td>
<td>65.7 msec/frame</td>
</tr>
<tr>
<td>Proposed Method</td>
<td>5.5 msec/frame</td>
</tr>
<tr>
<td>Oct Tree Method</td>
<td>4.6 msec/frame</td>
</tr>
</tbody>
</table>

**Rate-Distortion**

<table>
<thead>
<tr>
<th>Bit Rate [bit/pel]</th>
<th>PSNR [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPEG4</td>
<td>Proposed</td>
</tr>
<tr>
<td>Oct Tree</td>
<td></td>
</tr>
</tbody>
</table>

**Frame Image Quality**

Test Sequence “Miss America”
Selective Video Encryption Scheme for MPEG Compression Standard

- Video Conference
- Video Surveillance

Bitrate:
- Raw video data: 30-100Mb/s
- MPEG1: 1.5Mb/s
- MPEG2: 16Mb/s
- MPEG4: 32-384Kb/s

- Full Encryption (conventional)
- Selective Encryption (our approach)

DES / AES

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Event Shuffle

Block Group

ZigZag: <AC0,AC1,AC8,AC16...> RLE: <1,0,1,0,2,0,1,2,-1...>

ZigZag: <AC0,AC1,AC8,AC16...> RLE: <2,0,0,0,3,0,1,0,0,-4...>

ZigZag: <AC0,AC1,AC8,AC16...> RLE: <0,0,-6,0,2,0,0,0,5...>

Table for shuffle the Events in groups (36,12,1,63,27,2...15,3)

Detail information of blocks is concealed

### Evaluation results

#### Evaluation result of processing time

<table>
<thead>
<tr>
<th>Video Sequence</th>
<th>MPEG encoding Time(ms)</th>
<th>Event Shuffle (proposed method)</th>
<th>Block Shuffle</th>
<th>Subband Shuffle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Group Number</td>
<td>Time(ms)</td>
<td>Overhead</td>
</tr>
<tr>
<td>&quot;Carphone&quot;</td>
<td>6906</td>
<td>2831</td>
<td>15.09</td>
<td>0.22%</td>
</tr>
<tr>
<td>&quot;Susie&quot;</td>
<td>8407</td>
<td>2923</td>
<td>15.10</td>
<td>0.18%</td>
</tr>
<tr>
<td>&quot;Foreman&quot;</td>
<td>7343</td>
<td>4065</td>
<td>21.24</td>
<td>0.29%</td>
</tr>
<tr>
<td>&quot;Salesman&quot;</td>
<td>4985</td>
<td>4410</td>
<td>23.09</td>
<td>0.46%</td>
</tr>
</tbody>
</table>

#### Evaluation result of Bit overhead

<table>
<thead>
<tr>
<th>Scramble Method</th>
<th>File Size (Byte)</th>
<th>Bit Overhead (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Scramble</td>
<td>165,617</td>
<td>0</td>
</tr>
<tr>
<td>Event Shuffle(ours)</td>
<td>165,617</td>
<td>0</td>
</tr>
<tr>
<td>Sub band Shuffle</td>
<td>198,409</td>
<td>19.8</td>
</tr>
<tr>
<td>Block Shuffle</td>
<td>259,025</td>
<td>56.4</td>
</tr>
</tbody>
</table>
Sample video sequences of a surveillance camera

6X fixed-speed fast-forwarding (20 sec)

Proposed adaptive fast-forwarding (14 sec)
Sample video sequences of a camcorder

5X fixed-speed fast-forwarding (54 sec)  Proposed adaptive fast-forwarding (47 sec)
Adaptive fast-forwarding algorithm

Motion analysis

- # of motion vector
- # of intra block (macro block type)

I-picture

B-picture

P-picture

varied

monotonous

Display

Not display
Hardware evaluation

Process technology: ROHM 0.35 μm
Synthesis tool: DESIGN COMPILER (synopsys)
Back-end tool: Apollo (synopsys)
Number of Gate: 502 gates
Area: 0.2 × 0.2mm²
Clock frequency: 457MHz
Summary

- System LSI application group challenges to develop various kinds of video processing SoCs as well as security and network processing SoCs

- Activities for video processing SoC
  - From MPEG to H.264
  - From standard to non-standard video coding
  - From video coding to value-added new function (encryption, fast-forwarding, ..)