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The novel contributions include the following:

1. The first ever attempt to propose an energy efficient hardware architecture of SBPG compression integrated with SDC.

2. The concept of SBPG compression integrated with SDC, which is suitable for low power intelligent traffic surveillance.


4. An experimental analysis and evaluation of the proposed architecture.
Applications of the IoT

- Up to now, the concepts that make the IoT have been incorporated in a wide range of fields including transportation, logistics, energy, agriculture, defense, and smart environments such as personal residences, offices, buildings, or infrastructure.

- When things, as envisioned by the IoT, become part of the same network, many smart services and processes will become easily possible and will be able to change how people understand and deal with the economy and environmental issues.
IoT Challenges

Security
OBJECTIVE: Making IoT system provides maximum security function against threats.
THREATS: Unauthorized interruption, modification, fabrication, etc.

Privacy
OBJECTIVE: Making IoT users feel free from being public attention.
THREATS: Unauthorized interception, spy, etc.

Data Management
OBJECTIVE: 1. Reduce the storage of massive data. 2. Data must be preserved and remain available.
THREATS: The number of electronic devices in IoT is dramatically increased.
Framework Overview of SDC Integrated with SBPG in the IoT

Components of Intelligent Traffic Surveillance in the IoT
Architectural Overview of SBPG integrated SDC

- Secure Digital Camera is a novel approach in capturing images.

The proposed framework architecture offers:

1. Double-layer protection: encryption and watermarking that will address all issues related to security, privacy and digital rights management (DRM), including ownership rights, tracking usage, extent of tampering, and facilitation of content authentication.

2. Introduces a new hardware architecture of the Better Portable Graphics (BPG) Compression, which is integrated with SDC.
Proposed Secure BPG Architecture

Stages of the SBPG Integrated with SDC
What is Better Portable Graphics (BPG) compression?
BPG is a new image format offering several advantages over the JPEG format. It achieves a higher compression ratio with smaller size than JPEG for similar quality.

Since its introduction in 1987, the Joint Photographic Experts Group (JPEG) graphics format has been the de facto choice for image compression. However, the new compression technique BPG outperforms JPEG in terms of compression quality and size of the compressed file.

The reference BPG image library and utilities (libbpg) can be divided into four functions: [1]
1) BPG encoder
2) BPG decoder
3) Javascript decoder
4) BPG decoding

Why BPG compression instead of JPEG?

Attributes that differentiate BPG from JPEG and make it an excellent choice include the following:

1) Meeting modern display requirements: high quality and lower size.
2) BPG compression is based on the High Efficiency Video Coding (HEVC), which is considered a major advance in compression techniques.
3) Supported by most web browsers with a small embedded Javascript decoder.
Why BPG compression and not JPEG?

4) It is open source. No patent issues (unlike JPEG 2000).
5) BPG is close in spirit to JPEG and can offer lossless compression in the digital domain.
6) Different chroma formats supported include grayscale, RGB, YCgCo, YCbCr, Non-premultiplied alpha, and Premultiplied alpha.
7) BPG uses a range of metadata for efficient conversion including EXIF, ICC profile, and XMP.
The advantages of hardware versus software implementation:

1. Minimal hardware is used to encode real-time images.
2. Power usage is reduced significantly compared to a general purpose processor.
3. The host is not slowed down by the dedicated circuity.
4. Hardware implementation is not affected by malicious software such as worms, Trojans, etc.
Encryption and watermark module:

The invisible-robust-blind watermarking algorithm is summarized as follows:

1. Optimization for robustness, quality, and computational load because of the use of the center portion of the image.
2. Watermarking is done in the frequency domain using the Discrete Cosine Transform (DCT) that will increase watermarking insertion speed.
3. The insertion of the watermark is done in the midfrequency of the image block so that will increase the robustness since any removal of high or low frequency components of the watermarked image does not significantly affect the watermark.
Watermarking Module (Insertion Algorithm)

- Four mid frequency coefficients are chosen from each block in the center quarter of the image.
- A vector \( R \) of size \( K \) is generated where \( K \) is the number of blocks in the center quarter of the image given in:
  \[ R = \{ r_{1,i}, r_{2,i}, r_{3,i}, r_{4,i}, \ldots, r_{1,K}, r_{2,K}, r_{3,K}, \ldots, r_{4,K} \} \]
- A pseudo random sequence is chosen from bits in the encrypted signature, which will be used as the watermark represented shown in:
  \[ A = \{ a_1, a_2, a_3, \ldots, a_{4 \times K} \} \]
- The watermark \( A \) is inserted into the DCT coefficients of the image of vector \( R \) according to Eqn:
  \[ r'_i = r_i + \alpha |r_i| a_i, \]

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Simplified Analysis of the BPG algorithm

Figure 1: BPG Encoder Algorithm

Figure 2: BPG Image Encoder Algorithm

Figure 3: BPG Video Encoder Algorithm
Proposed Hardware Architecture for the BPG Encoder

Algorithm 1 BPG Encoder Algorithm.

1. **Input** imageX
2. **Get** Parameters ← \{PixelDepth, ColorSpace, Alpha\}
3. **Calculate** Resolution ← \{pixels/inch\}
4. **Calculate** ColorType ← \{TrueColor, GrayScale\}
5. **If** Length > 2 **then**
   6. **Bitdepth** ← \{MetaData/numChannel\}
   7. **If** Bitdepth ≠ 8 **then**
      8. AlphaChannel ← ∅
      9. **Print** ”ERROR: while opening bitdepth encoder”
   10. **Else**
    11. **If** Bitdepth ≠ 8 **then**
        12. AlphaChannel ← ∅
        13. **Print** ”ERROR: while opening bitdepth encoder”
        14. **If** ColorType < 1 **then**
            15. **Print** ”ERROR: Color space is not supported”
        16. **End**
        17. **Print** ”Bit Depth and color space is supported”
        18. **Print** ”Image accepted for BPG compression”
        19. **If** AlphaChannel ≠ Null **then**
            20. use appropriate BPG CS RGB converter
        21. **Else**
            22. **If** AlphaChannel < 51 **then**
                23. modify alpha to BPG configurable
            24. **End**
            25. use alpha image RGBA compatible HEVC
            26. save output file BPG image
            27. **End**

System Level Architecture of the Proposed Algorithm
Finite State Machine Presenting the Controller of the SBPG Architecture
Power consumption has become a major concern in any portable application.

Low power consumption means extended battery life, which increases portability. Moreover, low power consumption results in a decrease of the packaging cost, and it is beneficial for cooling in both portable and non-portable applications.

The aim of this paper is to optimize the SBPG baseline design, which is presented in the previous slides, to achieve an energy-efficient SBPG design.
The higher the level of abstraction, the higher is the possibility of optimization and the bigger is the granularity as the large building blocks or basic elements are used. At the same time, more time is required for design iterations for low-power optimization.

The higher the abstraction level, the lower is the accuracy and vice versa. The lower the level of abstraction, the lower is the optimization possibility.
Proposed Low-power SBPG: Optimization Perspective

- **DCT Optimization**: the aim is to minimize the number of arithmetic operations by reconstructing the image just with the DC component along with few AC component of low frequencies that leads to computationally efficient operations without compromising quality.

- **Sub-Sampling**: it is the process of encoding the image by implementing less resolution for chroma information than Luma information. It takes advantage of the fact that the human eye is less sensitive to colors than brightness.

- **In the intra Prediction**: the design simplified the mode decision by defining constant values as integers using round-off.

- **In the inter Prediction**: advanced Motion Vector Prediction (AMVP) is used to remove duplicate motion vector candidates.

- **Quantization**: increasing the sampling size to reduce the computational operations. In addition, the quantization block uses a parallel structure.
Mechanism of Power Measurement

- Power estimation can be broadly categorized into pattern-dependent and pattern-independent. In the pattern-dependent method, the simulation results are considered for estimating the power dissipation.
- In this design we have adopted pattern-independent method i.e. many simulations were run in the design with different inputs and the average of the power dissipated was considered.
- The design is considered as a black box and the current and voltage values are considered from the design, in order to calculate power. This was achieved with the help of sensors and power blocks available in Simulink ®. The design is simulated using the ode45 solver configuration.
The proposed algorithm is prototyped in Simulink®.

The methodology that is used to represent the high level system modeling is bottom-up.

The first step is focused on building functional units; the next step is to integrate these units into subsystems.

Finally, verifying and testing overall system functionality.
Experimental Results

- Five standard images are selected randomly from a large set of images of the Joint Picture Expert Graphics (.jpg) with different spatial and frequency characteristics.

- The cover image, watermarked image, and corresponding BPG image are shown for a sample image.

(a) Cover Image.  (b) Watermarked Image  (c) Watermarked Compressed Image

Secure BPG Compression of Resort Image (256×256).
Experimental Results

**TABLE1:** Quality metrics for the proposed architecture and comparative perspective with baseline design:

<table>
<thead>
<tr>
<th>Test</th>
<th>SBPG Baseline Design</th>
<th>SBPG Optimal Design</th>
<th>Power Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image</td>
<td>PSNR</td>
<td>Power (nW)</td>
<td>PSNR</td>
</tr>
<tr>
<td>Wallpaper 128×128</td>
<td>50.2</td>
<td>8.09</td>
<td>49.31</td>
</tr>
<tr>
<td>Resort 256×156</td>
<td>47.14</td>
<td>8.2</td>
<td>46.82</td>
</tr>
<tr>
<td>Squirrel 256×256</td>
<td>50.37</td>
<td>8.22</td>
<td>50.19</td>
</tr>
<tr>
<td>GoogleMap 256×256</td>
<td>48.09</td>
<td>8.3</td>
<td>47.5</td>
</tr>
<tr>
<td>F16 512×512</td>
<td>51.9</td>
<td>8.55</td>
<td>50.03</td>
</tr>
</tbody>
</table>
Experimental Results

![Bar Graph]

- **PSNR**
- **Baseline SBPG Design**
- **Optimal SBPG Design**

- **Wallpaper**
- **Resort**
- **Squirrel**
- **GoogleMap**
- **F16**
Experimental Results
This paper proposes frameworks for secure digital camera in the IoT. The objectives of this work are twofold:

1. The proposed framework architecture offers double-layer of protection: encryption and watermarking that will address all issues related to security, privacy, and digital rights management (DRM) with applying hardware architecture of state-of-the-art image compression technique of Better Portable Graphics (BPG), which achieves high compression ratio with small size.

2. The proposed framework of SBPG is integrated with Digital Camera. Thus, the proposed framework of SBPG integrated with SDC is suitable for high performance imaging in the IoT, such as Intelligent Traffic Surveillance (ITS) and Telemedicine.

As the visual quality of the watermarked and compressed images improves with the larger value of PSNR, the results show that the proposed SBPG substantially increases the quality of the watermarked compressed images.
The proposed methodology could be extended to energy-efficient design of secure image sensors in the IoT communication that could act as a wireless sensor framework.

Designing the proposed SBPG in a hardware description language such as Verilog, then implementing it using Field Programmable gate Array (FPGA).

Exploring mechanisms to integrate these SBPG and SDC in diverse Internet of Things (IoT) and smart cities applications is also future research.
References

[6] “An Introduction to the Internet of Things (IoT)” Copyright Lopez Research LLC.
Thank you !!!