# A Hardware Architecture for Better Portable Graphics (BPG) Compression Encoder

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# Outline of the talk

- Introduction and Motivation
- Novel Contributions
- A Simplified Analysis of the BPG algorithm.
- Proposed Hardware Architecture for the BPG Encoder
- Proposed BPG Encoder: Simulink® based simulations
- Conclusions

# Introduction

❑ **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.

[1] F. Bellard, "The BPG Image Format," http://bellard.org/bpg/, last Accessed on 09/20/2015.

# Introduction

❑ **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 Javascript decoder.

# Introduction

- **Why BPG compression Not JPEG?**

4) It is open source.
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.

# Novel Contributions of This Paper

❑**The novel contributions of this paper include the following:**

1. The first-ever architecture for hardware BPG compression.

2. A Simplified Analysis of the BPG algorithm.

3. A Simulink®–based prototype of the algorithm implementation.

4. Experimental analysis and comparison of the proposed architecture versus JPEG.

# Novel Contributions of This Paper

❑**The advantages of hardware versus software implementation:**

1. Real-time image encoding with minimal hardware.
2. Significant reduction in power usage.
3. Dedicated circuity that does not slow down the host.
4. Hardware is less susceptible to malicious software such as viruses, Trojans.
5. Performance is higher since the hardware can be custom-built.
6. Hardware-based BPG can be integrated with multimedia creating or processing components e.g. GPU

# BPG Image Compression Algorithm

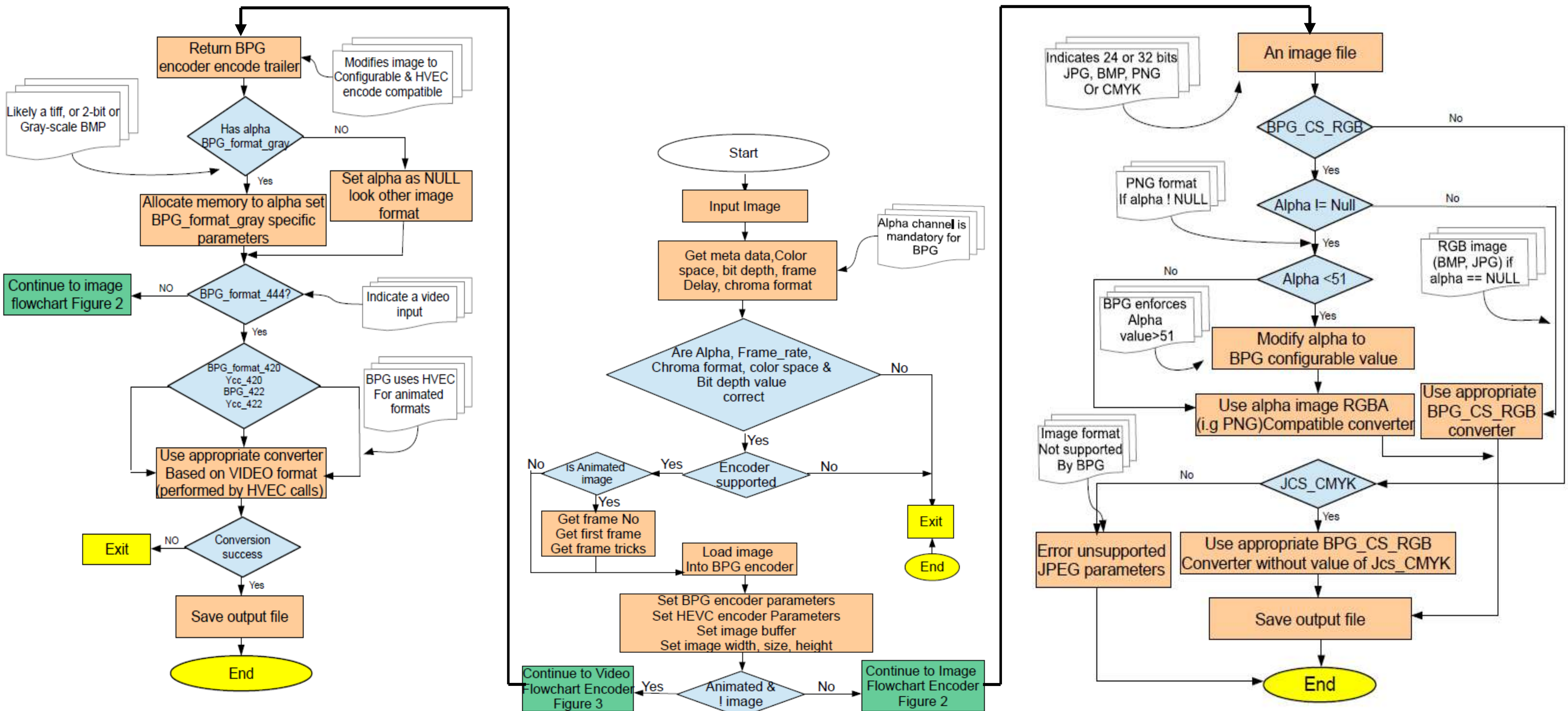



Fig. 3: BPG Video Encoder Algorithm.

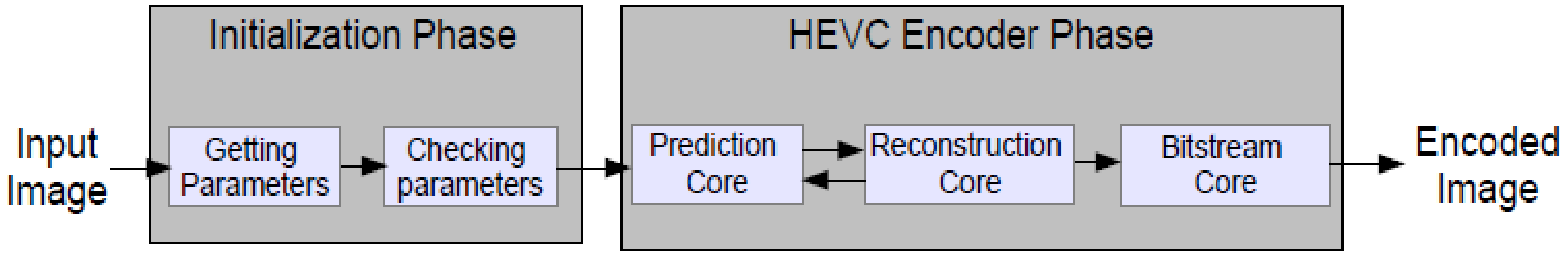
Fig. 1: BPG Encoder Algorithm.

Fig. 2: BPG Image Encoder Algorithm.

# Proposed Hardware Architecture for the BPG Encoder

***A. Initialization Phase:***

***B. HEVC Encoder Phase:***




BPG Encoder Block Diagram

# Proposed Hardware Architecture for the BPG Encoder

## *A. Initialization Phase:*

**Algorithm 1** Initialization phase algorithm

```
Parameters ← {PixelDpth, ColorSpace, AlphaChannel}
Resolution ← {pixels/inch}
Bitdepth ← {MateData/ImageSize}
while Lenght > 2 do
  if Bitdepth = 8 then
    AlphaChannel ← ∅
    PRINT "ERROR: BitDepth is not supported"
  if MetaDatacolor < 1 then
    PRINT "ERROR: ColorSpace is not supported"
PRINT "Bit Depth is 8 and correct color type"
PRINT "Image accepted for BPG compression"
end
```

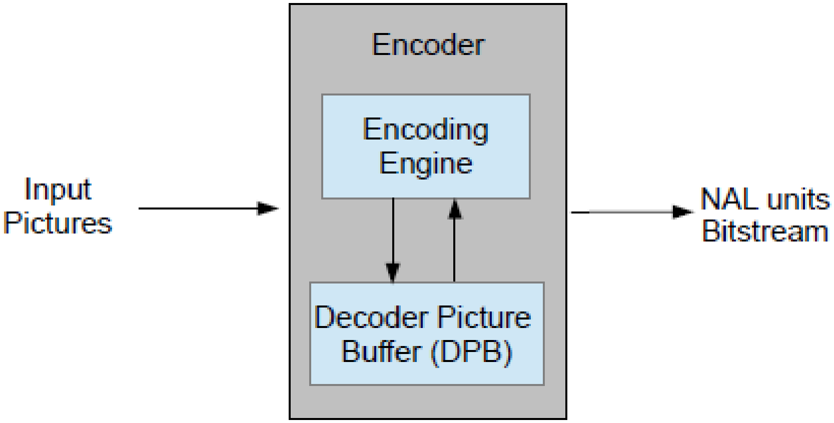
# Proposed Hardware Architecture for the BPG Encoder

## *B. HEVC Encoder Phase:*

✓HEVC offers high coding efficiency because of the intelligent approach that is used to reduce the area (pixels) that is encoded.

✓HEVC uses an 8×8 block, and DCT or DST as the transformation mechanism in the frequency domain.

✓The encoder stores pictures in the Decoder Picture Buffer (DPB).

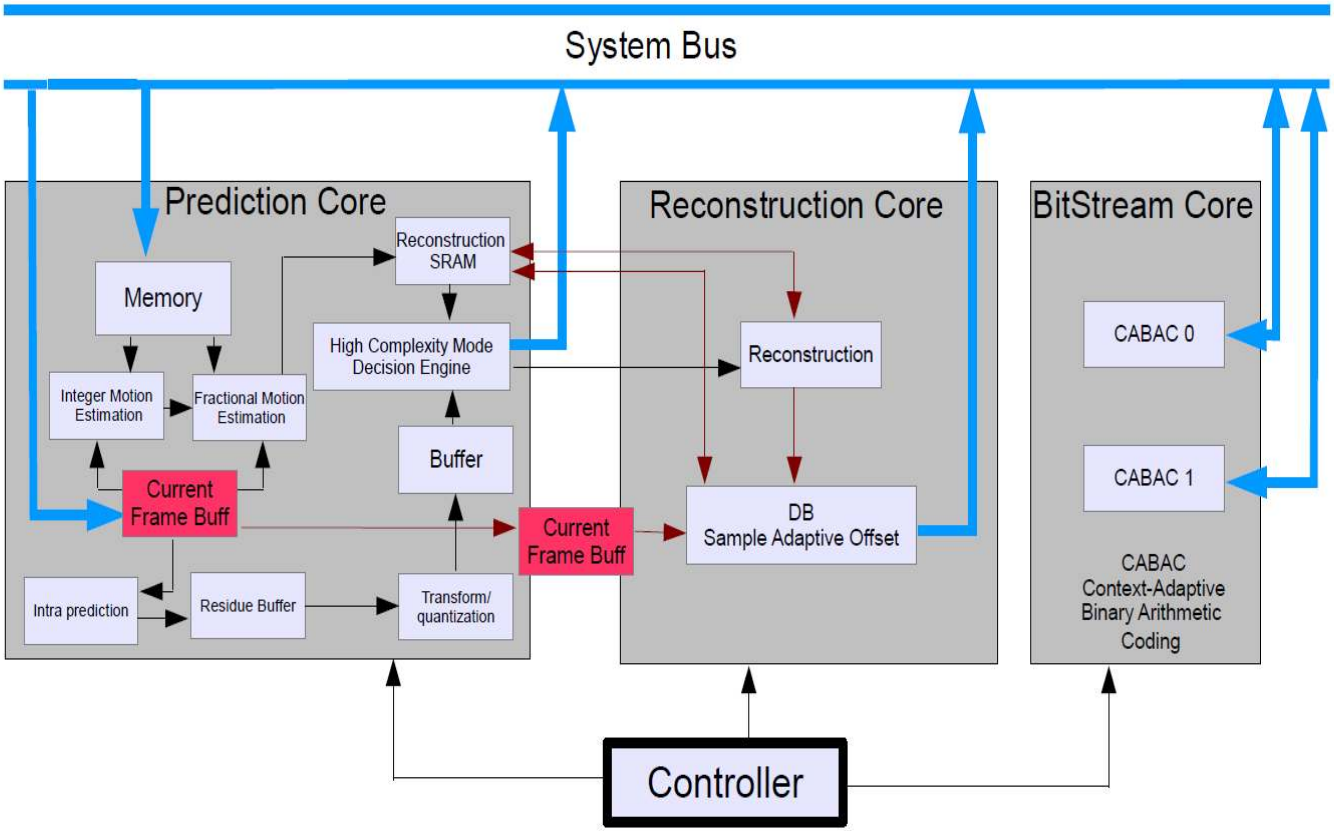



HEVC Encoder Block Diagram

# Proposed Hardware Architecture for the BPG Encoder

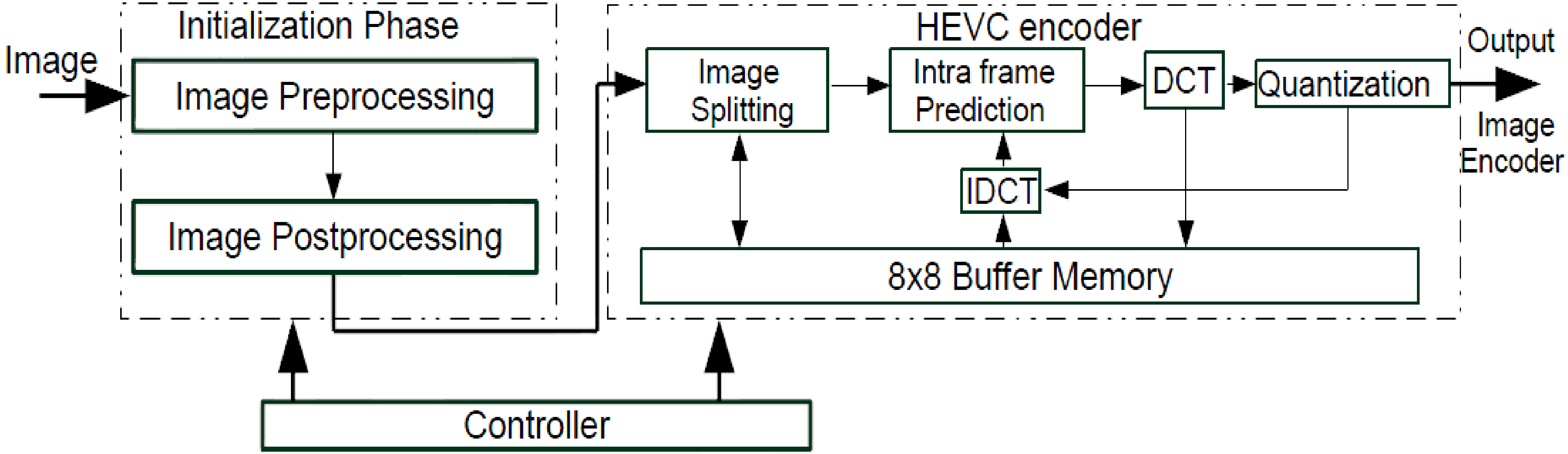
## *B. HEVC Encoder Phase:*

1. Prediction Core.
2. Reconstruction Core.
3. Bitstream core.




HEVC Encoder System

# System Level Architecture of the Proposed Algorithm




System Level Architecture of the Proposed Algorithm

# Simulink® Based Modeling

❖ 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

(a) JPEG Image (b) BPG Image

Compression of Bear Image (256×256)

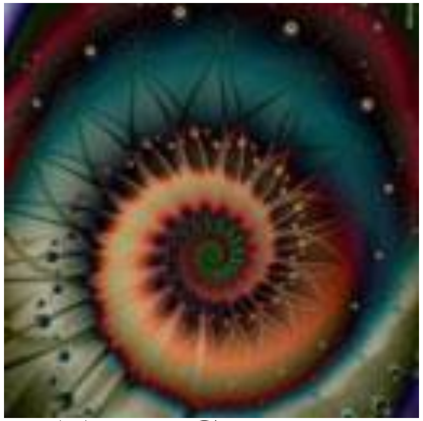
(a) JPEG Image (b) BPG Image

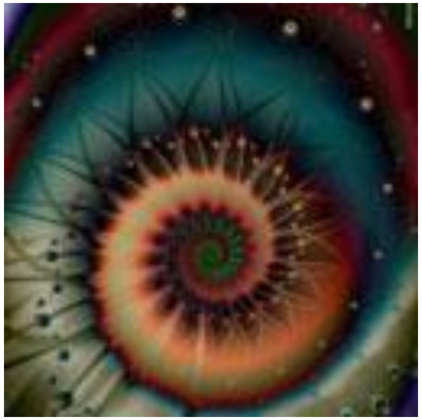
Compression of Ice Climb Image (512×512)

# Experimental Results

(a) JPEG Image (b) BPG Image

Compression of Lena Image (512×512)





(a) JPEG Image (b) BPG Image

Compression of Wallpaper Image (128×128)

# Experimental Results

- **Metrics to describe the type and amount of degradation in reconstructed compressed images:**

1. Root Mean Squared Error (RMSE).

2. Peak Signal to Noise Ratio (PSNR).

$$RMSE = \frac{1}{\sqrt{mn}} \sum_{j=1}^{m-1} \sum_{n=1}^{N} ||(O(i,j) - O'(i,j)||^2 \quad (1)$$

$$PSNR = 10 \log \left( \frac{(2^n - 1)^2}{MSE} \right) = 10 \log \left( \frac{255^2}{MSE} \right) \quad (2)$$

# Experimental Results

Table I: Quality Metrics for Compression Technique and Test Image

| Test Image | Code | Size (KB) | RMSE | PSNR |
|---|---|---|---|---|
| Bear Image | JPEG (input image) | 19.4 | 0.015 | 84.02 |
| | BPG image | 15.8 | 0.012 | 84.82 |
| IceClimb Image | JPEG (input image) | 85.3 | 0.012 | 86.035 |
| | BPG image | 78.4 | 0.010 | 86.11 |
| Lena Image | JPEG (input image) | 29.3 | 0.023 | 80.6 |
| | BPG image | 26.4 | 0.20 | 80.75 |
| Wallpaper Image | JPEG (input image) | 6.2 | 0.022 | 81.1 |
| | BPG image | 4.41 | 0.19 | 81.22 |

# Conclusions

- The first-ever hardware architecture to perform BPG compression encoder in images is presented.
- The proposed architecture is prototyped in Simulink ®.
- The experimental results are compared with existing JPEG techniques in terms of quality and size and indicate the superior compression characteristics of BPG.


Thank you !!!