An Industry Standard Benchmark Consortium

DENBench™ Version 1.0

Benchmark Name: RGB to YIQ Conversion

Highlights

- **Benchmarks digital video processing performance**
- **Provides opportunities for Full Fury optimization**
- **Integer implementation**
- **Seven datasets expand workload compared to comparable benchmark in ConsumerBench Version 1.1**
- **Input is comprised of .ppm files**
- **Implements Non-Intrusive Cyclical Redundancy Checksum (CRC) to Check Output Quality**

Application

RGB to YIQ conversion is used in the NTSC encoder where the RGB inputs from the camera are converted to luminance (Y) and chrominance (I,Q) information. In the NTSC encoder, the I,Q signals are modulated by a subcarrier and added to the Y signal. Historically, when color TVs appeared in the market, they had to coexist with the existing monochrome TVs and this was made possible with the NTSC signal structure. The chrominance signals are averaged out as a fine mesh of invisible signals in the monochrome TV sets. YUV used in the PAL standard and YCbCr used in the JPEG standard have different encodings. All three standards share the same luminance signal Y but the chrominance calculations are different. The matrix calculation scheme used in the RGB to YIQ can be applied to these standards too.

In the actual products, this trivial calculation is usually performed in dedicated hardware, especially in digital video products. For cost saving and flexibility, this algorithm can be implemented in software if the CPU is powerful enough and where the digital image is a still picture.

Benchmark Description

This benchmark explores the capability of the CPU to perform a straightforward matrix multiply/accumulate calculation.

The R, G, B 8-bit pixel color image input is processed as follows:

```
Y = 0.299*R + 0.587*G + 0.114*B

I = 0.596*R - 0.275*G - 0.321*B

Q = 0.212*R - 0.523*G + 0.311*B
```

RGB values are in the range of [0:255]. The conversion coefficients are 16 bits. The multiply/accumulate results are shifted right by 16 bits. Before the shift, 1 is added to a bit location right to the LSB of the shifted result for rounding to the nearest integer. The output is 8-bit data. Y is in the range of [0,255] and I,Q in the range of [-127, 127]. The input and output data size is 320 pixels in the horizontal direction and 240 pixels in the vertical direction.

The 320x240 data for RGB and YIQ are stored sequentially as:

R[0], G[0], B[0], R[1], G[1], B[1], R[76799], G[76799], B[76799]

Y[0], I[0], Q[0], Y[1], I[1], Q[1], Y[76799], I[76799], Q[76799]

The pointers are just incremented by one to access R, G,B or Y, I, Q data in this order.

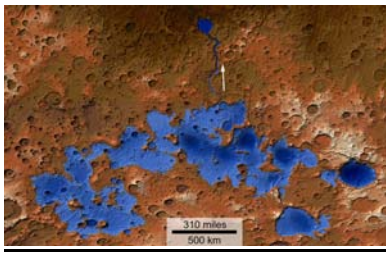
Description of Datasets

Rose Small

Rose Small is the default file for the JPEG Compression benchmark. It is a single image that is contained in both BMP and JPEG formats. The dimensions are 227x149, 256 colors. The image contains 256 unique colors.

Goose

Goose is the default file for the JPEG Decompression benchmark. It is a single image that is contained in both BMP and JPEG formats. The dimensions are 320x240, 256 colors. The image has 22,921 unique colors.



Mars Former Lakes

Mars Former Lakes is a NASA graphics picture. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 800x482, 16 million colors. The image has 91,152 unique colors.

Dragon Fly

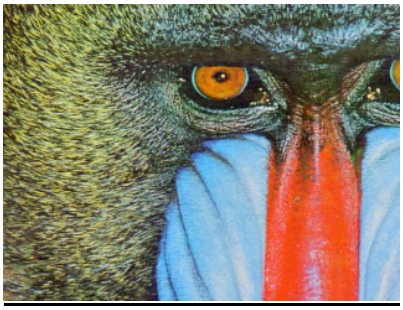
Dragon Fly is an image containing highlights, and a wide range of contrast. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 606x896, 16 million colors. The image has 162,331 unique colors.

EEMBC Group Shot

EEMBC Group Shot is a snapshot of EEMBC Board of Directors members at a 2003 meeting. It has a large number of flesh tones, and the highest number of unique colors in the library. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 640x480, 16 million colors. The image has 181,872 unique colors.

David and Dogs

David and Dogs is a snapshot of David Weiss and his dogs Sandy, Toga, and Trudy during a rare snowstorm in Austin. It is used as a grayscale image, with good contrast details in the melting snow. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 564x230, 256 shades of gray. The image has 215 unique colors.



Mandrake

Mandrake is a close up picture of a **Mandrill Baboon** (sometimes misnamed as "Mandrake"). It has a lot of detail and colors. It has been the default image for the filter benchmarks in both color and gray scale. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 320x240, 16 million colors. The image has 71,482 unique colors.

Galileo

Galileo is a NASA composite image based on actual images of the Jupiter and several of its moons. It is a single image that is contained in BMP, PPM, PGM, and JPEG formats. The dimensions are 290x415, 16 million colors. The image has 36,557 unique colors, and also contains “real black” for over 30% of the picture, which is interesting from an optimization perspective.

Output quality is measured using Non Intrusive CRC code developed by the EEMBC Certification Laboratory (ECL, LLC). It does not affect the benchmark score.

Analysis of Computing Resources

Out of the Box Benchmark: A “for loop” calculates the conversion of one set of RGB inputs and YIQ outputs at a time. A set of R, G, B input data is read from the memory by incrementing a read pointer. A set of output Y, I, Q output data is written back to the memory by incrementing a write pointer. There is no complex two-dimensonal access such as that in the high pass grey-scale filter benchmark. The calculation is a straightforward multiplication and accumulation that a microprocessor with a single-cycle MAC unit will benefit from. The code size is small and easily fits in to a small L1 Instruction Cache.

Full-Fury Benchmark: Because of the simple structure of the multiplication and accumulation, a VLIW or SIMD architecture with multiple of MAC units can be used to accelerate performance. A further optimization is the loading of multiple bytes at a time. Software pipelining could be used to pass the loaded data efficiently to the MAC unit for calculation.