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An Industry Standard Benchmark Consortium

DENBench™ Version 1.0

Benchmark Name: RGB to CMYK Conversion

Highlights

- Benchmarks digital image processing performance in printers and other digital imaging products
- Explores basic arithmetic and minimum value detection capability
- Provides opportunities for Full Fury benchmark optimization
- Conditional move and multi-byte processing, exercising SIMD and VLIW architectures

- Integer implementation
- Seven datasets provide a larger workload compared to the single dataset of ConsumerBench Version 1.1
- Input is comprised of .ppm files
- Implements Non-Intrusive Cyclical Redundancy Checksum (CRC) to Check Output Quality

Application

RGB to CMYK conversion is widely used in color printers. RGB inputs from PC data are converted to CMYK color signals for printing.

Benchmark Description

This benchmark explores the target CPU's ability to perform basic arithmetic and minimum value detection. The R, G, B 8-bit pixel color image input is fed to the following equation:

```
/* calculate complementary colors */
c = 255 – R;
m = 255 – G;
y = 255 – B;
/* find the black level k */
K = minimum (c,m,y)
/* correct complementary color lever based on k
*/
C = c – K
M = m – K
Y = y - K
```

RGB values are in the range of [0:255]

CMYK values are in the range of [0:255]

The input and output data sizes vary. For example, the 320x240 data for RGB and CMYK is stored sequentially as:

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

C[0], M[0], Y[0], K[0], C[1], M[1], Y[1],K[1] C[76799], M[76799], Y[76799], K[76799]

The pointers are incremented by one to access R, G, B or

C, M, Y, K data in this order. If the benchmark score is extrapolated for a larger image, the processing time will be almost linearly proportional to the pixel count (e.g. for a 640 x 480 image, it will be multiplied times 4). The iteration/second score will be the inverse (e.g. for a 640 x 480 image, iterations/sec will be multiplied by .25).

There is data dependency in the cycle counts for the minimum value K search, due to branch taken or not taken. If this operation is handled by conditional move, the cycle will be constant.

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.
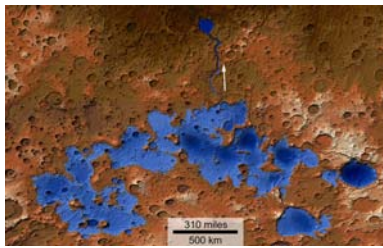
Mars Former Lakes

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

A "for loop" calculates the conversion of one set of RGB inputs and CMYK 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 C, M, Y, K output data is written back to the memory by incrementing a write pointer. There is no complex two-dimensonal access.

The complementary color calculation and correction are simple subtract calculations without any MAC operation.

The minimum value search has two branches for processing each pixel.

```
If (c<m) {
K = (Byte)(c<y ? c:y);
}
else {
K = (Byte)(m<y ? m:y);
}
```

This can be a very expensive routine because of the branch penalty.

Full-Fury Optimization: By using the compare and conditional moves, the branch penalty can be avoided. VLIW and SIMD can process multiple bytes of data at a time. For example, a four-way SIMD microprocessor can handle 4 x 8-bit data every cycle.