Bit-Plane Encoding of Binary Decision for Differential Images in DPCM

- A large portion of the pixel values in the differential image have magnitudes close to zero.
- Binary decision tree as shown below can transform the pixel values into a set of variable length binary strings, with minimum average number of decisions.
  - For a nonzero value n, the first two bits in the binary string are a "1" bit followed by the sign bit ("0" for "-", "1" for "+"). Then, there are $n-1$ "1" bits. The binary string ends with a "0" bit.
  - A zero pixel value is represented by a single "0" bit.
- There are generally more "1" bits in the most significant bits (disregard the first two bits in the binary string) in a binary string. Again, we can take advantage of this local probability distribution which is in favor of "1"s and encode the binary strings in the bit-plane order with adaptive arithmetic coding.

Example: Assume that we are to encode the following 7 values:

2, -3, -4, 6, -9, 5, 0.

First, the binary string representing each value are formed by passing each value down the binary decision tree:

$$
\begin{aligned}
2 &: 1\ 1\ 1\ 0 \\
-3 &: 1\ 0\ 1\ 1\ 0 \\
-4 &: 1\ 0\ 1\ 1\ 1\ 0 \\
6 &: 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0 \\
-9 &: 1\ 0\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 1\ 0 \\
5 &: 1\ 1\ 1\ 1\ 1\ 1\ 0 \\
0 &: 0
\end{aligned}
$$

For the first bit-plane, we know there are 7 symbols, i.e.,

1, 1, 1, 1, 1, 1, 0.

The last "0" bit suggests that the last value to be encoded is a zero and there will be no more symbols coming from the last string. Thus the second bit-plane consists of only six symbols, each of which representing a sign bit:

1, 0, 0, 1, 0, 1.

The third bit-plane will still have six symbols to determine the

magnitude of the six values left:

1, 1, 1, 1, 1, 1.

Since none of the symbols are zero, we know each of them will have at least one more bits. Thus the forth bit-plane is:

0, 1, 1, 1, 1, 1.

The first symbol "0" is this bit-plane indicates the termination of the binary string for the value "2". Then we know the fifth bit-plane will consists of five symbols:

0, 1, 1, 1, 1.

The process is repeated as described above until the 11th bit-plane, where only one symbol, a "0", is presented. This marks the end of bit-plane formation. Finally, the bit-plane streams can be encoded by adaptive arithmetic coding.