zhRGB565 Lossless Compression Algorithm

1. Compression Flag Code

A unique marker that signals the start of compressed data.

– Scan every high byte of the RGB565 pixels; pick one byte value that never appears (e.g. 0x11).

– The 16-bit flag code becomes 0x1100.

– If every value 0x00-0xFF has already been used, take the least-frequent one instead.

2. RLE (Run-Length Encoding)

Compresses runs of identical pixels.

Short form (≤127 repeats):

  [Flag+Count]   ReferencePixel

  Example: 8 consecutive 0x7899 → 0x1108, 0x7899

Long form (>127 repeats):

  0x1100, ReferencePixel, 16-bit Count

  Example: 300 repeats → 0x1100, 0x7899, 0x012C

Escape for flag-byte pixels: any pixel whose high byte equals the chosen flag value is stored as 0x1101, 0x11XX (slight expansion, negligible impact).

3. Delta (XOR) Compression

– Keep the first pixel as reference.

– XOR the next pixel with the reference; if the difference fits

  R: 0-3, G: 0-7, B: 0-3

  encode it as one byte: RRRGGGBB.

– Advance the reference and repeat; up to 7 consecutive deltas can be packed.

– Delta blocks always use short encoding for fast random access:

  0x1183   (flag | 0x80 | count-1)

  0x8920   reference pixel

  0x1222 0x0012 0xAD25   three 16-bit words holding 6 delta bytes → 6 pixels + ref = 7 pixels total.

4. Hybrid Mode

The encoder freely switches between RLE and Delta on the same line, usually yielding smaller files than pure RLE.

5. File Layout

Row-oriented: compression never spans scan-lines.

– Line-offset table: absolute position of each compressed row in the bit-stream.

– Carry table: flags which rows need an extra 65 536 added to their offset (carry increment).

```c
// Compressed RGB565 data
// Source file: C:\Users\Mayn\Desktop\121.c
// Original size: 360 x 360 = 129600 pixels
// Compression ratio: 69.63%

const uint16_t ww121_compressed[90236] = {
    /* width, height, encode_flag, upgrade_len, row_offset_addr, data_addr */
    360, 360, 0x0200, 1, 7, 367,
    /* 升阶表 */
    242,
    /* 行偏移表（共360行） */
    0, 224, 450, 678, 913, 1147, 1394, 1639, 1885, 2139, 2386, 2639, 2897, 3157, 3406, 3657,
    3920, 4171, 4411, 4643, 4867, 5088, 5310, 5531, 5761, 5992, 6221, 6448, 6682, 6922, 7164, 7398,
    7644, 7894, 8130, 8368, 8608, 8854, 9110, 9371, 9629, 9883, 10143, 10390, 10643, 10894, 11152, 11406,
    11670, 11946, 12215, 12483, 12758, 13026, 13295, 13548, 13818, 14108, 14381, 14671, 14946, 15229, 15518, 15811,
    16104, 16399, 16683, 16965, 17245, 17530, 17816, 18105, 18384, 18680, 18968, 19248, 19531, 19811, 20086, 20364,
    20632, 20922, 21213, 21506, 21790, 22072, 22361, 22657, 22948, 23241, 23528, 23817, 24105, 24406, 24699, 25003,
    25306, 25639, 25962, 26288, 26615, 26949, 27279, 27614, 27941, 28273, 28601, 28931, 29266, 29592, 29913, 30252,
    30587, 30907, 31229, 31552, 31875, 32184, 32505, 32824, 33141, 33462, 33779, 34090, 34404, 34727, 35033, 35344,
    35648, 35922, 36194, 36471, 36738, 36993, 37246, 37502, 37764, 38023, 38293, 38542, 38813, 39078, 39341, 39600,
    39864, 40142, 40411, 40685, 40957, 41223, 41499, 41762, 42035, 42319, 42600, 42879, 43159, 43438, 43717, 43993,
    44279, 44572, 44868, 45161, 45437, 45717, 46002, 46289, 46579, 46874, 47179, 47477, 47775, 48076, 48375, 48664,
    48959, 49266, 49569, 49858, 50152, 50448, 50738, 51038, 51339, 51622, 51897, 52180, 52456, 52728, 52996, 53262,
    53526, 53780, 54032, 54288, 54555, 54821, 55081, 55345, 55602, 55851, 56109, 56360, 56611, 56878, 57127, 57376,
    57637, 57886, 58136, 58378, 58615, 58865, 59113, 59352, 59599, 59848, 60087, 60336, 60579, 60823, 61074, 61324,
    61575, 61826, 62069, 62314, 62561, 62794, 63032, 63266, 63503, 63728, 63951, 64167, 64383, 64596, 64812, 65014,
    65218, 65406, 60, 247, 427, 620, 815, 1011, 1222, 1433, 1647, 1844, 2041, 2244, 2445, 2654,
    2866, 3076, 3280, 3476, 3685, 3899, 4124, 4345, 4572, 4812, 5032, 5243, 5441, 5648, 5855, 6072,
    6284, 6484, 6693, 6909, 7117, 7342, 7566, 7776, 7985, 8178, 8363, 8547, 8727, 8905, 9083, 9262,
    9439, 9581, 9708, 9828, 9951, 10072, 10205, 10337, 10470, 10595, 10723, 10859, 10987, 11111, 11240, 11375,
    11518, 11693, 11857, 12030, 12193, 12354, 12529, 12703, 12882, 13089, 13278, 13474, 13662, 13847, 14027, 14215,
    14405, 14603, 14809, 15006, 15190, 15376, 15564, 15755, 15958, 16189, 16424, 16665, 16912, 17160, 17410, 17660,
    17923, 18172, 18416, 18654, 18899, 19145, 19396, 19659, 19913, 20184, 20449, 20710, 20955, 21216, 21484, 21761,
    22042, 22336, 22622, 22912, 23200, 23483, 23764, 24048,
    /* 编码数据 */
    /* 0 */
    0x0289, 0xEF7E, 0x1D21, 0x18E0, 0xF900, 0xFD00, 0x2B20, 0xD74D, 0x0000, 0x0001, 0x0001, 0x0229, 0xFFFF, 0x0204, 0xF7FF, 0xEF9E,
    0xFFFF, 0xFFBE, 0xFFDF, 0xFF9F, 0xCD77, 0xC515, 0xD597, 0xDD97, 0xE5F9, 0xFE7B, 0xFEDD, 0xFE9C, 0xEDF9, 0xDD77, 0xD557, 0xEE7A,
    0xF6DC, 0xFF3D, 0xFF3E, 0xF6DC, 0xEE9B, 0xF6DC, 0xFF3E, 0xFF1D, 0xFF1D, 0xFEFC, 0x0203, 0xF6DC, 0xFEFD, 0xFF1D, 0x0208, 0xFF3D,
    0x0204, 0xFF1D, 0xFEFD, 0x0283, 0xFF1D, 0x0000, 0x0400, 0x0004, 0xF6FC, 0xF71D, 0xFF1D, 0xFF3D, 0xF6DC, 0xFF3D, 0xF6BB, 0xEE7B,
    0xFF5E, 0xFF1D, 0xE639, 0xE619, 0xF71C, 0xEEFC, 0xF6FC, 0xFF5E, 0xFF3E, 0xFE9C, 0xE5B8, 0x0284, 0xE557, 0x000C, 0x0000, 0x0004,
```