#Assignment 3

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- Huffman_Coding

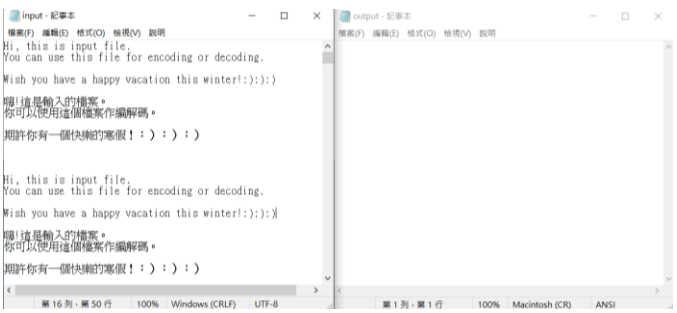
1. 編譯結果

```
PS D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src> cd D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src
PS D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src> gcc -o main main.c huffman.c utils.c
PS D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src> ./main
```

2. 執行結果

Test_1(編碼)

在 Huffman_coding\assignment_3\src 文件夾中增加 3 個 txt 檔案，分別為 input.txt、output.txt、decode.txt，其中 input.txt 檔案中有資料內容。



選擇 mode 為 0 (encoding)

輸入欲編碼檔案的檔案名字

輸入編碼後儲存資料的檔案名字

輸出編碼所花費的時間

```
PS D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src> ./main
Please input the mode [0(encoding)/1(decoding)/2(quick encoding)]: 0
Please input the input_file name: input.txt
Please input the output_file name: output.txt
Input file: input.txt
Output file: output.txt
Mode: encoding

time cost: 0.033000
Input successfully processed.
```

- Arithmetic_Coding

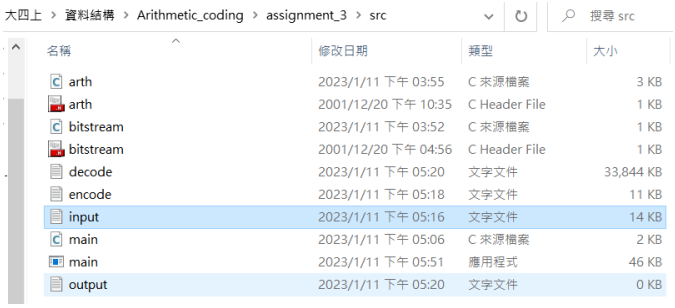
1. 編譯結果

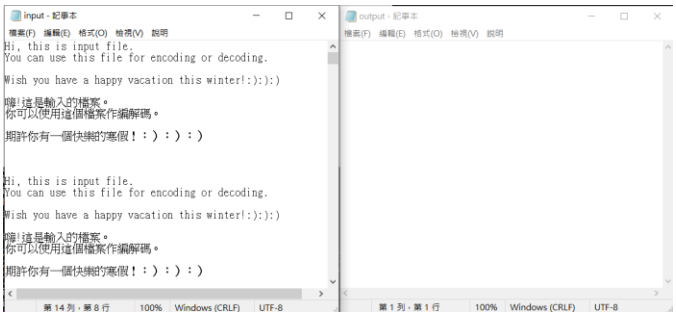
```
PS D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src> cd D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src
PS D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src> gcc -o main main.c arth.c bitstream.c
PS D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src> ./main
```

2. 執行結果

Test_1(編碼)

在 Arithmetic_coding\assignment_3\src 文件夾中增加 3 個 txt 檔案，分別為 input.txt、output.txt、decode.txt，其中 input.txt 檔案中有資料內容。





選擇 mode 為 e (encoding)

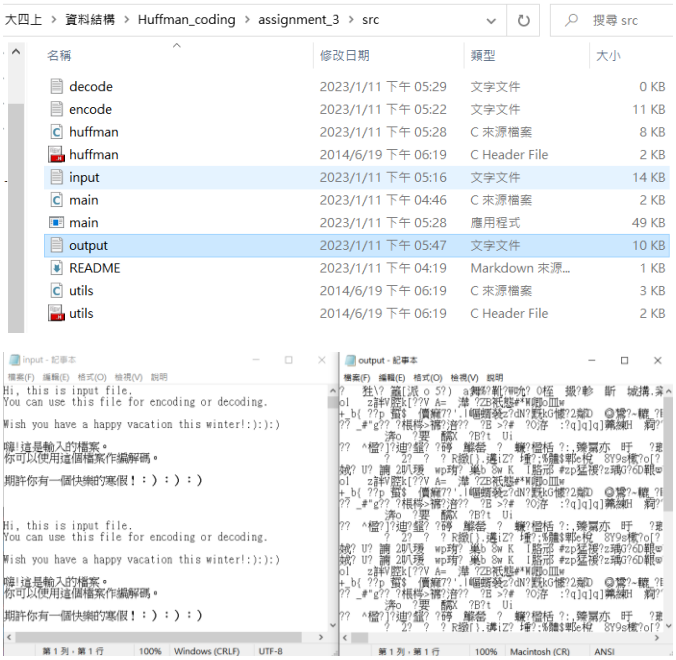
輸入欲編碼檔案的檔案名字

輸入編碼後儲存資料的檔案名字

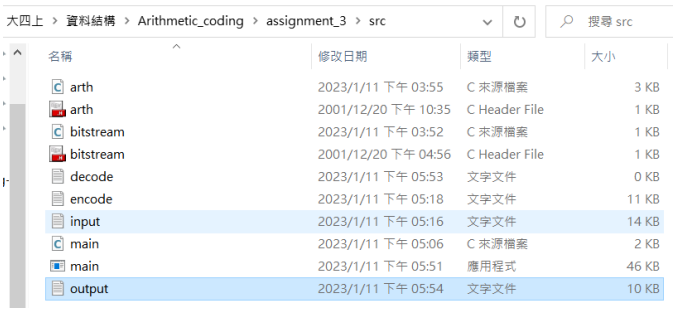
輸出編碼所花費的時間

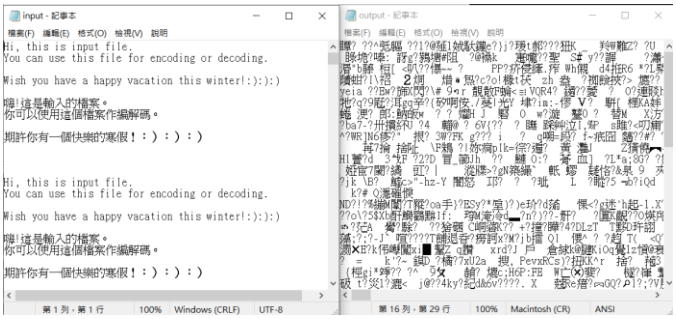
```
PS D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src> ./main
Please input the mode [e(encoding)/d(decoding)]: e
Please input the input_file name: input.txt
Please input the output_file name: output.txt
Input file: input.txt
Output file: output.txt
Mode: encoding

start encoding...
time cost: 0.006000
```

可觀察到 output.txt 的檔案大小增加了，內容為編碼後的資料，但其檔案大小會少於 input.txt



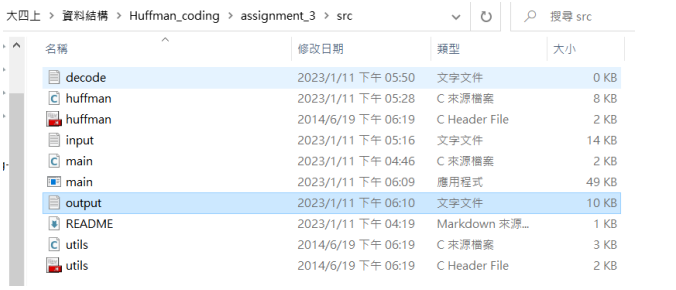
可觀察到 output.txt 的檔案大小增加了，內容為編碼後的資料，但其檔案大小會少於 input.txt





Test_2(解碼)

將剛剛編碼後的資料解碼，並將解碼後的資料儲存於 decode.txt，decode.txt 初始的檔案大小為 0



選擇 mode 為 1 (decoding)

輸入欲解碼檔案的檔案名字

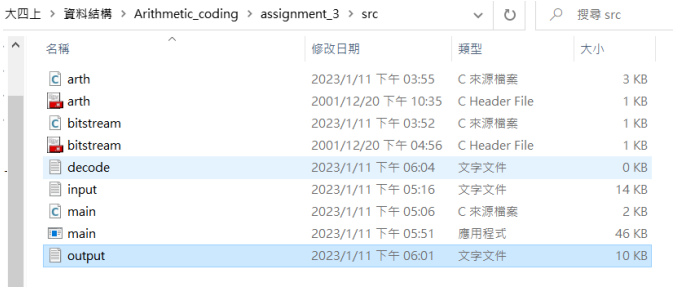
輸入解碼後儲存資料的檔案名字

輸出解碼所花費的時間

```
PS D:\文件\大四上\資料結構\Huffman_coding\assignment_3\src> ./main
Please input the mode [0(encoding)/1(decoding)/2(quick encoding)]: 1
Please input the input_file name: output.txt
Please input the output_file name: decode.txt
Input file: output.txt
Output file: decode.txt
Mode: decoding

time cost: 0.002000
Input successfully processed.
```

Test_2(解碼)

將剛剛編碼後的資料解碼，並將解碼後的資料儲存於 decode.txt，decode.txt 初始的檔案大小為 0



選擇 mode 為 d (decoding)

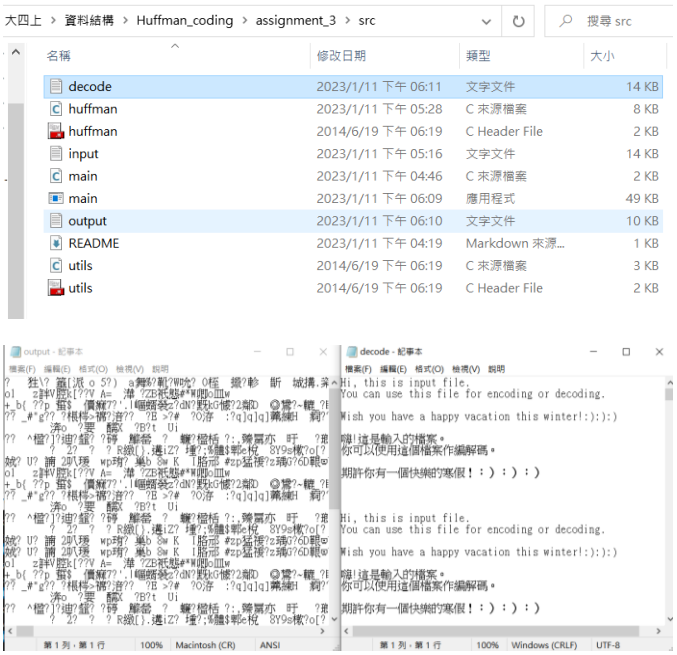
輸入欲解碼檔案的檔案名字

輸入解碼後儲存資料的檔案名字

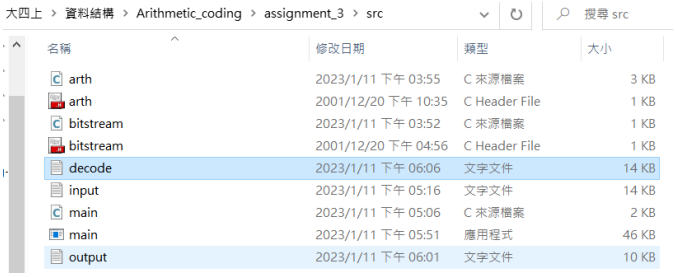
輸出解碼所花費的時間

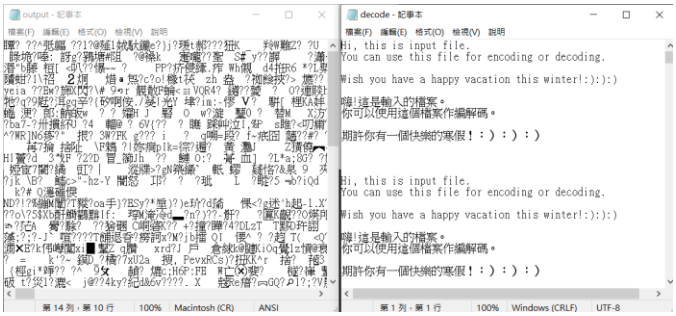
```
PS D:\文件\大四上\資料結構\Arithmetic_coding\assignment_3\src> ./main
Please input the mode [e(encoding)/d(decoding))]: d
Please input the input_file name: output.txt
Please input the output_file name: decode.txt
Input file: output.txt
Output file: decode.txt
Mode: decoding

start decoding...
time cost: 0.008000
```

可發現 decode.txt 與 input.txt 的檔案大小及內容相同



可發現 decode.txt 與 input.txt 的檔案大小及內容相同





3. 分析

編碼

```
void encode(FILE *infile, FILE *outfile)
{
  char *curCode;
  int len, i;
  Tree *tree;

  fseek(infile, 0L, SEEK_END);
  len = ftell(infile);
  rewind(infile);
  tree = generateHuffmanTree(infile, len);
  rewind(infile);
  writeHeader(outfile, tree, len);
  for (i = 0; i < len; i++)
    {
      curCode = getCode(tree, (unsigned char) fgetc(infile));
      writeCode(outfile, convertCode(curCode), strlen(curCode));
    }
  writeCode(outfile, 0, 8 - getCount());

  destroyTree(tree);
}
```

由於 Huffman coding 在編碼時除了計算每個字元出現的次數亦須建立一個 HuffmanTree 導致在編碼時需花費較多的時間

3. 分析

編碼

```
void encode(int code)
{
    long range;
    int symbol;

    if(code<0) symbol = EOF_symbol;
    else symbol = c2i[code];

    range = (long) (high - low) + 1;
    high = low + (range*cum[symbol-1])/cum[0] - 1;
    low = low + (range*cum[symbol])/cum[0];

    while(1)
    {
        if(high<Half)
        {
            putbit0();
        }
        else if (low>=Half)
        {
            putbit1();
            low -= Half;
            high -= Half;
        }
        else if (low >= First_qtr && high<Third_qtr)
        {
            refine += 1;
            low -= First_qtr;
            high -= First_qtr;
        }
        else break;

        low <<= 1;
        high = (high<<1) + 1;
    }

    update_freq(symbol);
```

解碼

```
/* Decoding functions implementations */

void decode(FILE *infile, FILE *outfile)
{
  int i, ch, length = 0;
  Tree *pTree;

  readHeader(infile, &pTree, &length);
  setCount(0);
  for (i = 0; i < length; i++)
    {
      ch = decodeByte(infile, pTree);
      fputc(ch, outfile);
    }
  destroyTree(pTree);
}
```

由於此次測試資料內容為一整串相同的文字重複出現，Huffman coding 所建立的 Huffman Tree 較廣而不深，解碼時速度較 Arithmetic coding 快

Arithmetic coding 在編碼時根據字元出現的機率及機率分布進行編碼，且編碼過程中不斷計算字串機率分布的區間，字元出現機率會受到之前出現的字元影響，機率分布區間亦隨之影響，直到整個字串演算編碼完成，算法較 Huffman 複雜，適用於出現機率平均的資料內容。

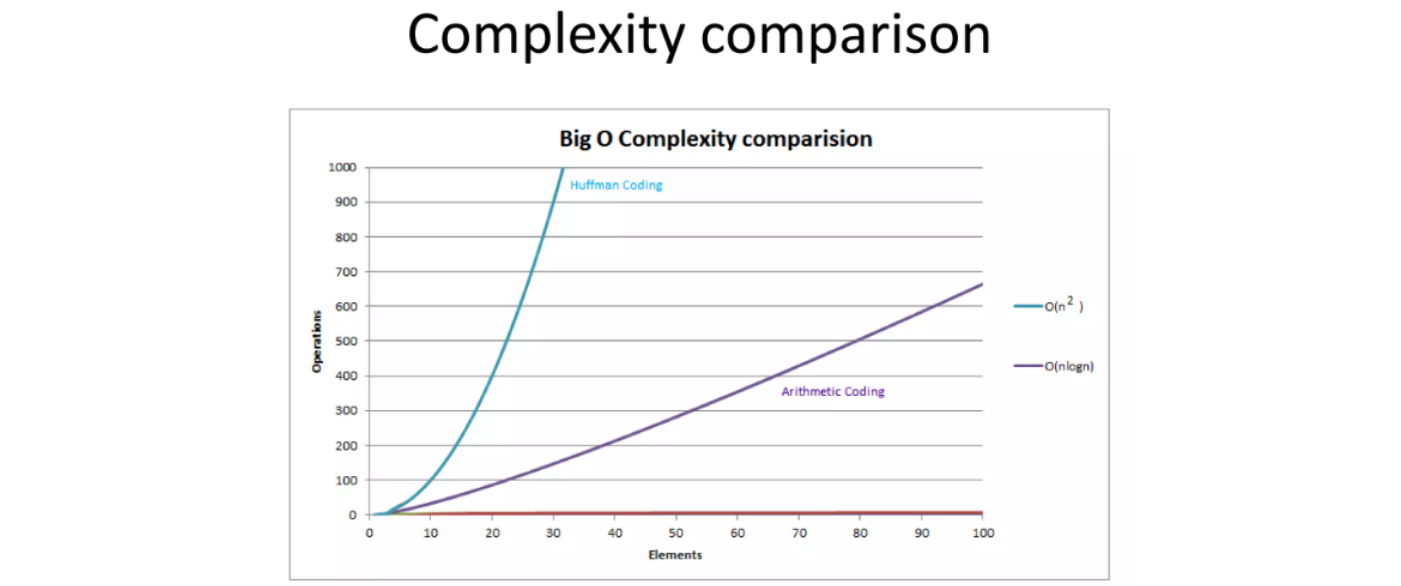
因此次測試資料內容為一整串相同的文字重複出現，每個字元出現機率平均，故 Arithmetic coding 的編碼速度較快

解碼

```
int decode(void)
{
    static bool first_time = 1;
    int range;
    int curr_cum, symbol;

    if(first_time)
    {
        for(range=1; range<=Code_value_bits; range++)
        {
            value = (value<<1) + getbit();
        }
        first_time = 0;
    }

    range = (high - low) + 1;
    curr_cum = (((value-low)+1)*
    for(symbol = 1; cum[symbol]>curr_cum; symbol++);
    high = low + (range*cum[symbol-1])/cum[0]-1;
    low = low + (range*cum[symbol])/cum[0];

    while(1)
    {
        if(high<Half)
        {

        }
        else if (low>=Half)
        {
            value -= Half;
            low -= Half;
            high -= Half;
        }
        else if(low>=First_qtr && high<Third_qtr)
        {
            value -= First_qtr;
            low -= First_qtr;
            high -= First_qtr;
        }
        else break;

        low <<= 1;
        high = (high<<1)+1;
        value = (value<<1)+getbit();
    }

    if(symbol==EOF_symbol) return -1;
    update_freq(symbol);

    return i2c[symbol];
}
```

解碼與編碼時的速度差不多，但解碼較 Huffman coding 慢

Complexity



Arithmetic coding 的時間複雜度較 Huffman coding 佳

Huffman coding
Running time Function：T(n) = N[log n + log(2n-1)] + Sn
Complexity：$O(N^2)$

Arithmetic coding
Running time Function：T(n) = N[log n + a] + Sn

N=>Number of input symbols
n=>current number of unique symbols
S=>Time to maintain internal data structure

Complexity：O(N log n)

資料來源：https://www.slideshare.net/ramakantsoni/performance-analysis-of-huffman-and-arithmetic-coding-compression