Huffman encoder/decoder

Huffman Encoding:

Key points:

1) Reading input: Used Hash table to store characters in the input file. The Data structure used had a array of pointers of basic node of HashMap. So effectively, only characters which were present in the file were instantiated using Heap. No entries with 0 frequencies were ever created.

```
____Huffman Hashtable____
S.no   Key    Value   Count
______|________|______|____
10     10
    1
32     32          4999
44     44     ,    666
46     46     .    773
59     59     ;    12
65     65     A    49
67     67     C    76
68     68     D    62
69     69     E    33
70     70     F    45
73     73     I    46
76     76     L    4
77     77     M    49
78     78     N    95
80     80     P    151
81     81     Q    22
83     83     S    73
85     85     U    21
86     86     V    72
97     97     a    2144
98     98     b    375
99     99     c    1104
100    100    d    714
101    101    e    3266
102    102    f    186
103    103    g    398
104    104    h    170
```

105	105	i	2696
106	106	j	30
108	108	l	1722
109	109	m	1234
110	110	n	1649
111	111	o	1154
112	112	p	666
113	113	q	334
114	114	r	1515
115	115	s	2352
116	116	t	2204
117	117	u	2622
118	118	v	384
121	121	y	19

2) Created an array of Huffman node to be sorted to get frequencies.
3) Sorted the array of Huffman node using Radix sort. Radix sort makes use of Count Sort.

Max Elemental Item Count = 4999
Sorted entries 0= 1 Ascii = 10
Sorted entries 1= 4 Ascii = 76
Sorted entries 2= 12 Ascii = 59
Sorted entries 3= 19 Ascii = 121
Sorted entries 4= 21 Ascii = 85
Sorted entries 5= 22 Ascii = 81
Sorted entries 6= 30 Ascii = 106
Sorted entries 7= 33 Ascii = 69
Sorted entries 8= 45 Ascii = 70
Sorted entries 9= 46 Ascii = 73
Sorted entries 10= 49 Ascii = 65
Sorted entries 11= 49 Ascii = 77
Sorted entries 12= 62 Ascii = 68
Sorted entries 13= 72 Ascii = 86
Sorted entries 14= 73 Ascii = 83
Sorted entries 15= 76 Ascii = 67
Sorted entries 16= 95 Ascii = 78
Sorted entries 17= 151 Ascii = 80
Sorted entries 18= 170 Ascii = 104
Sorted entries 19= 186 Ascii = 102
Sorted entries 20= 334 Ascii = 113
Sorted entries 21= 375 Ascii = 98
Sorted entries 22= 384 Ascii = 118
Sorted entries 23= 398 Ascii = 103

Sorted entries 24= 666 Ascii = 44
Sorted entries 25= 666 Ascii = 112
Sorted entries 26= 714 Ascii = 100
Sorted entries 27= 773 Ascii = 46
Sorted entries 28= 1104 Ascii = 99
Sorted entries 29= 1154 Ascii = 111
Sorted entries 30= 1234 Ascii = 109
Sorted entries 31= 1515 Ascii = 114
Sorted entries 32= 1649 Ascii = 110
Sorted entries 33= 1722 Ascii = 108
Sorted entries 34= 2144 Ascii = 97
Sorted entries 35= 2204 Ascii = 116
Sorted entries 36= 2352 Ascii = 115
Sorted entries 37= 2622 Ascii = 117
Sorted entries 38= 2696 Ascii = 105
Sorted entries 39= 3266 Ascii = 101
Sorted entries 40= 4999 Ascii = 32

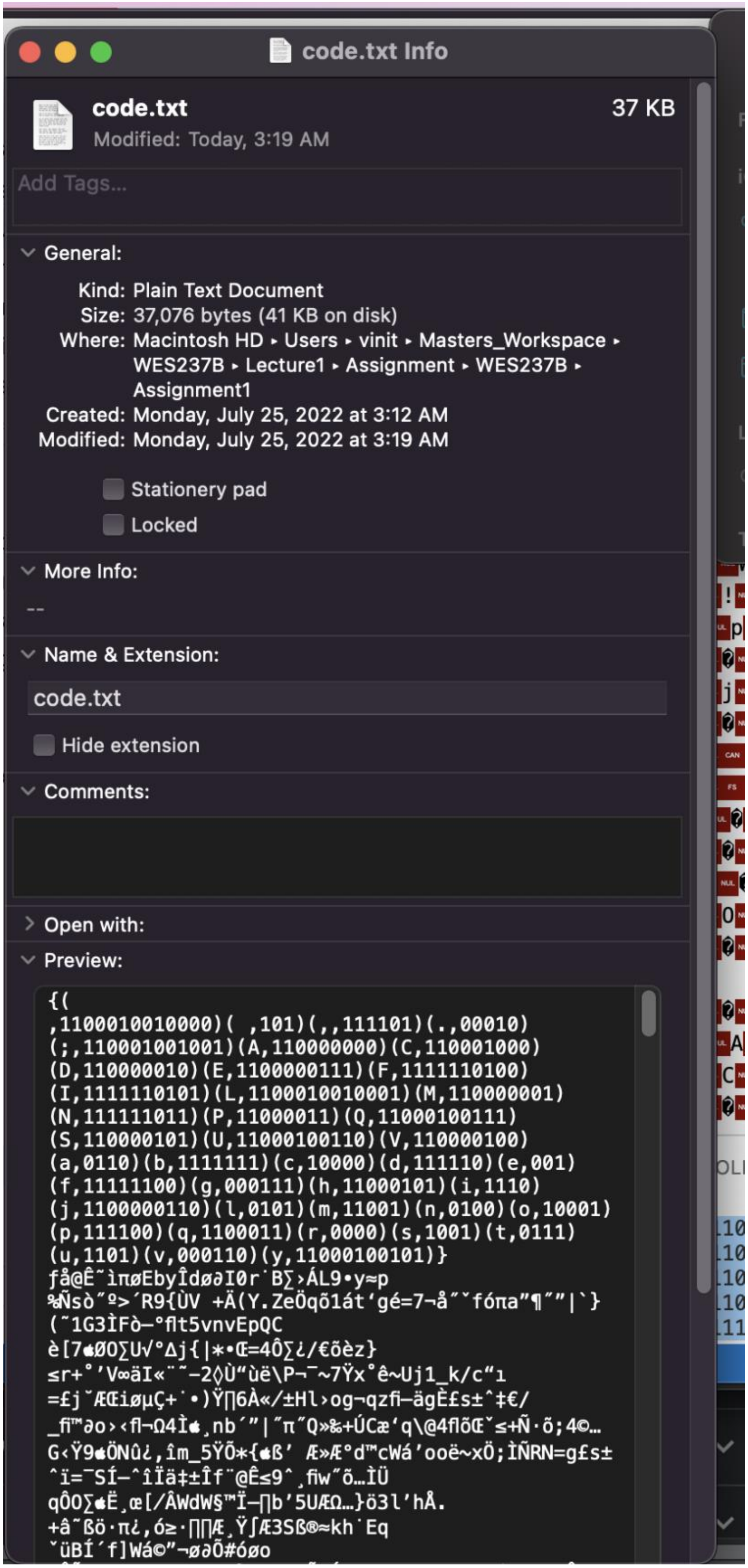
4) Created the priority queue to store these Huffman nodes with lease frequencies at first. Note: I explored the ways of using Radix sort and Count Sort to optimize Huffman Tree creation. There are papers published which states effectively proper use of sorting and using it again and again optimizes encoding. In case of priority queue creation, sorting could be avoided.
5) After creation of Priority queue, the Huffman node array was freed.
6) Create a tree following Greedy algorithm. Start with two nodes with least frequencies. Add their frequencies, create an intermediate node and add to priority queue. Note: By default, priority queue inserts in higher frequency order, overload the Compare method to do the opposite.
7) Store the Huffman Encoding table in the Map. Ascii Key is the key and its second is string of binary data symbol.
8) Create header of Encoding Map.

Ascii value --- Symbol -- Code
10
1100010010000
32 101
44 , 111101
46 . 00010
59 ; 110001001001
65 A 110000000
67 C 110001000
68 D 110000010
69 E 1100000111
70 F 1111110100

73	I	1111110101
76	L	1100010010001
77	M	110000001
78	N	111111011
80	P	11000011
81	Q	11000100111
83	S	110000101
85	U	11000100110
86	V	110000100
97	a	0110
98	b	1111111
99	c	10000
100	d	111110
101	e	001
102	f	11111100
103	g	000111
104	h	11000101
105	i	1110
106	j	1100000110
108	l	0101
109	m	11001
110	n	0100
111	o	10001
112	p	111100
113	q	1100011
114	r	0000
115	s	1001
116	t	0111
117	u	1101
118	v	000110
121	y	11000100101

9) Start reading input stream character by character, use map to find out the symbol. Add it in string object.
10) Write header created to the unsigned char type vector. (1 Byte per entry). Header format is
{(Ascii Key, "Binary symbol")(…)}
11) Use string object to read 8 Byte of bitstream data. Use 1 Byte of unsigned char data type to set/unset corresponding bits. Store the unsigned char to vector created for header. Make sure, padding is taken care of. In case the size of file is not multiple of 8, then there would be invalid byte information would be saved. One byte of binary data was followed by one byte of information regarding validity of data. This could be improved in later version. Out of word of 3 bytes would be used to show the compress data, one byte would be used to store validity information.

12) Get the size of vector, dynamically allocate the memory and populate the coded entries.
13) Store the file in code.txt


code.txt Info
code.txt
37 KB
Modified: Today, 3:19 AM
Add Tags...
General:
Kind: Plain Text Document
Size: 37,076 bytes (41 KB on disk)
Where: Macintosh HD ▸ Users ▸ vinit ▸ Masters_Workspace ▸ WES237B ▸ Lecture1 ▸ Assignment ▸ WES237B ▸ Assignment1
Created: Monday, July 25, 2022 at 3:12 AM
Modified: Monday, July 25, 2022 at 3:19 AM
Stationery pad
Locked
More Info:
--
Name & Extension:
code.txt
Hide extension
Comments:
Open with:
Preview:
{(
,1100010010000)(,101)(,,111101)(.,00010)
(;,110001001001)(A,110000000)(C,110001000)
(D,110000010)(E,1100000111)(F,1111110100)
(I,1111110101)(L,1100010010001)(M,110000001)
(N,111111011)(P,11000011)(Q,11000100111)
(S,110000101)(U,11000100110)(V,110000100)
(a,0110)(b,1111111)(c,10000)(d,111110)(e,001)
(f,11111100)(g,000111)(h,11000101)(i,1110)
(j,1100000110)(l,0101)(m,11001)(n,0100)(o,10001)
(p,111100)(q,1100011)(r,0000)(s,1001)(t,0111)
(u,1101)(v,000110)(y,11000100101)}

In the preview section the file shows , Header followed by binary data. The file size relatively remained unaffected due to Header. Improvement could be made in storing the information. For a larger file, the header would not impact the compression much.

Huffman Decoding:

1) Read the data from the code.txt. Parse the header and create MAP.

********* Decode *******
Header Start
Header creation successful
Ascii value --- Symbol -- Code
10
1100010010000

32		101
44	,	111101
46	.	00010
59	;	110001001001
65	A	110000000
67	C	110001000
68	D	110000010
69	E	1100000111
70	F	1111110100
73	I	1111110101
76	L	1100010010001
77	M	110000001
78	N	111111011
80	P	11000011
81	Q	11000100111
83	S	110000101
85	U	11000100110
86	V	110000100
97	a	0110
98	b	1111111
99	c	10000
100	d	111110
101	e	001
102	f	11111100
103	g	000111
104	h	11000101
105	i	1110
106	j	1100000110
108	l	0101

109	m	11001
110	n	0100
111	o	10001
112	p	111100
113	q	1100011
114	r	0000
115	s	1001
116	t	0111
117	u	1101
118	v	000110
121	y	11000100101

Creating Decoder Tree , node address = 0x127705f50

2) Create the Huffman Tree by parsing through every entry iterating over the map.
3) Read the binary data and create a string object to store intermediate bit streams information. Take care of invalid bits.
4) Decode by iterating over the tree. Keep traversing the tree till leaf is reached. From the encoding table, fetch the binary symbol and store is in vector of unsigned char.
5) Allocate the memory dynamically and store the decoded bit streams in unsigned char memory location.
6) For properly decoded bit streams, the output.txt file is created.
7) Diff command compares the file input.txt and output.txt and outputs the result.

****Decoding start*****
Bitstream length = 146438
SUCCESS