課題 データ圧縮（ランレングス符号化
ファイルの容量を圧縮するアルゴリズムとして，ランレングス符号化（run－length encoding）に基づくデータ圧縮と解凍プログラムを作成し，次ページのデータをファイルに保存し，圧縮前と圧縮後でのファイルサイズを比較せよ．また，圧縮されたデータから元のデータを復元できることを確認せよ．データはアルファベットのみの テキストデータとする．

ランレングス符号化
例えば，文字列「aaaaabbbbbbbcccddeeee」が与えられたとき，同じ文字か続く塊「aaaaa」，「bbbbbbb」，「ccc」，「dd」，「eeee」を「連」という．ランレングス符号化では各連を連の長さとその文字で表す．例えば「aaaaa」は $「 5 a 」 の よ う に$ 表す。こうすることで元の文字数 5 を文字数 2 に圧縮することができる。ただし，連の長さが 1 また は2のときは圧縮の効果が得られないのでそのまま表示するものとする。したがって「aaaaabbbbbbbcccddeeee」 は「5a7b3cdd4e」と圧縮される．こうした符号化は画像データで同じ色が続くような場合には特に有効である． （実行例）

2 ページに元データ， 3 ページに圧縮されたデータを示す。
この場合圧縮によってファイルサイズは $2388 / 8190=29.2 \%$ に縮小されている．








 jjjjjjjjjjjjjjjecccccccccccccccccccccffijjjjjjjjjjjjfccccccccccccccccccccfjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjfсccccccccccccccccccccccccfjjjjjjjjjjjjfсccccccccccccccccccccccfjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjfcccccccccccccccccccccccccfjjjjjjjjjfccccccccccccccccccccccfjjjjjjjjjjjjjjjj
 jjjjjjjjjjjjjjjjjjfccccccccccccccccccccccccccfjjjjjjffcccffcccccccccccccccccccccjjjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjecccccccccccccccccccccffcccfjfff cccfcccccccccccccccccccccccfjijjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjjifccccccccccccccccccccccccfccc'cccccfcccccccccccccccccccccccjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjfcccccccccccccccccccccccccccfccccfcccccccccccccccccccccccccfjjjjjjjjjjjjjjj



 jjjjjjjjjjjjjjjj'ccccccccccccccccccccff'fffffffffffffffffff'fffccccccccccccfjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjccccccссссссссссссссс'fffffffffffffffffffffffffff'fccccccccfjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjfcccccccccccccccccccc'ffffffffffffffffffffffffffffff'fccccccjjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjcccccccccccccccccccffffffffffffffffffffffffffffffffff'ccccfjjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjj'cccccccccccccccccf'fffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjjjjjjjjj jjjjjjijjjjjjjjifcccccccccccccc'fffffffffffffffffffffffffffffffffffffff'ijjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjifccccccccccccf'fffffffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjfcccccccccffffffffffffffffffffffffffffffffffffffffffffffffijjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjjjj'cccccc'fffffffffffffffffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjjjjj jjjjjjjjjjjjjjjjjff'f'f'fcc'fffffffffffffffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjjjj jjjjjjjjj jjj jijffffffffccfffffffffffffffffffffffffffffffffffffffffffffffffffijjjjjjjjjjjjjj jjjjjjjjjjjjjj'ffffff'cc'ffffffffffffffffffffffffffffffffffffffffffffffffffffijjjjjjjjjjjjj jјjj jijjjjjjjjfffffffccfffffffffffffffffffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjjj jjjjjjjjjjjjjiffffffffccfffffffffffffffffffffffffffffffffffffffffffffffffffffffffjjjjjjjjjjjj jjjjjjjjjjjj'fffffffcffffffffffffffffffffffffffffffffffffffffffffffffffffffff'fjjjjjjjjjjjj据 jjjjjjjjjjjjffffffffcf'fffffffffffffffffffffffffffffefff'iiffff'fffffffffffffffjjjjjjjjjjjjj jjjjjjjjjjjj 'fffffffffffffffffffffffffffffffffffffffhfffffidffffffffffffffffffffjjjjjjjjjjjjj] jjjjjjjjjjjffffffffff'ffffffffffffffffffffffffffffhiffffeaiffff'ffffffffffffff'jjjjjjjjjjjj jjjjjjjjjjjffffffff‘cffffffffffffffffffffffffffffeiifff'diiefff'fffffffffffffffjjjjjjjjjjjj jjjjjjjjjjj'ffffffff'ffffffffffffffffffffffffffffaii'fffiiieffffeffffffffffffffjjjjjjjjjjjj jjjjjjjjj'ffffffff'ffffffffffffffffffffffffffff'ihiifffeiiiefffea'fffffffff'fff‘jjjjjjjjjjj jjjjjjjjjffffffffffffffffffffffffffffffff'fffffadiiifffeiiiefffaifffffffffffj'fjjjjjjjjjjjjj jjjjjjjjifffffffffff'ffffffffffffffffefffffffffffiiiiefffiiiaefffihffffffffff‘jff‘jjjjjjjjjjjjj jjjjjjjifffffffffffffffffffffffffffeeffeffffffgiiiiifffdiiiieffdiifffffffffffjffjjjjjjjjjjjj jjjjjjjfffffffffffffffffffffffffffiaf'ea'ffffhiiiihffeiiiiieffiiiefffffffff‘jjf‘jjjjjjjjjjjj jjjjjj'fffffffffffffffffffffffffehe'fiiffffehaiiiieffgiiiiiffdiiiefffffffffffj‘jjjjjjjjjjjj jjjjjfffffffffffffffffffffff‘eihffaiihfffdiiiiiiiiffhiiiiiifeiiiieffffffffffjijjjjjjjjjjjjj jjjjj'fffffffffffffffffffffffaaiigidiifffgiiiiiiiiiehiiiiiifeiiiiii'ffffffffff‘jjjjjjjjjjjjjj jjjjjjffffffffffffffffffffffiiiiiiiiiief'eeiiiiiiiiiiiiiiiiiiiiiiiiiaffffffffff‘jjjjjjjjjjjjjjj jjjjff'ffffffffffffffffffffeiiiiieeeefeiiiiiiiiiiiiiiiieeeeeeeiiii'fffffffffffjjjjjjjjjjjjjjj jjjjjjffffffffffffffff‘ffffaiiiieaiif'‘fiiiiiiiiiiiiiiiiiiiiiiiaiiiffffffffff‘jjjjjjjjjjjjjjj jjjjj'ffffffffffffffffeaefffgiiiiiie'eedeeiiiiiiiiiiiiiiie،‘‘‘iiiiieffffffff'ffjjjjjjjjjjjjjjj jjjjjf'fffffffffffffaiiffeiiiiiieee‘‘'hiiiiiiiiiiiiiifeeefdfiiiieffffffffjffjjjjjjjjjjjjjj jjjjjjj'fff'ffffffffeiiii'eaiiiiiie'e‘'eiiiiiiiiiiiiiiiee'،'fhiiiii'ffffffff‘j'jjjjjjjjjjjjjjjjj jjjjjjjj'fffffffffffiiiifeiiiiiiie'،'،eiiiiiiiiiiiiiiiihfg''fhiiiffffffffffjjjjjjjjjjjjjjjjjj jjjjjjjjff'fffffffffeaiiieaiiiiiiiie'،'fhiiiiiiiiiiieiiih'،''eiiiifeeffffffjjjjjjjjjjjjjjjjjjj
 jjjjjjjjjjffffe'fffffeiiiiiiiiiiiiiihiiiiiiiiiiiiiiifiiiif'‘adiiieiiffff'fjjjjjjjjjjjjjjjjjjjj jjjjjjjjaefffffffffffiiiiiiiiiiiiiiiiiiiiiiiiiiiiiediiideiiiiiifidfff‘jjjjjjjjjjjjjjjjjjjjj jjjjjjjfbiaeffe'ffffffeiiiiiiiiiiiiiiiiiiiiiiiiiiiiifiiiiiiiiiideiefffjjjjjjjjjjjjjjjjjjjjjj jjjjjjjeiaaa'ffeffffff‘'iiiiiiiiiiiiiiiiiiiiiiiiiiiiiidiiiiiiiiiiieiiff'fffjjjjjjjjjjjjjjjjjjjjjjj jjjjjjjeaaaaefeefffffffeaiiiiiiiiiiiiiiiiiiiiiiiiiiifiiiiiiiiiiiieiffffedjjjjjjjjjjjjjjjjjjjjjjjj jjjjjjjeaaaaaaf'aeffffff‘‘eiiiiiiiiiiiiiiiiiiiiiiiiiihiiiiiiiiiiiefffefaaajjjjjjjjjjjjjjjjjjjj jjjjjjjeaaaaaaefaffff‘fff‘feiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiieffeadaaaafjjjjjjjjjjjjjjjjjjjj jjjjjjfaaaaaaaaadffffffffffffiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiefeaaaaaaajjjjjjjjjjjjjjjjjjj jjjfefaaaaaaaaaaaaefffefffffeiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiieaaaaaaaaaajjjjjjjjjjjjjjjjjjj jfedaeaaaaaaaaaaaafadaaf'ffffiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiaeaaaaaaaaaaa،'jjjjjjjjjjjjjjjjjj fdaafbaaaaaaaaaaaeaaaaaeeeeefiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiiieaaaaaaaaaaaaf jjjjjjjjjjjjjjjjjjj daaaeaaaaaaaaaaaeaaaaaaaeeeeeiiiiiiiiiiiiiiiaeeeeiiiiiiiiiiifaaaaaaaaaaaaeeefjjjjjjjjjjjjjj aaaafaaaaaaaaaaafaaaaaaaeighgfiiiiiiiiiiiiiiefeefiiiiiiiiiiieaaaaaaaaaaaaeeaadjjjjjjjjjjjjj aaaaeaaaaaaaaaaaeaaaaaaaaehhhheiiiiiiiiiiiiiaaaiiiiiiiiiiaeaaaaaaaaaaaaeaaaaefjjjjjjjjjjj aaaaeaaaaaaaaaaaafaaaaaaaaeeihedeiiiiiiiiiiiiiiiiiiiiiiiiideaaaaaaaaaaaaeeaaaaaejjjjjjjjjjj aaaaaaaaaaaaaaaabeaaaaaaaaaehfiifiiiiiiiiiiiiiiiiiiiiiiieeaaaaaaaaaaaaaeaaaaaadfjjjjjjjjjj aaaaaaaaaaaaaaaaaafaaaaaaaaaaeheiieeiiiiiiiiiiiiiiiiiiiiieaaaaaaaaaaaaaaeaaaaaaaadf jjjjjjjjjj aaaaaaaaaaaaaaaaaaeaaaaaaaaaadefiiiaeiiiiiiiiiiiiiiiiiiiaeaaaaaaaaaaaaaaf aaaaaaaaaejjjjjjjjj aaeaaaaaaaaaaaaaafaaaaaaaaaaaaediiiaeiiiiiiiiiiiiiiiaefaaaaaaaaaaaaaafaaaaaaaaaaejjjjjjjjj aaeaaaaaaaaaaaaaaaeaaaaaaaaaaaeiiiiiefiiiiiiiiiiildefaaaaaaaaaaaaaeaaaaaaaaaababjjjjjjjj aaeaaaaaaaaaaaaaaaeaaaaaaaaaaaafeiiiiieeiiiiiiileeeeiaaaaaaaaaaaaaeaaaaaaaaaaaaafjjjjjjjj
 aaaf aaaaaaaaaaaaaaaeaaaaaaaaaaaaaaaeiiiiiiiaiaiaaefiaaaaaaaaaaaaef aaaaaaaaaaaaaaaaf jjjjjjjjj








$22 j 5 f 63 j$
$20 j f 7 c f 31 j 3 f c 3 f 23 j$
19jf9cff27jf8cff21j
18jf12cf26j11cf20j
17jf14cf23jff12cf19j
16jf17cf20j16cf18j
15jf19cf18j'16cf18j
15jf20cff14jf19cf17j
$14 j e 22 c f f 12 j f 20 c f 17 j$
14jf24cf11jf21cf16j
14jf25cf9jf22cf16j
15jf25cf7jf23cf16j
15jf26cf5jf3cff20c16j
$15 j e 22 c f f 3 c f j f f$ ' $3 c f 22 c f 15 j$
15jf24cf3c'5cf23c16j
15jf27cf4cf25cf15j
15jf27cf4cf25c16j
14jf28cf30c'15j
$14 j f 28 c f 3 c f 26 c 16 j$
$14 j f 24 c f^{\prime} f{ }^{\prime}{ }^{\prime} f f^{\prime} f f^{\prime} f^{\prime} f f^{\prime} f$ 'f $17 c f 16 j$
$14 j^{\prime} 21 c f f$ ' $18 f$ ' $3 f 12 c f 16 j$
$13 j f 21 c$ '26f'f8cf17j
13jf20c'29f'f6c18j
14j19c33f'4cf18j
$13{ }^{\prime} 17 \mathrm{cf}$ '38f19j
$14 j f 15 c$ ' $39 f^{\prime} 19 j$
14jf13cf'42f18j
15jf10c47f'16j
$16 j^{\prime} 6 c^{\prime} 51 f 15 j$
$15 j f f$ 'f'f'fcc'50f14j
$14 j 8 f c c 51 f$ ' 14
$13 j^{\prime} 6 f^{\prime} c c^{\prime} 52 f^{\prime} 13 j$
$13 j 7 f c c 55 f 13 j$
12j8fcc56f12
$12 j^{\prime} 7 f c 55 f^{\prime} f 12 j$
12j7f'c29f'5fee19f'12j
11j8fcf'29fe3f'ii4f'15f12j
11 j '38fh5fid20f12j
$10 j 10 f$ ' 28 fhi 4 feai4f' 14 f' $12 j$
$10 j 8 f$ 'c28feii3f'diie3f'15f12j
10j'8f'28faii'3f3ie4fe14f12j
9j'8f'27f'ihii3fe3ie3fea'9f'3f'11j
8j32f'5fad3i3fe3ie3fai11fj'f12j
$7 j 11 f$ '16fe10f4ie3f3iae3fih10f'jff'11j
7j27feeffe6fg4i3fd4ieffdii11fjff12j
6j27fiaf'ea'4fh4ihffe5ieff3ie9f'jjf'11j
6j'24fehe'fii4feha4ieffg5iffd3ie11fj'12j
5j23f'eihffaiih3fd7iffh6ife4ie10f15j
5j'22faaiigidii3fg8ieh6ife6i'9f'14j
5j22f9ief'ee23ia10f'14j
$4 j f f ' 19 f e 5 i 4 e f e 16 i 7 e 4 i$ '10f14j
5j16f'4fa4ieaiif'‘f22ia3i10f'14j
$4 j^{\prime} 15 f e a e 3 f g 6 i e^{\prime} e e d e e 14 i e 4$ '5ie8f'ff14j
5jf'13faiiffe6i3e3'h14if3efdf4ie8fjff14j
$6 j^{\prime} 3 f^{\prime} 8 f e 4 i ' e a 6 i e^{\prime} e^{\prime \prime} e 14 i e e 3^{\prime} f h 4 i$ ' $7 f^{\prime} j^{\prime} 15 j$
$7 j^{\prime} 12 f 4 i f e 7 i e 4$ 'e14ihfg'‘fh3i10f17j
$7 j f f$ '9fea3iea7ie3'fh10ie3ih4'e4ifee6f18j
$8 j^{\prime} 4 f^{\prime} 5 f^{\prime} 4 i e 8 i g f$ '‘e11ie3ih4'diigfdg4f'f'18j
$9 j 4 f e ‘ 5 f e 13 i h 14 i f 4 i f ‘ ‘ a d 3 i e i i 4 f$ 'f19j
8jae11f28ied3ide6ifid3f'21j
jfbiaeffe'6fe28if10ideie3f22j
6jei3a'ffe6f'28id10ieiiff'3f20j
$6 j e 4 a e f e e 7 f e a 25 i f 11 i e i 4 f e d 21 j$
6je5af'ae6f'e25ih11ie3fef3a20j
6je6aefa4f'3f'fe34ieffead4af18j
5jf10ad11f33iefe7a19j
3jfef12ae3fe5fe32ie10a18
jfedae12afadaaf'4f31iae11a'16j
fdaafb11ae5a5ef31ie12af16j
d3ae12ae7a5e14ia4e11if12a3ef13j
4af12af7aeighgf13iefeef10ie12aeeaad13j
4ae12ae8ae4he13i4a9iae12ae4aef11j
4ae12af8aeeihede24ide12aee5ae11j
17abe9aehfiif22iee13ae6adf 10j
18af10aeheiiee19ie14ae8adf9j
18ae10adef3iae17iae14af9ae9j
aae15af12aed3iae14iaef14af10ae9j
aae16ae12ae5ief11idef14ae11abf8j
aae16ae13afe5iee7i4ei13ae13af8j
3ae15ae15ae5ia8ede14aee13ae8j
3af15ae16ae6iaiaiaaefi12aef15af8j
3aee15af16af10iefi31ae7j
4af15aee15aiee7ieai33ae6j
4abf15af18afa4if38aef3j
5ae16ae18aefiiei39ae3j
6ae15aee18aief23ae18aejj
6aee15aee8affe6aee24af19af j
8ae16ae4afefgiaefefeffefefeffefefe13ae19aej
8aee15af3ef7ieeh3da4dh4dheeff9af20aef

