```
 1 /*
 2    RA.c
 3                (c) DJCM 98 09 28
 4
 5    Repeat-accumulate code simulator
 6
 7  read in code definition
 8  loop {
 9    encode source string
10    add noise
11    decode
12  }
13
14  Code definition: (stored in "alist")
15
16        Use of alist allows arbitrary numbers of repetitions
17        of each bit.
18
19   K                       source block length
20   n_1 n_2 ... n_K         number of repetitions of each source bit
21   N = sum n_k
22   alist  defines          permutation of N encoded bits
23                           note, an additional permutation of the N
                             accumulated
24        bits may be a good idea. (for non-memoryless channels)
25
26  transmitted bits are integral of encoded bits
27
28  Future plans:
29   clump source bits into clumps. Have multiple parallel accumulated
     streams.
30   Have little sub-matrices (like GF(q) ) defining response of
     accumulator to
31   clumps.
32
33 */
34
35 #include "./ansi/r.h"
36 #include "./ansi/rand2.h"
37 #include "./ansi/mynr.h"
38 #include "./ansi/cmatrix.h"
39
40 #include "./RA.h" /* this defines  data_creation_param ; RA_control */
41
42 int RA_encode ( unsigned char * , RA_control * , unsigned char * ) ;
43 static int t_to_b (  unsigned char * ,  RA_control * ) ;
44 int RA_decode ( RA_control * ) ;
45 int RA_horizontal_pass ( RA_control * ) ;
46
47 static void dc_defaults ( RA_control * ) ;
48 static int  process_command ( int , char **  , RA_control * ) ;
49 static void print_usage ( char ** , FILE * ,  RA_control *  );
50 static int  make_sense ( RA_control * ) ;
51 static int  make_space ( RA_control * ) ;
52 static int  score ( RA_control *  ) ;
53
54 static void finalline (  FILE * , RA_control * , int ) ; /* int = 1 to
   get loads of info */
```

```
 55
 56 static double bern ( int  , int  , double * , double * ,  double * ,
    double );
 57 static void histo ( FILE * ,  RA_control * ) ;
 58 static void snappyline ( RA_control * ) ;
 59 static void RA_free ( RA_control * ) ;
 60 static int  check_alist_MN ( alist_matrix * , RA_control * ) ;
 61 static double h2 ( double ) ;
 62
 63 void   main ( int , char ** ) ;
 64
 65 /*
 66         MAIN
 67                       */
 68 void main ( int argc, char *argv[] )
 69 {
 70   FILE   *fp  ;
 71
 72   int k ;
 73   RA_control         c ;
 74   dc_defaults   ( &c ) ;
 75
 76   if ( process_command (argc, argv, &c ) < 0 ) exit (0) ;
 77   if ( read_allocate_alist ( &(c.a) , c.afile ) < 0 ) exit (0) ;
 78   if ( check_alist_MN ( &(c.a) , &c ) < 0 ) exit (0) ;
 79   if ( make_sense ( &c  ) < 0 ) exit (0) ;
 80
 81   fprintf(stderr,"RA N=%d, K=%d, x=%6.3g xass=%6.3g fn=%6.3g
    fnass=%6.3g\n",
 82     c.N , c.K , c.gcx , c.gcxass , c.fn , c.fnass ) ;
 83   fflush(stderr);
 84
 85   if ( make_space ( &c ) < 0 ) exit (0) ;
 86
 87   if ( c.writelog ) {
 88     fp = fopen ( c.logfile , "w" ) ;
 89     if ( !fp ) {
 90       fprintf ( stderr , " couldn't open logfile %s\n" , c.logfile ) ;
 91       c.writelog = 0 ;
 92     } else fclose (fp ) ;
 93   }
 94
 95   if ( c.writelog ) {
 96     fp = fopen ( c.logfile , "w" ) ;
 97     if ( !fp ) {
 98       fprintf ( stderr , " couldn't open logfile %s\n" , c.logfile ) ;
 99       c.writelog = 0 ;
100     } else fclose (fp ) ;
101   }
102
103   if ( c.error_log ) {
104     fp = fopen ( c.error_logfile , "w" ) ;
105     if ( !fp ) {
106       fprintf ( stderr , " couldn't open logfile %s\n" , c.error_logfile
        ) ;
107       c.error_log = 0 ;
108     } else fclose (fp ) ;
109   }
```

```
110
111   /*
112       MAIN LOOP
113                   */
114
115   ran_seed ( c.vseed ) ;
116   c.message = 1 ;
117   for ( ;       ( c.message <= c.MESSAGE ) &&
118     ( ( c.failures==0 ) || ( c.failcount < c.failures ) ) ;
119   c.message ++ ) {
120
121     snappyline( &c ) ;
122     /* force parity bit at end */
123     c.sourceweight = random_cvector ( c.s , c.fs , 1 , c.K ) ;
124
125     if ( c.verbose > 2) {
126       printf ( "source vector:\n" ) ;
127       for ( k = 1 ; k <= c.K ; k ++ ) {
128   if ( c.s[k] ) printf ("1 ") ; else printf ( "0 " );
129       }
130       printf ( "\n" ) ;
131     }
132     RA_encode ( c.s , &c , c.t ) ;
133     if ( c.verbose > 2) {
134       printf ( "transmitted vector:\n" ) ;
135       for ( k = 1 ; k <= c.N ; k ++ ) {
136   if ( c.t[k] ) printf ("1 ") ; else printf ( "0 " );
137       }
138       printf ( "\n" ) ;
139     }
140     c.flipped = t_to_b ( c.t , &c ) ;
141     if ( c.verbose > 2 ) {
142       printf ( "received likelihoods:\n" ) ;
143       for ( k = 1 ; k <= c.N ; k ++ ) {
144   printf ("%1d " , (int) ( c.bias[k][1] * 10.0 ) ) ;
145       }
146       printf ( "\n" ) ;
147       for ( k = 1 ; k <= c.N ; k ++ ) {
148   printf ("%1d " , (int) ( c.bias[k][1] * 2.0 ) ) ;
149       }
150       printf ( "\n" ) ;
151     }
152     RA_decode ( &c ) ;
153
154     if ( score ( &c ) < 0 ) exit ( 0 ) ;
155     if ( c.verbose > 0 ) finalline ( stdout , &c , 0 ) ;
156     if ( c.printout ) { /* append */
157       fp = fopen ( c.outfile , ((c.outappend)? "a":"w") ) ;
158       if( !fp ) {
159   fprintf( stderr, "No such file: %s\n", c.outfile ) ;
160   finalline ( stderr , &c , 0 ) ;
161       }      else   {
162   finalline ( fp ,  &c , 0 ) ;
163   fclose ( fp ) ;
164       }
165     }
166     if (  (!( ( c.message+1 <= c.MESSAGE ) &&
167     ( ( c.failures==0 )
```

```
168       || ( c.failcount < c.failures ) ) ) )
169     || (!(c.message % c.big_write_period ) ) ) {
170       if ( c.printtot ) { /* write */
171   fp = fopen ( c.totoutfile , "w" ) ;
172   if( !fp ) {
173     fprintf( stderr, "No such file: %s\n", c.totoutfile ) ;
174     finalline ( stderr , &c , 1 ) ; /* totalline */
175   }      else   {
176     finalline ( fp , &c , 1 ) ;
177     fclose ( fp ) ;
178   }
179       }
180       if ( c.printhisto && c.block_valid ) { /* update histogram file */
181   fp = fopen ( c.histofile , "w" ) ;
182   if( !fp ) {
183     fprintf( stderr, "No such file: %s\n", c.histofile ) ;
184   }      else   {
185     histo ( fp , &c ) ;
186     fclose ( fp ) ;
187   }
188       }
189     }
190   }
191   snappyline( &c ) ; printf("\n") ;
192   RA_free (  &c ) ;
193 }
194
195 static void histo ( FILE *fp ,  RA_control *c ) {
196   int l;
197   double t , cum = 0.0 ;
198   double  tot = (double) c->block_valid ;
199
200   fprintf ( fp , "# total valid blocks %d\n" , c->block_valid ) ;
201   for ( l = 1 ; l <= c->loops ; l ++ ) {
202     t= (double) c->histo[l] ;
203     cum += t ;
204     fprintf ( fp , "%d\t%d\t%d\t%9.4g\t%9.4g\n" , l , (int)(t) ,
      (int)(cum) ,
205         t/tot , cum/tot ) ;
206   }
207
208 }
209 static void snappyline ( RA_control *c ) {
210   printf ( "%d:%du%dd%dl/%d\t" , c->block_errs , c->block_undet,
    c->block_det, c->block_detlw , c->message - 1 ) ; fflush ( stdout ) ;
211
212 }
213
214 /*                                                  <<<<N>>>>
215   Encoding method:
216   source bits d[1]..d[K] are mapped via an alist  ^ 1    1 1
217   into a pre-transmission vector                  K  1 1  1
218   s[1]..s[N] .                                    V   1 1   1
219
220   t[n] = t[n-1] ^ s[n]
221
222      s[n]      s[n+1]
223       |         |
```

```
  224 0 .. -+-> t[n] -+-> t[n+1] ..... t[N]
  225            |        |            |
  226            V        V    V
  227           y[n]      y[n+1]   y[N]
  228
  229   */
  230
  231 int RA_encode ( unsigned char *d , RA_control *c , unsigned char *t ) {
  232   int n , k ; int status = 0 ;
  233   alist_transpose_cvector_sparse_mod2 ( &c->a , d , t ) ; /* here 't'
        doubles as 's' */
  234   /* accumulate */
  235
  236   if ( c->verbose > 2) {
  237     printf ( "extended source vector:\n" ) ;
  238     for ( k = 1 ; k <= c->N ; k ++ ) {
  239       if ( t[k] ) printf ("1 ") ; else printf ( "0 " );
  240     }
  241     printf ( "\n" ) ;
  242   }
  243
  244   for ( n = 2 ; n <= c->N ; n ++ ) {
  245     t[n] = t[n]^t[n-1] ;
  246   }
  247
  248   if ( c->verbose > 2) {
  249     printf ( "accumulated transmission:\n" ) ;
  250     for ( k = 1 ; k <= c->N ; k ++ ) {
  251       if ( t[k] ) printf ("1 ") ; else printf ( "0 " );
  252     }
  253     printf ( "\n" ) ;
  254   }
  255   return status ;
  256 }
  257
  258 /*
  259    The channel outputs a normalized likelihood vector
  260    bias[n] = P( yn | tn = 1 )
  261
  262    The state of the decoder is  q[1..N][0/1] and r[1..N][0/1]
  263
  264    q[n][s] = pseudoprior( s[n] = s )     s=0/1      initially 0.5
  265
  266    Use f/b algorithm to find:
  267                                          initial conditions:
  268    f[n][t] = P( y1...yn , tn=t )         f[0][0] = 1 ; f[0][1] = 0 ;
  269    b[n][t] = P( yn...yN | tn=t )         b[N+1][0] = 1 ; b[N+1][1] = 1 ;
  270
  271    Using
  272    f[n][t] = bias[n][t] * sum_{t': t'+s=t} ( f[n-1][t'] pi[n][s] )
  273    b[n][t] = bias[n][t] * sum_{t': t'+s=t} ( b[n+1][t'] pi[n+1][s] )
  274
  275    Find likelihood contribution at n:
  276       r[n][s] `=' P(y1..yN|s[n]=s) = sum_{s: t'+s=t} f[n-1][t] b[n][t']
  277
  278    Then in the vertical step we visit each incarnation of the source bit
  279    for( r = 1 .. repetitions[k] ) (number on mlist)  n=nlist[r]
  280       d[r][s] = d[r-1][s] * r[n][s] ;
```

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