

```
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
24                      accumulated
25                      bits may be a good idea. (for non-memoryless channels)
26
27  transmitted bits are integral of encoded bits
28
29  Future plans:
30  clump source bits into clumps. Have multiple parallel accumulated
31  streams.
32  Have little sub-matrices (like GF(q) ) defining response of
33  accumulator to
34  clumps.
35
36  */
37
38  #include "./ansi/r.h"
39  #include "./ansi/rand2.h"
40  #include "./ansi/mynr.h"
41  #include "./ansi/cmatrix.h"
42
43  #include "./RA.h" /* this defines  data_creation_param ; RA_control */
44
45  int RA_encode ( unsigned char * , RA_control * , unsigned char * ) ;
46  static int t_to_b ( unsigned char * , RA_control * ) ;
47  int RA_decode ( RA_control * ) ;
48  int RA_horizontal_pass ( RA_control * ) ;
49
50  static void dc_defaults ( RA_control * ) ;
51  static int  process_command ( int , char ** , RA_control * ) ;
52  static void print_usage ( char ** , FILE * , RA_control * ) ;
53  static int  make_sense ( RA_control * ) ;
54  static int  make_space ( RA_control * ) ;
55  static int  score ( RA_control * ) ;
56
57  static void finalline ( FILE * , RA_control * , int ) ; /* int = 1 to
58  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 ( "%ld " , (int) ( c.bias[k][1] * 10.0 ) ) ;
145          }
146          printf ( "\n" ) ;
147          for ( k = 1 ; k <= c.N ; k ++ ) {
148              printf ( "%ld " , (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) ,
205             (int)(cum) ,
206             t/tot , cum/tot ) ;
207     }
208 }
209 static void snappyline ( RA_control *c ) {
210     printf ( "%d:%du%dd%dl/%d\t" , c->block_errs , c->block_undet,
211             c->block_det, c->block_detlw , c->message - 1 ) ; fflush ( stdout ) ;
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'
234     doubles as 's' */
235     /* accumulate */
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
268     f[n][t] = P( y1...yn , tn=t )          initial conditions:
269     b[n][t] = P( yn...yN | tn=t )          f[0][0] = 1 ; f[0][1] = 0 ;
270                                           b[N+1][0] = 1 ; b[N+1][1] = 1 ;
271
272     Using
273     f[n][t] = bias[n][t] * sum_{t': t'+s=t} ( f[n-1][t'] pi[n][s] )
274     b[n][t] = bias[n][t] * sum_{t': t'+s=t} ( b[n+1][t'] pi[n+1][s] )
275
276     Find likelihood contribution at n:
277     r[n][s] = P(y1..yN|s[n]=s) = sum_{s: t'+s=t} f[n-1][t] b[n][t']
278
279     Then in the vertical step we visit each incarnation of the source bit
280     for( r = 1 .. repetitions[k] ) (number on mlist) n=mlist[r]
281         d[r][s] = d[r-1][s] * r[n][s] ;

```

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