Supplementary file S3 contains H4code74\_GNU.py script to generate H4(7,4) code, random\_GNU.py generates random errors in the H4(7,4) code and and decoder\_GNU.py scripts corrects those errors correspondingly. Note that all those codes operate within Gnumeric spreadsheet. Gnumeric files are available on request. H4code74.r and H4code74\_decoder.r are two R-scripts written by Erik Zwart.

#script H4code74\_GNU.py

# this script generates quaternary Hamming codes

#It requires Gnumeric spreadsheet

import Gnumeric, os

wb=Gnumeric.workbooks()[0] #output in workbook sheet1

s=wb.sheets()[1]

c=s[0,1]

x=1

total=0

p=[0,0,0,0,0,0,0,0]

d=[0,0,0,0,0,0,0,0]

base=['A','C','G','T']

s[0,0].set\_text('Index')

s[1,0].set\_text('Data')

s[2,0].set\_text('HQ code')

s[3,0].set\_text('Barcode')

while x<257:

 H74=[]

 s[0,x].set\_text(str(x-1)) #decimal counter#

 data=d[1],d[2],d[3],d[4]

 s[1,x].set\_text(str(data)) #set data values

#count parity bits.

 p[1]=(4-(d[1]+d[2]+d[4])%4)%4

 p[2]=(4-(d[1]+d[3]+d[4])%4)%4

 p[3]=(4-(d[2]+d[3]+d[4])%4)%4

 #generates binary Hamming sequence

 H74.extend([p[1],p[2],d[1],p[3],d[2],d[3],d[4]])

 s[2,x].set\_text(str(H74))

#generates sequence out of H74 code and base coding table

 seq=''

 mylen=len(H74)

 w=0

 while w<mylen:

 seq=seq+base[H74[w]]

 w+=1

# print seq

 s[3,x].set\_text(str(seq)) #writes the barcode

 d[4]+=1 # counter for the next HQ code

 if d[4]==4:

 d[4]=0

 d[3]+=1

 if d[3]==4:

 d[3]=0

 d[2]+=1

 if d[2]==4:

 d[2]=0

 d[1]+=1

 x+=1

#execfile('/home/leonid/Desktop/Pytrhon/Hamming/H4code74\_GNU.py')

#end of script---------------------------------------------------------------------------------------------

#Script random\_GNU.py

#This script is designed for gnumeric file

#decoder.gnumeric

#it will read H4 codes in the column 2

#(note row and column count begins with 0)

#and create mutated barcodes in the column 3

import Gnumeric, os

wb=Gnumeric.workbooks()[0]

s=wb.sheets()[0] #output in workbook sheet1

#c=s[0,1]

# this is my random numbers generator

#based on the random bytes generator

si= os.urandom(100)

num = int(si.encode('hex'), 16)

L=list(str(num))

base=list('ACGT')

for i in range(1,30):

#read barcodes in the 2nd column

 tag=s.cell\_fetch(1,i).get\_value()

 if tag==None:

 break

 b=list(tag)

#generate random base at random position

 myvalue=(int(L[i])\*10+int(L[i+1]))%7

 mybase=(int(L[i])\*10+int(L[i+1]))%4

#replace by random base

 b[myvalue]=base[mybase]

#generate mutated barcode

 s[2,i].set\_text(b[0]+b[1]+b[2]+b[3]+b[4]+b[5]+b[6])

# type there the line below to execute (uncomment first)

#execfile('/home/leonid/Desktop/Python/Hamming/random\_GNU.py')

#end of script---------------------------------------------------------------------------------------------

#Script decoder\_GNU.py

#this script is written for the gnumeric file decoder.gnumeric

#it reads mutated barcodes from column 3 and further

# corrects quaternary Hamming codes

import Gnumeric, os

wb=Gnumeric.workbooks()[0] #output in workbook sheet2

s=wb.sheets()[0]

c=s[0,1]

x=1

total=0

p=[0,0,0,0,0,0,0,0]

d=[0,0,0,0,0,0,0,0]

base=['A','C','G','T']

#check range of barcodes

for x in range (1,30):

 mystring=s.cell\_fetch(2,x).get\_value()

 if mystring==None:

 break

#clear previous data

 for y in range (1,7):

 s[2+y,x].set\_text('')

 H74=list(mystring)

 HQ74=[]

#check each position in the barcode

 for n in H74:

#convert bases to values

 for i in range(0,4):

 if n==base[i]:

 HQ74.append(i)

#show values

 s[3,x].set\_text(str(HQ74))

#checksums

 p[1]=(HQ74[0]+HQ74[2]+HQ74[4]+HQ74[6])%4

 p[2]=(HQ74[1]+HQ74[2]+HQ74[5]+HQ74[6])%4

 p[3]=(HQ74[3]+HQ74[4]+HQ74[5]+HQ74[6])%4

#find the maximum

 p\_max=max(p[1],p[2],p[3])

#convert checksums in binaries

 for i in range (0,4):

 if p[i]>0:

 p[i]=1

 s[4,x].set\_text(str(p\_max))

 if p\_max>0:

#concatenate in reverse

# bin\_pos=bin(p[3]+p[2]+p[1])

 bin\_pos=str(p[3])+str(p[2])+str(p[1])

 print bin\_pos

 s[5,x].set\_text(bin\_pos)

 err\_pos=int(bin\_pos,2)

 s[6,x].set\_text(str(err\_pos))

#wrong value min error type %4 should give the right answer

 corr\_value=(HQ74[err\_pos-1]-p\_max)%4

 s[7,x].set\_text(str(corr\_value))

 s[8,x].set\_text(H74[err\_pos-1] +' to '+ base[corr\_value] + ' at pos '+ str(err\_pos))

 H74[err\_pos-1]=base[corr\_value]

 s[9,x].set\_text(str(H74[0]+H74[1]+H74[2]+H74[3]+H74[4]+H74[5]+H74[6]))

#use python console inside gnumeric to execute this script

#execfile('/home/leonid/Desktop/Python/Hamming/decoder\_GNU.py')

#end of script---------------------------------------------------------------------------------------------

#Script H4code74.r

# modification of H4code74\_GNU.py script

# Generate quaternary Hamming codes

# number of possible barcodes 4^4=256

# set data matrix

# p1 p2 d1 p3 d2 d3 d4 (d=data, p=parity)

data = matrix(nrow=(4^4),ncol=7)

colnames(data) = c("p1","p2","d1","p3","d2","d3","d4")

# set dummy counter

c = 1;

# begin creating barcodes

for (d1 in 0:3) {

 for (d2 in 0:3) {

 for (d3 in 0:3) {

 for (d4 in 0:3) {

 # set the parity bits

 p1 = (4-((d1+d2+d4)%%4))%%4

 p2 = (4-((d1+d3+d4)%%4))%%4

 p3 = (4-((d2+d3+d4)%%4))%%4

 # put data sequence into data matrix

 data[c,c(1:7)] = c(p1,p2,d1,p3,d2,d3,d4)

 c = c+1

 }

 }

 }

}

# create the actual barcodes out of the H74 coding table (data)

barcodes = data

barcodes[barcodes == 0] <- "A"

barcodes[barcodes == 1] <- "C"

barcodes[barcodes == 2] <- "G"

barcodes[barcodes == 3] <- "T"

# print numeric encoded barcodes

data

# print DNA barcodes

Barcodes

#end of script---------------------------------------------------------------------------------------------

#Script H4code74\_decoder.r

# modification of decoder\_GNU.py script

# Corrects quaternary Hamming codes

# set of valid hamming codes

valid\_codes = c("GGCTAAC","TTCAAAA","GAACTCT","CCAGTTA","GCCGACC","GCAGTAT","CGATTGA","AGATTCC")

# set of mutated hamming codes (correspond with the above valid codes) error at position 1,2,3,4,5,6,7 and none

error\_codes = c("TGCTAAC","TACAAAA","GAGCTCT","CCATTTA","GCCGCCC","GCAGTGT","CGATTGG","AGATTCC")

# convert to numeric

# in example below the first code is called from error\_codes "TGCTAA" (error\_codes[1])

x = as.matrix(rbind(unlist(strsplit(error\_codes[1],""))))

# convert characters to numeric

x[x == "A"] <- 0

x[x == "C"] <- 1

x[x == "G"] <- 2

x[x == "T"] <- 3

# calculate the checksums

p1 = (as.numeric(x[1])+as.numeric(x[3])+as.numeric(x[5])+as.numeric(x[7]))%%4

p2 = (as.numeric(x[2])+as.numeric(x[3])+as.numeric(x[6])+as.numeric(x[7]))%%4

p3 = (as.numeric(x[4])+as.numeric(x[5])+as.numeric(x[6])+as.numeric(x[7]))%%4

# find the maximum

p\_max = max(p1,p2,p3)

# 'convert' checksums in binary

if (p1>0) {p1=1}

if (p2>0) {p2=1}

if (p3>0) {p3=1}

# concatenate in reverse

bin\_pos = paste(p3,p2,p1, sep="")

# the error position

err\_pos = bin2dec(bin\_pos)

# calculate the correct value of the error

# wrong value min error type %%4 should give the right answer

corr\_value = (as.numeric(x[err\_pos])-p\_max)%%4

# remember to load this function before calling it.

bin2dec <- function(x) {

 x <- as.character(as.numeric(x))

 b <- as.numeric(unlist(strsplit(x, "")))

 pow <- 2 ^ ((length(b) - 1):0)

 sum(pow[b == 1])

}

# corr\_value = correcting value

# 0,1,2,3 == A,C,G,T

corr\_value

# err\_pos = error position

err\_pos