A Genetic Analysis Package with R

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1 Introduction

This package was initiated to integrate some C/Fortran/SAS programs I have written or used over the years. As such, it would rather be a long-term project, but an immediate benefit would be something complementary to other packages currently available from CRAN, e.g. genetics, hwde, etc. I hope eventually this will be part of a bigger effort to fulfill most of the requirements foreseen by many, e.g. Guo and Lange (2000), within the portable environment of R for data management, analysis, graphics and
object-oriented programming. My view has been outlined more formally in Zhao and Tan (2006a) and Zhao and Tan (2006b) in relation to other package systems. Also reported are Zhao (2005) and Zhao (2006) on package kinship.

The number of functions are quite limited and experimental, but I already feel the enormous advantage by shifting to R and would like sooner rather than later to share my work with others. I will not claim this work as exclusively done by me, but would like to invite others to join me and enlarge the collections and improve them.

2 Implementation

The following list shows the data and functions currently available.
**ANALYSIS**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE3</td>
<td>AE model using nuclear family trios</td>
</tr>
<tr>
<td>bt</td>
<td>Bradley-Terry model for contingency table</td>
</tr>
<tr>
<td>ccsize</td>
<td>Power and sample size for case-cohort design</td>
</tr>
<tr>
<td>fbsize</td>
<td>Sample size for family-based linkage and association design</td>
</tr>
<tr>
<td>gc.em</td>
<td>Gene counting for haplotype analysis</td>
</tr>
<tr>
<td>gcontrol</td>
<td>Genomic control</td>
</tr>
<tr>
<td>gcontrol2</td>
<td>Genomic control based on p values</td>
</tr>
<tr>
<td>gcp</td>
<td>Permutation tests using GENECOUNTING</td>
</tr>
<tr>
<td>genecounting</td>
<td>Gene counting for haplotype analysis</td>
</tr>
<tr>
<td>gif</td>
<td>Kinship coefficient and genetic index of familiality</td>
</tr>
<tr>
<td>grmMCMC</td>
<td>Mixed modeling with genetic relationship matrices</td>
</tr>
<tr>
<td>hap</td>
<td>Haplotype reconstruction</td>
</tr>
<tr>
<td>hap.em</td>
<td>Gene counting for haplotype analysis</td>
</tr>
<tr>
<td>hap.score</td>
<td>Score statistics for association of traits with haplotypes</td>
</tr>
<tr>
<td>htr</td>
<td>Haplotype trend regression</td>
</tr>
<tr>
<td>hwe</td>
<td>Hardy-Weinberg equilibrium test for a multiallelic marker</td>
</tr>
<tr>
<td>hwe.cc</td>
<td>A likelihood ratio test of population Hardy-Weinberg equilibrium</td>
</tr>
<tr>
<td>hwe.hardy</td>
<td>Hardy-Weinberg equilibrium test using MCMC</td>
</tr>
<tr>
<td>kin.morgan</td>
<td>Kinship matrix for simple pedigree</td>
</tr>
<tr>
<td>LD22</td>
<td>LD statistics for two diallelic markers</td>
</tr>
<tr>
<td>LDkl</td>
<td>LD statistics for two multiallelic markers</td>
</tr>
<tr>
<td>masize</td>
<td>Sample size calculation for mediation analysis</td>
</tr>
<tr>
<td>mia</td>
<td>Multiple imputation analysis for hap</td>
</tr>
<tr>
<td>ndtdt</td>
<td>Transmission/disequilibrium test of a multiallelic marker</td>
</tr>
<tr>
<td>ndtdt2</td>
<td>Transmission/disequilibrium test of a multiallelic marker by Bradley-Terry model</td>
</tr>
<tr>
<td>mvmeta</td>
<td>Multivariate meta-analysis based on generalized least squares</td>
</tr>
<tr>
<td>pbsize</td>
<td>Power for population-based association design</td>
</tr>
<tr>
<td>pbsize2</td>
<td>Power for case-control association design</td>
</tr>
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<td>pfc</td>
<td>Probability of familial clustering of disease</td>
</tr>
<tr>
<td>pfc.sim</td>
<td>Probability of familial clustering of disease</td>
</tr>
<tr>
<td>pgc</td>
<td>Preparing weight for GENECOUNTING</td>
</tr>
<tr>
<td>print.hap.score</td>
<td>Print a hap.score object</td>
</tr>
<tr>
<td>s2k</td>
<td>Statistics for 2 by K table</td>
</tr>
<tr>
<td>tscc</td>
<td>Power calculation for two-stage case-control design</td>
</tr>
</tbody>
</table>
* GRAPHICS *

asplot Regional association plot
ESplot Effect-size plot
mhtplot Manhattan plot
mhtplot2 Manhattan plot with annotations
pedtodor Converting pedigree(s) to dot file(s)
plot.hap.score Plot haplotype frequencies versus haplotype score statistics
qqfun Quantile-comparison plots
qqunif Q-Q plot for uniformly distributed random variable

* DATASETS *

PD A study of Parkinson’s disease and APOE, LRRK2, SNCA markers
aldh2 ALDH2 markers and alcoholism
apoeapoc APOE/APOC1 markers and schizophrenia
cf Cystic Fibrosis data
crohn Crohn’s disease data
fa Friedreich ataxia data
fsnps A case-control data involving four SNPs with missing genotype
hla HLA markers and schizophrenia
l51 An example pedigree data
lukas An example pedigree
mao A study of Parkinson’s disease and MAO gene
meyer A pedigree data on 282 animals deriving from two generations
nep499 A study of Alzheimer’s disease with eight SNPs and APOE
* UTILITIES *

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNP</td>
<td>Functions for single nucleotide polymorphisms (SNPs)</td>
</tr>
<tr>
<td>BFDP</td>
<td>Bayesian false-discovery probability</td>
</tr>
<tr>
<td>FPRP</td>
<td>False-positive report probability</td>
</tr>
<tr>
<td>ab</td>
<td>Test/Power calculation for mediating effect</td>
</tr>
<tr>
<td>b2r</td>
<td>Obtain correlation coefficients and their variance-covariances</td>
</tr>
<tr>
<td>chow.test</td>
<td>Chow’s test for heterogeneity in two regressions</td>
</tr>
<tr>
<td>comp.score</td>
<td>Score statistics for testing genetic linkage of quantitative trait</td>
</tr>
<tr>
<td>h2</td>
<td>Heritability estimation according to twin correlations for case-control studies</td>
</tr>
<tr>
<td>klem</td>
<td>Haplotype frequency estimation based on a genotype table of two multiallelic markers</td>
</tr>
<tr>
<td>makeped</td>
<td>A function to prepare pedigrees in post-MAKEPED format</td>
</tr>
<tr>
<td>metap</td>
<td>Meta-analysis of p values</td>
</tr>
<tr>
<td>metareg</td>
<td>Fixed and random effects model for meta-analysis</td>
</tr>
<tr>
<td>muvar</td>
<td>Means and variances under 1- and 2- locus (diallelic) QTL model</td>
</tr>
<tr>
<td>read.ms.output</td>
<td>A utility function to read ms output</td>
</tr>
<tr>
<td>twinan90</td>
<td>Classic twin models</td>
</tr>
<tr>
<td>whscore</td>
<td>Whittemore-Halpern scores for allele-sharing</td>
</tr>
<tr>
<td>GRM functions</td>
<td>ReadGRM, ReadGRMBin, ReadGRMPLINK, ReadGRMPCA, WriteGRM, handle genomic relationship matrix involving other software</td>
</tr>
<tr>
<td>heritability functions</td>
<td>h2G, VR, h2GC, h2l give point estimates as with their variances for continuous traits and binary traits under liability threshold model and case-control sampling</td>
</tr>
</tbody>
</table>

Assuming proper installation, you will be able to obtain the list by typing `library(help=gap)` or view the list within a web browser via `help.start()`. Assuming that you have already loaded the package via `library(gap)`, you can use `lsf.str("package:gap")` and `data(package="gap")` to generate a list of functions and a list of datasets, respectively. If this looks odd to you, you might try `search()` within R to examine what is available in your environment before issuing the `lsf.str` command.

```r
> library(gap)
> search()

[1] ".GlobalEnv"  "package:gap"  "package:stats"
[10] "package:base"

> lsf.str("package:gap")
```

5
a2g : function (a1, a2)
ab : function (type = "power", n = 25000, a = 0.15, sa = 0.01, b = log(1.19),
       sb = 0.01, alpha = 0.05, fold = 1)
AE3 : function (model, random, data, seed = 1234, n.sim = 50000, verbose = TRUE)
allele.recode : function (a1, a2, miss.val = NA)
asplot : function (locus, map, genes, flanking = 1000, best.pval = NULL, sf = c(4,
          4), logpmx = 10, pch = 21)
b2r : function (b, s, rho, n)
BFDP : function (a, b, p1l, W, logscale = FALSE)
btep : function (x)
ccsize : function (n, q, pD, p1, alpha, theta, power = NULL, verbose = FALSE)
chow.test : function (y1, x1, y2, x2, x = NULL)
comp.score : function (ibddata = "ibd_dist.out", phenotype = "pheno.dat", mean = 0,
       var = 1, h2 = 0.3)
cov.invlogit : function (logit.p1, logit.p2, cov.logit)
Cox.est : function (case, ctl, k0, initial)
Cox.T : function (parms, case, control, k)
DevH0dominant : function (parms, case, control, k)
DevH0dominant.est : function (case, ctl, k0, initial)
DevH0recessive : function (parms, case, control, k)
DevH0recessive.est : function (case, ctl, k0, initial)
DevHaGdominant : function (parms, case, control, k)
DevHaGdominant.est : function (case, ctl, k0, initial)
DevHaGgressive : function (parms, case, control, k)
DevHaGgressive.est : function (case, ctl, k0, initial)
ESplot : function (ESdat, SE = TRUE, logscale = TRUE, alpha = 0.05, xlim = c(-2,
          8), v = 1, ...)
fbsize : function (gamma, p, alpha = c(1e-04, 1e-08, 1e-08), beta = 0.2, debug = 0,
       error = 0)
FPRP : function (a, b, p1l, W, logscale = FALSE)
g2a : function (g)
g2a.c : function (g)
gc.control : function (xdata = FALSE, convll = 1, handle.miss = 0, eps = 1e-06, tol
       maxit = 50, pl = 0.001, assignment = "assign.dat", verbose = T)
gc.em : function (data, locus.label = NA, converge.eps = 1e-06, maxiter = 500,
       handle.miss = 0, miss.val = 0, control = gc.control())
gcode : function (a1, a2)
gcontrol : function (data, zeta = 1000, kappa = 4, tau2 = 1, epsilon = 0.01, ngib =
       burn = 50, idum = 2348)
gcontrol2 : function (p, col = palette()[4], lcol = palette()[2], ...)
gcp : function (y, cc, g, handle.miss = 1, miss.val = 0, n.sim = 0, locus.label = NULL,
       quietly = FALSE)
genecounting : function (data, weight = NULL, loci = NULL, control = gc.control())
genorecode : function (geno, miss.val = 0)
getb1star : function (b1, b2, rho, sdx1 = 1, sdx2 = 1)
getPTE : function (b1, b2, rho, sdx1 = 1, sdx2 = 1)
gif : function (data, gifset)
grec2g : function (h, n, t)
h2 : function (mzDat = NULL, dzDat = NULL, rmz = NULL, rdz = NULL, nmz = NULL, ndz = NULL, selV = NULL)
h2G : function (V, VCOV, verbose = TRUE)
h2GE : function (V, VCOV, verbose = TRUE)
h2l : function (K = 0.05, P = 0.5, h2, se, verbose = TRUE)
hap : function (id, data, nloci, loci = rep(2, nloci), names = paste("loci", 1:nloci, sep = ","), control = hap.control())
hap.control : function (mb = 0, pr = 0, po = 0.001, to = 0.001, th = 1, maxit = 100, n = 0, ss = 0, rs = 0, rp = 0, ro = 0, rv = 0, sd = 0, mm = 0, mi = 0, mc = 50, ds = 0.1, de = 0, q = 0, hapfile = "hap.out", assignfile = "assign.out")
hap.em : function (id, data, locus.label = NA, converge.eps = 1e-06, maxiter = 500, miss.val = 0)
hap.score : function (y, geno, trait.type = "gaussian", offset = NA, x.adj = NA, skip.haplo = 0.005, locus.label = NA, miss.val = 0, n.sim = 0, method = "gc", id = NA, handle.miss = 0, mloci = NA, sexid = NA)
HapDesign : function (HaploEM)
HapFreqSE : function (HaploEM)
hmht.control : function (data = NULL, colors = NULL, yoffset = 0.25, cex = 1.5, boxed = FALSE)
htr : function (y, x, n.sim = 0)
hwe : function (data, data.type = "allele", yates.correct = FALSE, miss.val = 0)
hwe.cc : function (model, case, ctrl, k0, initial1, initial2)
hwe.hardy : function (a, alleles = 3, seed = 3000, sample = c(1000, 1000, 5000))
invlogit : function (x = 0)
k : function (r, N, adjust = TRUE)
KCC : function (model, GRR, p1, K)
kin.morgan : function (ped, verbose = FALSE)
klem : function (obs, k = 2, l = 2)
LD22 : function (h, n)
LDkl : function (n1 = 2, n2 = 2, h, n, opthr = 2, verbose = FALSE)
logit : function (p = 0.5)
m2plem : function (a1, a2)
makeped : function (pifile = "pedfile.pre", pofile = "pedfile.ped", auto.select = 1, with.loop = 0, loop.file = NA, auto.proband = 1, proband.file = NA)
masize : function (model, opts, alpha = 0.025, gamma = 0.2)
MCMCgrm : function (model, prior, data, GRM, eps = 0, n.thin = 10, n.burnin = 3000, n.iter = 13000, ...)
xline = 3) mhtplot : function (data, control = mht.control(), hcontrol = hmht.control(), ...) mhtplot2 : function (data, control = mht.control(), hcontrol = hmht.control(), ...) mia : function (hapfile = "hap.out", assfile = "assign.out", miafile = "mia.out", so = 0, ns = 0, mi = 0, allsnps = 0, sas = 0) micombine : function (est, std.err, confidence = 0.95) mtdt : function (x, n.sim = 0) mtdt2 : function (x, verbose = TRUE, n.sim = NULL, ...) muvar : function (n.loci = 1, y1 = c(0, 1, 1), y12 = c(1, 1, 1, 1, 1, 0, 0, 0), pl = 0.99, p2 = 0.9) mvmeta : function (b, V) PARn : function (p, RRlist) pbsize : function (kp, gamma = 4.5, p = 0.15, alpha = 5e-08, beta = 0.2) pbsize2 : function (N, fc = 0.5, alpha = 0.05, gamma = 4.5, p = 0.15, kp = 0.1, model = "additive") pedtodot : function (pedfile, makeped = FALSE, sink = TRUE, page = "B5", url = "http://www.mrc-epid.cam.ac.uk", height = 0.5, width = 0.75, rotate = 0, dir = "none") pfc : function (famdata, enum = 0) pfc.sim : function (famdata, n.sim = 1e+06, n.loop = 1) pgc : function (data, handle.miss = 1, is.genotype = 0, with.id = 0) plem2m : function (a) plot.hap.score : function (x, ...) print.hap.score : function (x, ...) qqfun : function (x, distribution = "norm", ylab = deparse(substitute(x)), xlab = paste(distribution, "quantiles"), main = NULL, las = par("las"), envelope = 0.95, labels = FALSE, col = palette()[4], lcol = palette()[2], xlim = NULL, ylim = NULL, lwd = 1, pch = 1, bg = palette()[4], cex = 0.4, line = c("quartiles", "robust", "none"), ...) qqunif : function (u, type = "unif", logscale = TRUE, base = 10, col = palette()[4], lcol = palette()[2], ci = FALSE, alpha = 0.05, ...) read.ms.output : function (msout, is.file = TRUE, xpose = TRUE, verbose = TRUE, outfile = NULL, outfileonly = FALSE) ReadGRM : function (prefix = 51) ReadGRMBin : function (prefix, AllN = FALSE, size = 4) ReadGRMPCA : function (prefix) ReadGRMPLINK : function (prefix, diag = 1) revhap : function (loci, hapid) revhap.i : function (loci, hapid) s2k : function (y1, y2) se.exp : function (p, se.p) se.invlogit : function (logit.p, se.logit) snp.ES : function (beta, SE, N) snp.HWE : function (g) snp.PAR : function (RR, MAF, unit = 2) solve_skol : function (rootfun, target, lo, hi, e)
toETDT : function (a)
tscc : function (model, GRR, p1, n1, n2, M, alpha.genome, pi.samples, pi.markers, K)
ungcode : function (g)
VR : function (v1, vv1, v2, vv2, c12)
whscore : function (allele, type)
WriteGRM : function (prefix = 51, id, N, GRM)
WriteGRMBin : function (prefix, grm, N, id, size = 4)
WriteGRMSAS : function (grmlist, outfile = "gwas")
x2 : function (p1, p2, n1, n2)
z : function (p1, p2, n1, n2, r)

> data(package="gap")$results

<table>
<thead>
<tr>
<th>Package</th>
<th>LibPath</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
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<td>&quot;PD&quot;</td>
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<td>[2,] &quot;gap&quot;</td>
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<tr>
<td>[3,] &quot;gap&quot;</td>
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<td>&quot;apoeapoc&quot;</td>
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<tr>
<td>[4,] &quot;gap&quot;</td>
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<td>[6,] &quot;gap&quot;</td>
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<td>&quot;/tmp/RtmpLinNA0/Rinst7d65377639d3&quot;</td>
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<tr>
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<td>&quot;nep499&quot;</td>
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<table>
<thead>
<tr>
<th>Title</th>
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<tbody>
<tr>
<td>[1,] &quot;A study of Parkinson's disease and APOE, LRRK2, SNCA makers&quot;</td>
<td></td>
</tr>
<tr>
<td>[2,] &quot;ALDH2 markers and Alcoholism&quot;</td>
<td></td>
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<tr>
<td>[3,] &quot;APOE/APOC1 markers and Alzheimer's&quot;</td>
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<tr>
<td>[4,] &quot;Cystic fibrosis data&quot;</td>
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<tr>
<td>[5,] &quot;Crohn's disease data&quot;</td>
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<tr>
<td>[6,] &quot;Friedreich Ataxia data&quot;</td>
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</tr>
<tr>
<td>[7,] &quot;A case-control data involving four SNPs with missing genotype&quot;</td>
<td></td>
</tr>
<tr>
<td>[8,] &quot;The HLA data&quot;</td>
<td></td>
</tr>
<tr>
<td>[9,] &quot;An example pedigree data&quot;</td>
<td></td>
</tr>
<tr>
<td>[10,] &quot;An example pedigree&quot;</td>
<td></td>
</tr>
<tr>
<td>[11,] &quot;A study of Parkinson's disease and MAO gene&quot;</td>
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<tr>
<td>[12,] &quot;A pedigree data on 282 animals deriving from two generations&quot;</td>
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</tr>
<tr>
<td>[13,] &quot;Example data for ACEnucfam&quot;</td>
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<tr>
<td>[14,] &quot;A study of Alzheimer's disease with eight SNPs and APOE&quot;</td>
<td></td>
</tr>
</tbody>
</table>

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A PDF version of this file can be viewed with command `vignette("gap", package="gap")`.

You can cut and paste examples at end of each function’s documentation.

Both `genecounting` and `hap` are able to handle SNPs and multiallelic markers, with the former being flexible enough to include features such as X-linked data and the later being able to handle large number of SNPs. But they are unable to recode allele labels automatically, so functions `gc.em` and `hap.em` are in `haplo.em` format and used by a modified function `hap.score` in association testing.

It is notable that multilocus data are handled differently from that in `hwde` and elegant definitions of basic genetic data can be found in the `genetics` package.

Incidentally, I found my C mixed-radixed sorting routine as in Zhao and Sham (2003) is much faster than R’s internal function.

With exceptions such as function `pfc` which is very computer-intensive, most functions in the package can easily be adapted for analysis of large datasets involving either SNPs or multiallelic markers. Some are utility functions, e.g. `muvar` and `whscore`, which will be part of the other analysis routines in the future.

The benefit with R compared to standalone programs is that for users, all functions have unified format. For developers, it is able to incorporate their C/C++ programs more easily and avoid repetitive work such as preparing own routines for matrix algebra and linear models. Further advantage can be taken from packages in Bioconductor, which are designed and written to deal with large number of genes.

### 3 Independent programs

To facilitate comparisons and individual preferences, The source codes for 2LD, EHPLUS, GENECOUNTING, HAP, now hosted at GitHub, have enjoyed great popularity ahead of the genomewide association studies (GWAS) therefore are likely to be more familiar than their R counterparts in `gap`. However, you need to follow their instructions to compile for a particular computer system.

I have included ms code (which is required by `read.ms.output`) and .xls files to accompany `read.ms.output` and `FPRP` and `BFDP` functions as with
a classic twin example for ACE model in OpenMx. The package is now available from CRAN and earlier it can be installed with command,

\texttt{source('http://openmx.psyc.virginia.edu/getOpenMx.R')}

For these models it is actually simpler to use facilities as in package \texttt{mets}, which I now suggest.

A final category is \texttt{twinan90}, which is now dropped from the package function list due to difficulty to keep up with the requirements by the R environment but nevertheless you will still be able to compile and use otherwise.

4 Demos

You can also try several simple examples via \texttt{demo}:

\begin{verbatim}
library(gap)
demo(gap)
\end{verbatim}

5 Examples

I would like to highlight \texttt{peddot dot pbsize}, \texttt{fbsize} and \texttt{ccsize} functions used for pedigree drawing and power/sample calculations in a genome-wide association study as reported in Zhao (2007).

5.1 Pedigree drawing

I have included the original file for the \texttt{R News} as well as put examples in separate vignettes. They can be accessed via \texttt{vignette("rnews",package="gap")} and \texttt{vignette("peddot dot", package="gap")}, respectively.

5.2 Kinship calculation

Next, I will provide an example for kinship calculation using \texttt{kin.morgan}. It is recommended that individuals in a pedigree are ordered so that parents always precede their children. In this regard, package \texttt{pedigree} can be used, and package \texttt{kinship2} can be used to produce pedigree diagram as with kinship matrix.
Pedigree diagram

> # pedigree diagram
> data(lukas, package="gap")
> library(kinship2)
> ped <- with(lukas, pedigree(id, father, mother, sex))
> pdf("figures/lukas.pdf", height=14, width=15)
> plot(ped)
> dev.off()

null device
   1

The pedigree diagram is as follows,
Kinship calculation

We then turn to the kinship calculation.

```r
# unordered individuals
library(gap)
gk1 <- kin.morgan(lukas)
write.table(gk1$kin.matrix, "results/gap_1.txt", quote=FALSE)
library(kinship2)
kk1 <- kinship(lukas[,1], lukas[,2], lukas[,3])
write.table(kk1, "results/kinship_1.txt", quote=FALSE)
d <- gk1$kin.matrix - kk1
sum(abs(d))
```

[1] 2.443634

```r
# order individuals so that parents precede their children
library(pedigree)
op <- orderPed(lukas)
olukas <- lukas[order(op),]
gk2 <- kin.morgan(olukas)
write.table(olukas, "olukas.csv", quote=FALSE)
write.table(gk2$kin.matrix, "results/gap_2.txt", quote=FALSE)
kk2 <- kinship(olukas[,1], olukas[,2], olukas[,3])
write.table(kk2, "results/kinship_2.txt", quote=FALSE)
z <- gk2$kin.matrix - kk2
sum(abs(z))
```

[1] 0

We see that in the second case, the result agrees with **kinship2**.

5.3 Study design

Family-based design

The example involving family-based design is as follows,

```r
library(gap)
models <- matrix(c(  
  4.0, 0.01,  
  4.0, 0.10,  
  4.0, 0.50,  
  4.0, 0.80,  
  2.0, 0.01,  
  2.0, 0.10,  
)
```
```r
> outfile <- "fbsize.txt"
> cat("gamma","p","Y","N_asp","P_A","H1","N_tdt","H2","N_asp/tdt","L_o","L_s\n",
+ file=outfile,sep="\t")
> for(i in 1:12) {
+ g <- models[i,1]
+ p <- models[i,2]
+ z <- fbsize(g,p)
+ cat(z$gamma,z$p,z$y,z$n1,z$pA,z$h1,z$n2,z$h2,z$n3,z$lambdao,z$lamdas,
+ file=outfile,append=TRUE,sep="\t")
+ cat("\n",file=outfile,append=TRUE)
+ }
> table1 <- read.table(outfile,header=TRUE,sep="\t")
> nc <- c(4,7,9)
> table1[,nc] <- ceiling(table1[,nc])
> dc <- c(3,5,6,8,10,11)
> table1[,dc] <- round(table1[,dc],2)
> unlink(outfile)
> # APOE-4, Scott WK, Pericak-Vance, MA & Haines JL
> # Genetic analysis of complex diseases 1327
> g <- 4.5
> p <- 0.15
> cat("\nAlzheimer's:

")
> fbsize(g,p)

$gamma
[1] 4.5

$p
[1] 0.15

$y
[1] 0.6256916

$n1
[1] 162.6246

Alzheimer's:
Population-based design

The example involving population-based design is as follows,

```r
> library(gap)
> kp <- c(0.01,0.05,0.10,0.2)
> models <- matrix(c(
  4.0 0.01 0.52 6402 0.80 0.05 1201 0.11 257 1.08 1.09,
  4.0 0.10 0.60 277 0.80 0.35 165 0.54 53 1.48 1.54,
  4.0 0.50 0.58 446 0.80 0.50 113 0.42 67 1.36 1.39,
  4.0 0.80 0.53 3024 0.80 0.24 244 0.16 177 1.12 1.13,
  2.0 0.01 0.50 445964 0.67 0.03 6371 0.04 2155 1.01 1.01,
  2.0 0.10 0.52 8087 0.67 0.25 761 0.32 290 1.07 1.08,
  2.0 0.50 0.53 3753 0.67 0.50 373 0.47 197 1.11 1.11,
  2.0 0.80 0.51 17909 0.67 0.27 701 0.22 431 1.05 1.05,
  1.5 0.01 0.50 6944779 0.60 0.02 21138 0.03 8508 1.00 1.00,
  1.5 0.10 0.51 101926 0.60 0.21 2427 0.25 1030 1.02 1.02,
  1.5 0.50 0.51 27048 0.60 0.50 1039 0.49 530 1.04 1.04,
  1.5 0.80 0.51 101926 0.60 0.29 1820 0.25 1030 1.02 1.02)
```

> table1

<table>
<thead>
<tr>
<th>gamma</th>
<th>p</th>
<th>Y</th>
<th>N_asp</th>
<th>P_A</th>
<th>H1</th>
<th>N_tdt</th>
<th>H2</th>
<th>N_asp.tdt</th>
<th>L_o</th>
<th>L_s</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>0.01</td>
<td>0.52</td>
<td>6402</td>
<td>0.80</td>
<td>0.05</td>
<td>1201</td>
<td>0.11</td>
<td></td>
<td>257</td>
<td>1.08</td>
</tr>
<tr>
<td>4.0</td>
<td>0.10</td>
<td>0.60</td>
<td>277</td>
<td>0.80</td>
<td>0.35</td>
<td>165</td>
<td>0.54</td>
<td></td>
<td>53</td>
<td>1.48</td>
</tr>
<tr>
<td>4.0</td>
<td>0.50</td>
<td>0.58</td>
<td>446</td>
<td>0.80</td>
<td>0.50</td>
<td>113</td>
<td>0.42</td>
<td></td>
<td>67</td>
<td>1.36</td>
</tr>
<tr>
<td>4.0</td>
<td>0.80</td>
<td>0.53</td>
<td>3024</td>
<td>0.80</td>
<td>0.24</td>
<td>244</td>
<td>0.16</td>
<td></td>
<td>177</td>
<td>1.12</td>
</tr>
<tr>
<td>2.0</td>
<td>0.01</td>
<td>0.50</td>
<td>445964</td>
<td>0.67</td>
<td>0.03</td>
<td>6371</td>
<td>0.04</td>
<td></td>
<td>2155</td>
<td>1.01</td>
</tr>
<tr>
<td>2.0</td>
<td>0.10</td>
<td>0.52</td>
<td>8087</td>
<td>0.67</td>
<td>0.25</td>
<td>761</td>
<td>0.32</td>
<td></td>
<td>290</td>
<td>1.07</td>
</tr>
<tr>
<td>2.0</td>
<td>0.50</td>
<td>0.53</td>
<td>3753</td>
<td>0.67</td>
<td>0.50</td>
<td>373</td>
<td>0.47</td>
<td></td>
<td>197</td>
<td>1.11</td>
</tr>
<tr>
<td>2.0</td>
<td>0.80</td>
<td>0.51</td>
<td>17909</td>
<td>0.67</td>
<td>0.27</td>
<td>701</td>
<td>0.22</td>
<td></td>
<td>431</td>
<td>1.05</td>
</tr>
<tr>
<td>1.5</td>
<td>0.01</td>
<td>0.50</td>
<td>6944779</td>
<td>0.60</td>
<td>0.02</td>
<td>21138</td>
<td>0.03</td>
<td></td>
<td>8508</td>
<td>1.00</td>
</tr>
<tr>
<td>1.5</td>
<td>0.10</td>
<td>0.51</td>
<td>101926</td>
<td>0.60</td>
<td>0.21</td>
<td>2427</td>
<td>0.25</td>
<td></td>
<td>1030</td>
<td>1.02</td>
</tr>
<tr>
<td>1.5</td>
<td>0.50</td>
<td>0.51</td>
<td>27048</td>
<td>0.60</td>
<td>0.50</td>
<td>1039</td>
<td>0.49</td>
<td></td>
<td>530</td>
<td>1.04</td>
</tr>
<tr>
<td>1.5</td>
<td>0.80</td>
<td>0.51</td>
<td>101926</td>
<td>0.60</td>
<td>0.29</td>
<td>1820</td>
<td>0.25</td>
<td></td>
<td>1030</td>
<td>1.02</td>
</tr>
</tbody>
</table>


```r
gamma p p1 p5 p10 p20
1 4.0 0.01 46681 8959 4244 1887
2 4.0 0.10 8180 1570 744 331
3 4.0 0.50 10891 2091 991 441
4 4.0 0.80 31473 6041 2862 1272
5 2.0 0.01 403970 77530 36725 16323
6 2.0 0.10 52709 10116 4792 2130
7 2.0 0.50 35285 6772 3208 1426
8 2.0 0.80 79391 15237 7218 3208
9 1.5 0.01 1599920 307056 145448 64644
10 1.5 0.10 192105 36869 17465 7762
11 1.5 0.50 98013 18811 8911 3961
12 1.5 0.80 192105 36869 17465 7762
```

Case-cohort design

For case-cohort design, we obtain results for ARIC and EPIC studies.
library(gap)

# ARIC study
outfile <- "aric.txt"
n <- 15792
pD <- 0.03
p1 <- 0.25
alpha <- 0.05
theta <- c(1.35, 1.40, 1.45)
beta1 <- 0.8
s_nb <- c(1463, 722, 468)
cat("n", "pD", "p1", "hr", "q", "power", "ssize\n", file=outfile, sep="\t")
for(i in 1:3)
  {
    q <- s_nb[i]/n
    power <- ccs(size(n, q, pD, p1, alpha, log(theta[i]), beta1))
    ssize <- ccs(size(n, q, pD, p1, alpha, log(theta[i]), beta1))
    cat(n, "pD", "p1", "hr", "q", "power", "ssize\n", file=outfile, sep="\t")
  }
read.table(outfile, header=TRUE, sep="\t")
unlink(outfile)

# EPIC study
outfile <- "epic.txt"
n <- 25000
alpha <- 0.00000005
power <- 0.8
s_pD <- c(0.3, 0.2, 0.1, 0.05)
s_p1 <- seq(0.1, 0.5, by=0.1)
s_hr <- seq(1.1, 1.4, by=0.1)
cat("n", "pD", "p1", "hr", "alpha", "ssize\n", file=outfile, sep="\t")
# direct calculation
for(pD in s_pD)
  {
    for(p1 in s_p1)
      {
        for(hr in s_hr)
          {
            ssize <- ccs(size(n, q, pD, p1, alpha, log(hr), power))
          }
        }
      }

17
```r
if (ssize>0) {cat(n,"\t",pD,"\t",p1,"\t",hr,"\t",alpha,"\t",ssize,"\n",
file=outfile,append=TRUE)
}
}
>
read.table(outfile,header=TRUE,sep="\t")

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>pD</th>
<th>p1</th>
<th>hr</th>
<th>alpha</th>
<th>ssize</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25000</td>
<td>0.3</td>
<td>0.1</td>
<td>1.3</td>
<td>5e-08</td>
<td>14391</td>
</tr>
<tr>
<td>2</td>
<td>25000</td>
<td>0.3</td>
<td>0.1</td>
<td>1.4</td>
<td>5e-08</td>
<td>5732</td>
</tr>
<tr>
<td>3</td>
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<td>0.2</td>
<td>1.2</td>
<td>5e-08</td>
<td>21529</td>
</tr>
<tr>
<td>4</td>
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<td>0.2</td>
<td>1.3</td>
<td>5e-08</td>
<td>5099</td>
</tr>
<tr>
<td>5</td>
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<td>0.3</td>
<td>0.2</td>
<td>1.4</td>
<td>5e-08</td>
<td>2613</td>
</tr>
<tr>
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<td>0.3</td>
<td>1.2</td>
<td>5e-08</td>
<td>11095</td>
</tr>
<tr>
<td>7</td>
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<td>5e-08</td>
<td>3490</td>
</tr>
<tr>
<td>8</td>
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<td>0.3</td>
<td>1.4</td>
<td>5e-08</td>
<td>1882</td>
</tr>
<tr>
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<td>0.4</td>
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<td>5e-08</td>
<td>8596</td>
</tr>
<tr>
<td>10</td>
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<td>0.4</td>
<td>1.3</td>
<td>5e-08</td>
<td>2934</td>
</tr>
<tr>
<td>11</td>
<td>25000</td>
<td>0.3</td>
<td>0.4</td>
<td>1.4</td>
<td>5e-08</td>
<td>1611</td>
</tr>
<tr>
<td>12</td>
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<td>0.5</td>
<td>1.2</td>
<td>5e-08</td>
<td>7995</td>
</tr>
<tr>
<td>13</td>
<td>25000</td>
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<td>0.5</td>
<td>1.3</td>
<td>5e-08</td>
<td>2786</td>
</tr>
<tr>
<td>14</td>
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<td>0.5</td>
<td>1.4</td>
<td>5e-08</td>
<td>1538</td>
</tr>
<tr>
<td>15</td>
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<td>0.1</td>
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<td>5e-08</td>
<td>9277</td>
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<tr>
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<td>5e-08</td>
<td>7725</td>
</tr>
<tr>
<td>17</td>
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<td>0.2</td>
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<td>5e-08</td>
<td>3164</td>
</tr>
<tr>
<td>18</td>
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<td>0.3</td>
<td>1.3</td>
<td>5e-08</td>
<td>4548</td>
</tr>
<tr>
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<td>0.3</td>
<td>1.4</td>
<td>5e-08</td>
<td>2152</td>
</tr>
<tr>
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<td>5e-08</td>
<td>20131</td>
</tr>
<tr>
<td>21</td>
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<td>0.4</td>
<td>1.3</td>
<td>5e-08</td>
<td>3648</td>
</tr>
<tr>
<td>22</td>
<td>25000</td>
<td>0.2</td>
<td>0.4</td>
<td>1.4</td>
<td>5e-08</td>
<td>1805</td>
</tr>
<tr>
<td>23</td>
<td>25000</td>
<td>0.2</td>
<td>0.5</td>
<td>1.2</td>
<td>5e-08</td>
<td>17120</td>
</tr>
<tr>
<td>24</td>
<td>25000</td>
<td>0.2</td>
<td>0.5</td>
<td>1.3</td>
<td>5e-08</td>
<td>3422</td>
</tr>
<tr>
<td>25</td>
<td>25000</td>
<td>0.2</td>
<td>0.5</td>
<td>1.4</td>
<td>5e-08</td>
<td>1713</td>
</tr>
<tr>
<td>26</td>
<td>25000</td>
<td>0.1</td>
<td>0.2</td>
<td>1.4</td>
<td>5e-08</td>
<td>8615</td>
</tr>
<tr>
<td>27</td>
<td>25000</td>
<td>0.1</td>
<td>0.3</td>
<td>1.4</td>
<td>5e-08</td>
<td>3776</td>
</tr>
<tr>
<td>28</td>
<td>25000</td>
<td>0.1</td>
<td>0.4</td>
<td>1.3</td>
<td>5e-08</td>
<td>13479</td>
</tr>
<tr>
<td>29</td>
<td>25000</td>
<td>0.1</td>
<td>0.4</td>
<td>1.4</td>
<td>5e-08</td>
<td>2824</td>
</tr>
<tr>
<td>30</td>
<td>25000</td>
<td>0.1</td>
<td>0.5</td>
<td>1.3</td>
<td>5e-08</td>
<td>10837</td>
</tr>
<tr>
<td>31</td>
<td>25000</td>
<td>0.1</td>
<td>0.5</td>
<td>1.4</td>
<td>5e-08</td>
<td>2606</td>
</tr>
</tbody>
</table>
>
unlink(outfile)
```

5.4 Graphics examples

I now include some figures from the documentation that may be of interest.

Genome-wide association

The following code is used to obtain a Q-Q plot via `qqunif` function,

```r
> library(gap)
> pdf("figures/qqunif.pdf", height=10, width=10)
> u_obs <- runif(1000)
> r <- qqunif(u_obs, pch=21, bg="blue", bty="n")
> u_exp <- r$y
> hits <- u_exp >= 2.30103
> points(r$x[hits], u_exp[hits], pch=21, bg="green")
> dev.off()
```

null device

1

Based on a chicken genome scan data, the code below generates a Manhattan plot, demonstrating the use of gaps to separate chromosomes.
> library(gap)
> ord <- with(w4,order(chr,pos))
> w4 <- w4[ord,]
> pdf("figures/w4.pdf",height=9,width=10)
> oldpar <- par()
> par(cex=0.6)
> colors <- c(rep(c("blue","red"),15),"red")
> mhtplot(w4,control=mht.control(colors=colors,gap=1000,pch=19,srt=0)
> axis(2,cex.axis=2)
> suggestiveline <- -log10(3.60036E-05)
> genomewideline <- -log10(1.8E-06)
> abline(h=suggestiveline, col="blue")
> abline(h=genomewideline, col="green")
> abline(h=0)
> dev.off()
> glist <- c("IRS1","SPRY2","FTO","GRIK3","SNED1","HTR1A","MARCH3","WISP3","PPP1R3B", + "RP1L1","FDFT1","SLC39A14","GFRA1","MC4R")
> hdata <- subset(mhtdata,gene%in%glist)[c("chr","pos","p","gene")]
> color <- rep(c("lightgray","gray"),11)
> glen <- length(glist)
> hcolor <- rep("red",glen)
> par(las=2, xpd=TRUE, cex.axis=1.8, cex=0.4)
> ops <- mht.control(colors=color,yline=1.5,xline=3)
> hops <- hmht.control(data=hdata,colors=hcolor)
> mhtplot(data,ops,hops,pch=19)
> axis(2,pos=2,at=1:16,cex.axis=0.5)
> title("Manhattan plot with genes highlighted",cex.main=1)
> dev.off()

All these look familiar, so revised form of the function called mhtplot2 was created for additional features such as centering the chromosome ticks, allowing for more sophisticated coloring schemes, using prespecified fonts, etc. Please refer to the function’s documentation example. The code below obtains a regional association plot with the asplot function,

> library(gap)
> pdf("figures/asplot.pdf",height=14,width=14)
> asplot(CDKNlocus, CDKNmap, CDKNgenes, best.pval=5.4e-8, sf=c(3,6))

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The function predates the currently popular **locuszoom** software but leaves the option open for generating such plots on the fly and locally.

**Effect size plot**

The code below obtains an effect size plot via the ESplot function.

```r
> library(gap)
> pdf("figures/ESplot.pdf", height=10, width=10)
> options(stringsAsFactors=FALSE)
> testdata <- data.frame(models=c("Basic model","Adjusted","Moderately adjusted", + "Heavily adjusted","Other"),
+ OR = c(4.5,3.5,2.5,1.5,1),
```
Note that all these can serve as templates to customize features of your own.

6 Polygenic modeling

In line with the recent surge of interest in the polygenic models, a separate vignette is available through `vignette("h2", package="gap")` demonstrating aspect of the models on heritability.

7 Known bugs

Unaware of any bug. However, better memory management is expected.
8 Summary

I believe by now the package should have given you a flavour of initiatives I have made so far in relation to how the project was envisaged. More importantly, it is clear that availability of the package will serve as a platform on which future work can be accumulated and collaboration can be built.

9 Bibliographic note

The main references are Chow (1960); Guo and Thompson (1992); Williams et al. (1992); Gholamic and Thomas (1994); Hartung et al. (2008); Risch and Merikangas (1996); Spielman and Ewens (1996); Risch and Merikangas (1997); Miller (1997); Sham (1997); Elston (1975); Sham (1998); Devlin and Roeder (1999); Zhao et al. (1999); Guo and Lange (2000); Hirotsu et al. (2001); Zhao et al. (2002); Zaykin et al. (2002); Zhao (2004); Wacholder et al. (2004); Wang (2005); Skol et al. (2006); Wakefield (2007).

References


