```lua
#!/usr/bin/env lua
-- vim: filetype=lua ts=2 sw=2 et:
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-- retained with the works, so that any entity that uses the works is
-- notified of this instrument.  DISCLAIMER: THE WORKS ARE WITHOUT WARRANTY.

local b4={}; for k,v in pairs(_ENV) do b4[k]=v end
local any,bins,coerce,csv,ent,fails,fmt,fu,go,id,lt,many,map,obj,push
local no,o,oo,ok,per,r,rnd,rnds,same,sd,sort,sum,the,work1,work
-------------------------------------------------------------------------------------
local the, help={}, [[
wicked: explore the world better,  explore the world for good.
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   .-------.             (planning = (better - bad))
   | Ba    |    Bad <----(monitor  = (bad - better))
   |    56 |             |
   .-------.------.      |
           | Be   |      v
           |    4 |   Better
           .------.

USAGE:
  wicket.lua [OPTIONS]

OPTIONS:
  --cohen   -c  cohen                       = .35
  --K       -K  manage low class counts     = 1
  --M       -M  manage low evidence counts  = 2
  --far     -F  how far to go for far       = .9
  --p       -p  coefficient on distance     = 2
  --seed    -S  seed                        = 10019
  --some    -s  sample size for distances   = 512
  --stop    -T  how far to go for far       = 20
  --min     -m  size of min space           = .5

OPTIONS (other):
  --dump    -d  dump stack+exit on error    = false
  --file    -f  file name                   = ../etc/data/auto93.csv
  --help    -h  show help                   = false
  --rnd     -r  rounding numbers            = %5.3f
  --todo    -t  start up action             = nothing ]]

-------------------------------------------------------------------------------------
r   = math.random
fmt = string.format
function same(x) return x end
function fu(x)    return function(t) return t[x] end end
function lt(x)    return function(t,u) return t[x] < u[x] end end

function push(t,x)    t[1+#t]=x; return x end
function map(t,f, u) u={};for _,v in pairs(t) do u[1+#u]=f(v) end;return u end
function sort(t,f)    table.sort(t,f); return t end
function sum(t,f,n)  n=0; for _,x in pairs(t) do n=n+f(x) end; return n end

function any(a, i)     i=r()*#a//1; i=math.max(1,math.min(i,#a)); return a[i] end
function many(a,n, u) u={};for j=1,n do push(u,any(a)) end;return u end

function sd(t,f)   f=f or same; return (f(per(t,.9)) - f(per(t,.1)))/2.56 end
function per(t,p)  return t[ ((p or .5)*#t) // 1 ] end

function rnds(t,f) return map(t, function(x) return rnd(x,f) end) end
function rnd(x,f)
  return fmt(type(x)=="number" and (x~=x//1 and f or the.rnd) or"%s",x) end

function oo(t) print(o(t)) end
function o(t,    u,one)
  one= function(k,v) return #t>0 and tostring(v) or fmt(":%s %s",k,v) end
  u={}; for k,v in pairs(t) do u[1+#u] = one(k,v) end
  if #t==0 then sort(u) end
  return (t.is or "").."{"..table.concat(u," ").."}" end

function coerce(x)
  x = x:match"^%s*(.-)%s*$"
  if x=="true" then return true elseif x=="false" then return false end
  return math.tointeger(x) or tonumber(x) or x end

function csv(src)
  src = io.input(src)
  return function(line, row)
    line=io.read()
    if not line then io.close(src) else
      row={}; for x in line:gmatch("([^,]+)") do row[1+#row]=coerce(x) end
      return row end end end

function work1(x,    b4)
  b4={}; for k,v in pairs(the) do b4[k]=v end
  math.randomseed(the.seed)
  if go[x] then print(x); go[x]() end
  for k,v in pairs(b4) do the[k]=v end end

function work(   t)
  t={}; for k,_ in pairs(go) do push(t,k) end
  for _,x in pairs(sort(t)) do work1(x) end  end

-----------------------------------------------------------------------------------
local _id=0
function id() _id = _id+1; return _id end

function obj(name,    t,new,str)
  function new(kl,...)
    local x=setmetatable({id=id()},kl); kl.new(x,...); return x end
  t = {__tostring=o, is=name or ""}; t.__index=t
  return setmetatable(t, {__call=new}) end

-------------------------------------------------------------------------------------
local Bin=obj"Bin"
function Bin:new(txt,at,n, lo,hi,ystats)
  self.at, self.txt, self.n     = at, txt, n
  self.lo, self.hi, self.ystats = lo, hi, ystats end

function Bin:__tostring()
  local x,lo,hi,big = self.txt, self.lo, self.hi, math.huge
  if     lo ==  hi  then return fmt("%s == %s",x, lo)
  elseif hi ==  big then return fmt("%s >= %s",x, lo)
  elseif lo == -big then return fmt("%s < %s", x, hi)
  else                   return fmt("%s <= %s < %s",lo,x,hi) end end

function Bin:select(t)
  t = t.cells and t.cells or t
  local x, lo, hi = t[self.at], self.lo, self.hi
  return x=="?" or lo == hi and lo == x or lo <= x and x < hi end

-------------------------------------------------------------------------------------
local Sym=obj"Sym"
function Sym:new(at,txt)
   self.at  = at or 0
   self.txt = txt or ""
   self.n   = 0
   self.has, self.mode, self.most = {},nil,0 end

function Sym:sub(x) return self:add(x,-1) end

function Sym:add(x,inc)
  if x ~= "?" then
    inc = inc or 1
    self.n = self.n + inc
    self.has[x] = (self.has[x] or 0) + inc
    if self.has[x] > self.most then self.most,self.mode = self.has[x],x end end
  return x end

function Sym:mid() return self.mode end
function Sym:div(   e)
  e=0; for _,m in pairs(self.has) do
         if m>0 then e = e-m/self.n * math.log(m/self.n,2) end end
  return e end

function Sym:dist(x,y) return x=="?" and y=="?" and 1 or x==y and 0 or 1 end

function Sym:bins(rows,     x,n,out,has,tmp,inc)
  n,out,tmp = 0,{},{}
  function inc(x) n=n+1; return n end
  function has(x) tmp[x] = tmp[x] or Bin(self.txt, self.at,inc(x),x,x,Sym()) end
  for _,r in pairs(rows) do
    x = r.cells[self.at]; has(x); tmp[x].ystats:add(r.klass) end
  for _,x in pairs(tmp) do push(out, x) end
  return out end

------------------------------------------------------------------------------------
local Num=obj"Num"
function Num:new(at,txt)
   self.at  = at or 0
   self.txt = txt or ""
   self.n, self.mu, self.m2 = 0,0,0
   self.w   = self.txt:find"-$" and -1 or 1
   self.lo, self.hi = math.huge, -math.huge end

function Num:add(x,        d)
  if x ~="?" then
    self.n  = self.n + 1
    self.lo = math.min(x, self.lo)
    self.hi = math.max(x, self.hi)
    d       = x - self.mu
    self.mu = self.mu + d/self.n
    self.m2 = self.m2 + d*(x - self.mu) end
  return x end

function Num:mid() return self.mu end
function Num:div() return (self.m2/(self.n - 1))^0.5 end

function Num:norm(x,   lo,hi)
  lo,hi= self.lo, self.hi
  return x=="?" and x or hi-lo < 1E-9 and 0 or (x - lo)/(hi - lo) end

function Num:dist(x,y)
  if     x=="?" and y=="?" then return 1 end
  if     x=="?"            then y = self:norm(y); x = y<.5 and 1 or 0
  elseif y=="?"            then x = self:norm(x); y = x<.5 and 1 or 0
  else x,y = self:norm(x), self:norm(y) end
  return math.abs(x - y) end

function Num:bins(left,right,       t,f,xy)
  t,f,xy = true,false,{}
  for _,r in pairs(left)  do
    if x ~="?" then push(xy,{x=r.cells[self.at],y=t}) end end
  for _,r in pairs(right) do
    if x ~="?" then push(xy,{x=r.cells[self.at],y=f}) end end
  return bins(self.txt, self.at, sort(xy, lt"x"),
              sd(xy, fu"x")*the.cohen, (#xy)^the.min) end

function bins(txt, at, xy, epsilon, small,        div,b4,out)
  function div(lo,hi,        x,y,cut,lhs,rhs,tmp,best,overall)
    lhs, rhs, overall = Sym(), Sym(), Sym()
    for i=lo,hi do overall:add( rhs:add(xy[i].y) ) end
    best = rhs:div()
    for i=lo,hi do
      x, y = xy[i].x, xy[i].y
      lhs:add(y)
      rhs:sub(y)
      if lhs.n > small and rhs.n > small then
        if x - xy[lo].x > epsilon and xy[hi].x - x > epsilon then
          if x ~= xy[i+1].x then
            tmp = (lhs.n*lhs:div() + rhs.n*rhs:div())  / (lhs.n + rhs.n)
            if tmp < best then
              best,cut = tmp,i end end end end end
    if   cut
    then div(lo,    cut)
         div(cut+1, hi)
    else b4 = push(out, Bin(txt, at, 1+#out, b4, xy[hi].x, overall)).hi end
  end --------------------
  b4, out = -math.huge, {}
  div(1,#xy)
  out[#out].hi = math.huge
  return out end
```

```
-------------------------------------------------------------------
local Row=obj"Row"
function Row:new(t) self.cells = t end

-------------------------------------------------------------------
local Cols=obj"Cols"
function Cols:new(names,    col)
  self.names, self.all, self.x, self.y, self.klass = names, {}, {}, {}, nil
  for at,txt in pairs(names) do
    col = push(self.all, (txt:find"^[A-Z]" and Num or Sym)(at,txt))
    if not txt:find":$"  then
      if txt:find"!$" then self.klass=col end
      col.indep = not txt:find"[-+!]$"
      push(col.indep and self.x or self.y, col) end end  end

function Cols:add(row)
  for _,col in pairs(self.all) do col:add(row[col.at]) end
  return row end

-------------------------------------------------------------------
local Egs=obj"Egs"
function Egs:new() self.rows,self.cols = {}, nil end

function Egs:clone(rows,   out)
  out = Egs():add(self.cols.names)
  for _,row in pairs(rows or {}) do out:add(row) end
  return out end

function Egs:load(file)
  for row in csv(file) do self:add(row) end; return self end

function Egs:add(t)
  t = t.cells and t.cells or t
  if   self.cols
  then push(self.rows, Row(self.cols:add(t)))
  else self.cols=Cols(t) end
  return self end

function Egs:better(row1,row2)
  local s1, s2, n, e = 0, 0, #self.cols.y, math.exp(1)
  for _,col in pairs(self.cols.y) do
    local a = col:norm(row1.cells[col.at])
    local b = col:norm(row2.cells[col.at])
    s1      = s1 - e^(col.w * (a - b) / n)
    s2      = s2 - e^(col.w * (b - a) / n) end
  return s1 / n < s2 / n  end

function Egs:betters(rows)
  return sort(rows or self.rows, function(a,b) return self:better(a,b) end) end

function Egs:mid(cols)
  return rnds(map(cols or self.cols.y, function(col) return col:mid() end)) end

function Egs:dist(row1,row2,   d,n)
  d = sum(self.cols.x, function(col)
            return col:dist(row1.cells[col.at], row2.cells[col.at])^the.p end)
  return (d / (#self.cols.x)) ^ (1/the.p) end

function Egs:around(row1, rows,    around)
  function around(row2) return  {dist=self:dist(row1,row2),row=row2} end
  return sort(map(rows or self.rows,around), lt"dist") end

function Egs:far(row, rows)
  return per(self:around(row, rows or many(self.rows,the.some)),the.far).row end

function Egs:unsuper(n,     recurse,known,rows,used,rest)
  function known(row) used[row.id]=true; return row end
  function recurse(rows,some,x,      y,best,a,b,c)
    if #rows <= 20 then
      oo(self:clone(rows):mid())
    else
      x = known( x or self:far(any(some),some))
      y = known(      self:far(x,some))
      if self:better(y, x) then io.write("/"); x,y = y,x else io.write(".") end
      c = self:dist(x,y)
      best = {}
      for _,r in pairs(rows) do
        a,b= self:dist(r,x), self:dist(r,y); r.x = (a^2+ c^2-b^2) / (2*c) end
      for i,row in pairs(sort(rows, lt"x")) do
         push(i < #rows//2 and best or rest,row) end
      recurse(best, many(best,n), x)  end
  end --------------
  used, rest = {}, {}
  recurse(self.rows, many(self.rows,n)) end

function Egs:branches(rows1,rows2,    n)
  n = #left + #right
  function f(bins) return {
    bins = bins,
    w  = sum(bins,function(bin) return bin.ystats.n*bin.ystats:div()/n end)} end
  bins = sort(map(self.cols.x, function(c) f(c:bins(rows,rows)) end), lt"w")[1]
.bins
end


-------------------------------------------------------------------
fails,go,no = 0,{},{}
function ok(test,msg)
  print("", test and "PASS "or "FAIL ", msg or "")
  if not test then
    fails= fails+1
    if  the.dump then assert(test,msg) end end end

function go.div(  s)
  s=Sym()
  for _,x in pairs{"a","a","a","a","a","b","b","c"} do s:add(x) end
  ok(math.abs(1.376 - s:div()) < 0.01, "ent") end

function go.symbins(  eg,right,left,rows,x,col)
  eg = Egs():load(the.file)
  rows = eg:betters()
  for i=1,50                do rows[i].klass=1 end
  for i=#rows-50+1, #rows do rows[i].klass=0 end
  -- for _,col in pairs(eg.cols.x) do print(""); print(col.at)
  col=eg.cols.x[4]
  for k,v in pairs(col:bins(rows)) do print(v) end end

function go.many()
  oo(many({10,20,30,40,50,60,70,80,90,100},3)) end

function go.unsuper(   eg,best)
  eg = Egs():load(the.file)
  oo(map(eg.cols.y, function(col) return col.txt end))
  oo(map(eg.cols.y, function(col) return col.w end))
  oo(eg:mid())
  print("---")
  for i=1,20 do eg:unsuper(128) end
  eg:betters()
  best = eg:clone()
  for i=1,20 do best:add(eg.rows[i]) end
  print("---")
  oo(best:mid()) end

function go.eg1(   eg)
  eg = Egs():load(the.file)
  print(#eg.rows, eg.cols.y[1]) end

function go.dist(  eg,row2,t)
  eg = Egs():load(the.file)
  t={}; for i=1,20 do
    row2= any(eg.rows)
    push(t, {dist=eg:dist(eg.rows[1],row2), row = row2}) end
  oo(eg.rows[1])
  for _,two in pairs(sort(t,lt"dist")) do oo(two.row.cells) end end

function go.mids( eg,hi,lo,out)
  eg = Egs():load(the.file)
  oo(map(eg.cols.y, function(col) return col.txt end))
  oo(map(eg.cols.y, function(col) return col.w end))
  print("all",o(eg:mid()))
  lo,hi = eg:clone(), eg:clone()
  for i,row in pairs(eg:betters()) do
    if i < 20              then lo:add(row) end
    if i > #eg.rows - 20 then hi:add(row) end end
  print("lo",o(lo:mid()))
  print("hi",o(hi:mid())) end

-------------------------------------------------------------------
help:gsub("\n  ([-][-]([^%s]+))[%s]+(-[^%s]+)[^\n]*%s([^%s]+)",
  function(long,key,short,x)
    for n,flag in ipairs(arg) do
      if flag==short or flag==long then
        x = x=="false" and "true" or x=="true" and "false" or arg[n+1] end end
    the[key] = coerce(x) end)

if the.help then print(help) end
if the.todo=="all" then work() else work1(the.todo) end
for k,v in pairs(_ENV) do if not b4[k] then print("?",k,type(v)) end end
os.exit(fails)

--                 _   _   _
--                (_) (_) (_)
--                 |   |   |
--                 p   |   |
--                 k   |   |
--                 w   |   |
--                 |   |   |
--                 |   _   |
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--                  \  |____|
```