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Firstname Lastname, *University of Examples*

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$$A = \begin{bmatrix} A_{11} & A_{21} \\ A_{21} & A_{22} \end{bmatrix} \tag{1}$$

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```
#!/usr/bin/env python3.9
# vim: ts=2 sw=2 sts=2 et :
# autopep8: ignore E20,E401,E226,E302,E41
```

```
import re, sys, math, argparse, itertools
from argparse import ArgumentParser as parse
from argparse import RawTextHelpFormatter as textual
Float = Str = Int = Bool = lambda *l: l[0]
fails=0

def keys(
  BINS    : Float(”bins are of size n**BINS”) = .5,
  COLS    : Str(”columns to use for inference”) = ”x”,
  DATA    : Str(”where to read data”) = ”../data/auto2.csv”,
  EPSILON: Float(”small = sd**EPSILON”) = .3,
  FAR     : Float(”where to look for far things”) = .9,
  GOAL    : Str(”learning goals: best—rest—other”) = ”best”,
  K       : Int(”bayes low class frequency hack”) = 2,
  M       : Int(”bayes low range frequency hack”) = 1,
  P       : Int(”distance calculation exponent”) = 2,
  SAMPLE : Int(”#samples to find far things?”) = 20,
  VERBOSE: Bool(”set verbose”) = False,
  TOP     : Int(”focus on this many”) = 20,
  XAMPLE : Str(”egs: fl-x lsfl lists all, fl-x allfl runs all”) = ”” ):
  ”””
    ,-˙—“      (c) Tim Menzies, 2021, unlicense.org.
   /      “     The delta between things is
   “˙,-.˙*      simpler than the things.
        v ”””

  GOAL = –flbestfl : lambda b, r: b**2/b+r,
          flrestfl : lambda b, r: r**2/(b+r),
          flotherfl: lambda b, r: 1/(b+r)     ”[GOAL]
  #---------------------------------------------------------------------------
  class Col(o):
    ”Store columns in `Col`, `Skip`, `Sym`, `Num`.”
    def ¨init¨(i, at=0, txt=””, inits=[]):
      i.n, i.at, i.txt = 0, at, txt
      i.w = -1 if ”-” in txt else 1
      [i.add(x) for x in inits]

    def add(i, x, n=1):
      if x != ”?”: i.n += 1; x = i.add1(x, n)
      return x
  # ------------------------------------
  class Skip(Col):
    def add1(i, x, n=1): return x
  # ------------------------------------
  class Sym(Col):
    def ¨init¨(i, **kw): i.has = –”; super().¨init¨(**kw)

    def add1(i, x, n=1): inc(i.has, x, n); return x

    def bins(i, j):
      for k in (i.has — j.has):
        yield i.has.get(k, 0), True, (i.at, (k, k))
        yield j.has.get(k, 0), False, (j.at, (k, k))

    def dist(i, x, y): return 0 if x == y else 1

    def ent(i):
      return sum(-v/i.n * math.log(v/i.n) for v in i.has.values())

    def merge(i, j):
      k = Sym(at=i.at, txt=i.txt)
      [k.add(x, n) for has in (i.has, j.has) for x, n in has.items()]
      return k

    def merged(i, j):
      k = i.merge(j)
      e1, n1, e2, n2, e, n = i.ent(), i.n, j.ent(), j.n, k.ent(), k.n
      if e1 + e2 ¡ 0.01 or e * .95 ¡ n1 / n * e1 + n2 / n * e2:
        return k
  # ------------------------------------
  class Num(Col):
    def ¨init¨(i, **kw):
      i.˙all, i.ok = [], False
      super().¨init¨(**kw)

    def add1(i, x, n):
      x, i.ok = float(x), False
      for ˙ in range(n): i.˙all += [x]
      return x

    def all(i):
      if not i.ok: i.ok = True; i.˙all = sorted(i.˙all)
      return i.˙all
```

```

    def bins(i, j):
      xy = [(z, True) for z in i.˙all]+[(z, False) for z in j.˙all]
      eps = EPSILON * (i.n*i.sd() + j.n*j.sd()) / (i.n + j.n)
      for ((lo, hi),s) in bins(xy,epsilon=eps,size=len(xy)**BINS):
        for klass, n in s.has.items():
          yield n, klass, (i.at, (lo, hi))

    def dist(i, x, y):
      if    x == ”?”: y = i.norm(y); x = 1 if y ¡ 0.5 else 0
      elif y == ”?”: x = i.norm(x);y = 1 if x ¡ 0.5 else 0
      else          : x, y = i.norm(x), y.norm(y)
      return abs(x-y)

    def norm(i, x):
      if x == ”?”: return x
      a = i.all()
      return max(0, min(1, (x-first(a))/(last(a)-first(a)+1E-32)))

    def sd(i) : return (per(i.all(), .9) - per(i.all(), .1))/2.56
    def span(i) : return (first(i.all()), last(i.all()))
    def wide(i, n=0): return last(i.all()) - first(i.all()) ¿= n
  #---------------------------------------------------------------------------
  class Row(o):
    ”Data is in `Row`s which, in turn, are in `Table`s.”
    def ¨init¨(i, lst, tab=None): i.tab, i.cells = tab, lst

    def dist(i, j):
      d = n = 1E-32
      for col in i.tab.cols[COLS]:
        n += 1
        x, y = i.cells[at], j.cells[at]
        d += 1 if x == ”?” and y == ”?” else col.dist(x, y) ** P
      return (d/n) ** (1/P)

    def far(i, rows):
      tmp = [(dist(i, j), j) for ˙ in range(SAMPLE)]
      return per(sorted(tmp, key=first), FAR)
  # ------------------------------------
  class Table(o):
    def ¨init¨(i, inits=[]):
      i.rows = []
      i.cols = o(all=[], names=[], x=[], y=[], klass=None)
      [i.add(x) for x in inits]

    def add(i, a): i.data(a) if i.cols.names else i.header(a)
    def clone(i, inits=[]): return Table([i.cols.names] + inits)

    def data(i, a):
      a = a.cells if type(a) == Row else a
      a = [col.add(a[col.at]) for col in i.cols.all]
      i.rows += [Row(a, tab=i)]

    def header(i, a):
      i.cols.names = a
      for at, x in enumerate(a):
        new = Skip if i.skipp(x) else (Num if i.nump(x) else Sym)
        new = new(at=at, txt=x)
        i.cols.all += [new]
        if not i.skipp(x):
          i.cols[”y” if i.yp(x) else ”x”] += [new]
          if i.klassp(x):
            i.cols.klass = new

    def klassp(i, x): return ”!” in x
    def nump(i, x): return x[0].isupper()
    def skipp(i, x): return ”?” in x
    def yp(i, x): return ”-” in x or ”+” in x or i.klassp(x)

  # ------------------------------------
  def stratify(src):
    all, klass = None,–”
    for n,row in enumerate(src):
      if all:
        kl    = row[all.cols.klass.at]
        here = klass[kl] = klass.get(kl,None) or all.clone()
        here.add(row)
        all.add(row)
      else:
        all = Table([row])
    return o(all=all, klass=klass)
  #---------------------------------------------------------------------------
  def bins(xy, epsilon=0, size=30):
```

```
  "Use `bins` to divide numeric data into ranges."
  def merge(b4):
    j, tmp, n = 0, [], len(b4)
    while j ¡ n:
      a = b4[j]
      if j ¡ n - 1:
        b = b4[j + 1]
        print(" “na",a[1])
        print("b",b[1])
        if cy := a[1].merged(b[1]):
          print("c",cy)
          a = ((a[0][0], b[0][1]), cy)
          j += 1
      tmp += [a]
      j += 1
    return merge(tmp) if len(tmp) ¡ len(b4) else b4

  def divide(xy):
    bin = o(x=Num(), y=Sym())
    bins = [bin]
    for i, (x, y) in enumerate(xy):
      if bin.x.n ¿= size:
        if x != b4 and i ¡ len(xy)-size and bin.x.wide(epsilon):
          bin = o(x=Num(), y=Sym())
          bins += [bin]
      bin.x.add(x)
      bin.y.add(y)
      b4 = x
    return bins

  return merge([(bin.x.span(), bin.y)
               for bin in divide(sorted(xy, key=first))])
#-----------------------------------------------------------------------
def contrasts(here, there, t):
  "Report ranges that are most different in two classes."
  def like(d, kl):
    out = prior = (hs[kl] + K) / (n + K*2)
    for at, span in d.items():
      f = has.get((kl, (at, span)), 0)
      out *= (f + M*prior) / (hs[kl] + M)
    return out

  def val(d): return GOAL(like(d, True), like(d, False)), d
  def top(a): return sorted(a,reversed=True,key=first)[:TOP]

  has = –(kl, (at, (lo, hi))): f
         for col1, col2 in zip(here.cols.x, there.cols.x)
         for f, kl, (at, (lo, hi)) in col1.bins(col2)˝
  n = len(here.rows, there.rows)
  hs = –True: len(here.rows), False: len(there.rows)˝
  solos = [val(dict(at=x)) for at, x in set([z for ˙, z in has])]
  ranges = –˝
  for ˙, d in top(solos):
    for k in d:
      ranges[k] = ranges.get(k, set()).add(d[k])
  for rule in top([val(d) for d in dict˙product(ranges)]):
    print(rule)
#-----------------------------------------------------------------------
# Unit tests.
class Eg:
  def ls():
    "list  all examples."
    print(" “nexamples:")
    for k, f in vars(Eg).items():
      if k[0] != "˙": print(f"  –k:¡13˝ –f.˙˙doc˙˙˝")

  def ˙fail():
    "testing failure"
    assert False, "failing"

  def data(file="../data/vote.csv"):
    "simple load of data into  a table"
    t = Table(csv(file))
    assert 435 == len(t.rows)
    assert 195 == t.cols.all[1].has[flyfl]

  def nclasses(file="../data/diabetes.csv", kl="positive"):
    "read data with nclasses"
    ts = stratify(csv(file))
    assert 2       == len(ts.klass)
    assert 268     == len(ts.klass[kl].rows)
    assert 768     == len(ts.all.rows)
    assert 3.90625 == ts.klass[kl].cols.all[0].sd()

    def bins(file="../data/diabetes.csv",
           k1= "positive", k2= "negative"):
      "discretize some data"
      ts = stratify(csv(file))
      goods, bads = ts.klass[k1], ts.klass[k2]
      for good,bad in zip(goods.cols.all, bads.cols.all):
        print(f" “n–good.at˝")
        [print(f" “t–x˝") for x in good.bins(bad)]
        return 1

  #-----------------------------------------------------------------------
  # main program for keys
  if XAMPLE == "all":
    for k, f in vars(Eg).items():
      if k[0] != "˙":  run(f)
  else:
    if XAMPLE and XAMPLE in vars(Eg):
      f = vars(Eg)[XAMPLE]
      f() if XAMPLE=="ls" else run(f)

##############################
#-----------------------------------------------------------------------
# things that donflt use the config vars
# tests
def run(fun):
  global fails
  s= f"–fun.˙˙name˙˙:¡12˝"
  try:
    fun()
    color(green=("! " + s),white=fun.˙˙doc˙˙)
  except Exception as err:
    fails += 1
    color(red="x " + s,white= str(err))

# string stuff
def color(end=" “n", **kw):
  s, a, z = "", " “u001b[", ";1m"
  c = dict(black=30, red=31,  green=32, yellow=33, purple=34,
           pink=35,  blue=36, white=37, reset=" “033[0m")
  for col,txt in kw.items(): s = s + a + str(c[col]) + z + txt +
  ↪  c["reset"]
  print(s, end=end)

# dictionary stuff
def has(d, k): return d.get(k, 0)
def inc(d, k, n=1): tmp = d[k] = n + d.get(k, 0); return tmp

def dict˙product(d):
  keys = d.keys()
  for p in itertools.product(*d.values()):
    yield dict(zip(keys, p))

# list stuff
def first(a): return a[0]
def last(a): return a[-1]  #
def per(a, p=.5): return a[int(p*len(a))]

# object stuff
class o(object):
  def ˙˙init˙˙(i, **k): i.˙˙dict˙˙.update(**k)
  def ˙˙getitem˙˙(i, k): return i.˙˙dict˙˙[k]
  def ˙˙repr˙˙(i):  return i.˙˙class˙˙.˙˙name˙˙+str(
        –k:v for k, v in i.˙˙dict˙˙.items() if k[0] != "˙"˝)
  def ˙˙setitem˙˙(i, k, v): i.˙˙dict˙˙[k] = v

# file stuff
def csv(f=None, sep=","):
  def prep(s): return re.sub(rfl([“n“t“r ]—#.*)fl, flfl, s)
  if f:
    with open(f) as fp:
      for s in fp:
        if s := prep(s): yield s.split(sep)
  else:
    for s in sys.stdin:
      if s := prep(s): yield s.split(sep)

# command-line stuff
def cli(f):
  used, p = –˝, parse(prog="./"+f.˙˙name˙˙, description=f.˙˙doc˙˙,
                      formatter˙class=textual)
  for (k, h),b4 in zip(list(f.˙˙annotations˙˙.items()),f.˙˙defaults˙˙):
    k0 = k[0]
```

Table 1: *Random table*

Name		
First name	Last Name	Grade
John	Doe	7.5
Richard	Miles	2

```
    used[k0] = c = k0 if k0 in used else k0.lower()
    if b4==False:
        p.add˙argument("-"+c, dest=k, help=h, default=False,
                         action="store˙true")
    else: p.add˙argument("-"+c, dest=k, default=b4,
                         help=h+" ["+str(b4)+"]", type=type(b4),
                         metavar=k)
  f( **p.parse˙args().¨dict¨ )

# start up stuff
if ¨name¨ == "¨main¨":
  cli(keys)
  sys.exit(fails)
```

Heading on level 1 again

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Heading on level 2

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Last This is the last item

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