データ解析

Rによる多変量解析入門

R入門

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R

- データ操作，統計計算，グラフィックスのための統合ソフトウエア環境
- 行列操作に優れている，データ解析の一貫したツール群，簡単で効率的なプログラム言語
- Rはフリーソフトでソースも公開（http://cran.r-project.org）
- Rの開発は１９９０年代後半からネット上で行われている
- Rの前身であるはSはC言語やUNIXと同じAT&T(現Lucent Technologies）のベル研究所で１９８４年ころ開発（ちなみにC言語およびUNIXの開発は１９７１年ころ）
- そのほかのソフトウエア：　Matlab（Octave），Mathematica，SAS，SPSS

講義内容

- 「データ解析」 Rを用いた実践的な多変量解析
- Rの使用法について簡単に紹介（演習とレポート）
- 実際にRを使ったデータ解析
- 単にソフトの使用法を学ぶのではなく，その背後にある数学を自分のものにすることが目標
- 回帰分析や主成分分析のためのR関数を自分自身で書き，それを使ってデータ解析を行う
- このような経験は将来未知の問題で新しい手法を開発する場面で役立つ
- 総合的な課題　（レポート１〜２回）

講義予定

- R入門
- 端末室での演習（西７号館，edu)
- Rによる線形代数
- 回帰分析
- 主成分分析
- クラスター分析
- 正準相関分析
- 判別分析
- モデル選択
- ブートストラップ法

講義について

- ホームページ
  http://www.is.titech.ac.jp/~shimo/class/
- 担当：下平
- ティーチングアシスタント：　坂口，鈴木
- 評価方法：　出席とレポート
- 質問受け付け：　まずティーチングアシスタントに質問内容のメールを出すこと．面談が必要な場合はあらかじめメールにてアポイントを取ること．もしくは講義か演習時に直接質問する．
- **１０月９日は演習@西７端末室⇒ レポート提出１１月１０日**
- **かならず「データ解析　資料」にあらかじめ目を通すこと**
- 演習のページ（鈴木）
  http://www.is.titech.ac.jp/~suzuki3/class/data_ana03/

eduでのRの利用の準備

- 最新版のRが~shimo/program/Rにインストールされている．利用するにはまず自分の.cshrcファイルに以下のように書き加える．

```
setenv SHIMO ~shimo/program
setenv PATH ${SHIMO}/R/bin:${PATH}
```

- 以上の設定を有効にするため，source ~/.cshrcを実行する．(次回にログインするときはこの必要ない)
- 作業用ディレクトリを作る．例えば

```
shimo@edu[~] mkdir -p class/data_ana03
shimo@edu[~] chmod og-rx class/data_ana03
```


eduでのRの利用

- 作業用ディレクトリに移動しRを起動

```
shimo@edu[~] cd class/data_ana03
shimo@edu[data_ana03] R
```

- たとえば $\sin(x)$ の曲線を描く

```
> x <- seq(0,10,0.1)
> plot(x,sin(x),type="l")
```

- Rの終了は q()コマンド

```
> q()
Save workspace image? [y/n/c]: y
```

- 作業用ディレクトリにファイル.RDataが自動的に作られる．

emacsでの統合環境 ESS

- .emacsファイルに以下を書き加えてからemacsを再起動．

```
;;; ess
(setq load-path (cons
   (expand-file-name  "~shimo/program/ess/lisp") load-path ))
(autoload 'R "ess-site" "" t)
(add-hook 'ess-post-run-hook (function (lambda ()
   (set-buffer-process-coding-system 'euc-japan 'euc-japan))))
```

- emacs内でM-x RによってRを起動する．
- セッションはC-x C-wによってxxxx.Rtのような名前でセーブする．
- プログラムのファイルはyyyy.Rのような名前で作成しRコマンド source ("yyyy.R")でロード．
- RのヘルプはC-c C-vで別ウィンドウが開く

講義で用いるデータセット

総務庁統計局統計センターが公開している社会・人口統計体系
http://www.stat.go.jp/data/ssds/index.htm

edu:~shimo/class/gakubu200209/data/X2000.R
というファイルでX2000というリスト型の変数を定義している．

X2000$x	[データ本体]	サイズ 47×1173の行列
X2000$item	[項目名]	サイズ 1173の文字型ベクトル
X2000$jitem		(日本語)
X2000$pref	[県名]	サイズ 47の文字型ベクトル
X2000$jpref		(日本語)

項目例

1 A05201 自然増加率
2 A06102 一般世帯の平均人員
3 A06202 核家族世帯割合
4 F01503 共働き世帯割合
5 A06205 単独世帯割合
6 A06301 65歳以上の親族のいる世帯割合
7 A06302 高齢夫婦のみの世帯の割合
8 A06304 高齢単身世帯の割合
9 A06601 婚姻率（人口千人当たり）
10 A06602 離婚率（人口千人当たり）

データ行列の一部

	A05201	A06102	A06202	F01503	···
Hokkaido	0.04	2.42	60.54	26.54	···
Aomori	-0.02	2.86	54.20	34.38	···
Iwate	-0.07	2.92	50.87	38.82	···
Miyagi	0.18	2.80	51.96	31.88	···
Akita	-0.25	3.00	50.48	39.55	···
Yamagata	-0.12	3.25	45.79	47.09	···
Fukushima	0.06	3.05	52.12	39.53	···
Ibaraki	0.16	2.99	58.28	35.84	···
Tochigi	0.13	2.97	56.47	37.59	···
Gumma	0.12	2.88	60.07	36.35	···
Saitama	0.36	2.78	65.46	30.89	···
Chiba	0.27	2.70	62.55	29.57	···
Tokyo	0.11	2.21	52.15	22.09	···
Kanagawa	0.36	2.53	62.04	25.04	···
⋮	⋮	⋮	⋮	⋮	
Okinawa	0.67	2.91	64.54	25.70	···

サンプルセッション

Rを実際に使ったデータ解析とR言語入門 (必ずしも自分でやる必要はない)

- サンプルセッション１
  Rによるデータ解析１（主成分分析，クラスタリング，重回帰分析）
  ファイル： ~shimo/class/gakubu200209/note20020919a.Rt
- サンプルセッション２
  Rによるデータ解析２（ランダムにデータ項目を選ぶ）
  ファイル： ~shimo/class/gakubu200209/note20020919b.Rt
- サンプルセッション３
  R言語入門
  ファイル： ~shimo/class/gakubu200209/note20020919c.Rt

サンプルセッション１

```
Last login: Fri Sep 20 2002 15:54:22 +0900 from grandma
Sun Microsystems Inc.   SunOS 5.8       Generic Patch   October 2001
No mail.
Sun Microsystems Inc.   SunOS 5.8       Generic Patch   October 2001
shimo@edu[~] cd class/gakubu200209
shimo@edu[gakubu200209] R

R : Copyright 2002, The R Development Core Team
Version 1.5.1 Patched (2002-09-08)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type ‘license()’ or ‘licence()’ for distribution details.

R is a collaborative project with many contributors.
Type ‘contributors()’ for more information.
```



```
Type ‘demo()’ for some demos, ‘help()’ for on-line help, or
‘help.start()’ for a HTML browser interface to help.
Type ‘q()’ to quit R.

[Previously saved workspace restored]

> source("~shimo/class/gakubu200209/data/X2000.R")
> names(X2000)
 [1] "x"      "pref"  "code"  "item"  "cate"  "clab"  "jpref" "jitem" "junit"
[10] "jcate" "rm"
> dim(X2000$x)
[1]   47 1173
> X2000$pref
 [1] "Hokkaido"  "Aomori"    "Iwate"     "Miyagi"    "Akita"     "Yamagata"
 [7] "Fukushima" "Ibaraki"   "Tochigi"   "Gumma"     "Saitama"   "Chiba"
[13] "Tokyo"     "Kanagawa"  "Niigata"   "Toyama"    "Ishikawa"  "Fukui"
[19] "Yamanashi" "Nagano"    "Gifu"      "Shizuoka"  "Aichi"     "Mie"
[25] "Shiga"     "Kyoto"     "Osaka"     "Hyogo"     "Nara"      "Wakayama"
[31] "Tottori"   "Shimane"   "Okayama"   "Hiroshima" "Yamaguchi" "Tokushima"
```

```
[37] "Kagawa"    "Ehime"     "Kochi"     "Fukuoka"   "Saga"      "Nagasaki"
[43] "Kumamoto"  "Ooita"     "Miyazaki"  "Kagoshima" "Okinawa"
> X2000$jpref
  Hokkaido     Aomori      Iwate     Miyagi      Akita   Yamagata  Fukushima
"北 海 道" "青 森 県" "岩 手 県" "宮 城 県" "秋 田 県" "山 形 県" "福 島 県"
   Ibaraki    Tochigi      Gumma    Saitama      Chiba      Tokyo   Kanagawa
"茨 城 県" "栃 木 県" "群 馬 県" "埼 玉 県" "千 葉 県" "東 京 都" "神奈川県"
   Niigata     Toyama   Ishikawa      Fukui  Yamanashi     Nagano       Gifu
"新 潟 県" "富 山 県" "石 川 県" "福 井 県" "山 梨 県" "長 野 県" "岐 阜 県"
  Shizuoka      Aichi        Mie      Shiga      Kyoto      Osaka      Hyogo
"静 岡 県" "愛 知 県" "三 重 県" "滋 賀 県" "京 都 府" "大 阪 府" "兵 庫 県"
      Nara   Wakayama    Tottori    Shimane    Okayama  Hiroshima  Yamaguchi
"奈 良 県" "和歌山県" "鳥 取 県" "島 根 県" "岡 山 県" "広 島 県" "山 口 県"
 Tokushima     Kagawa      Ehime      Kochi    Fukuoka       Saga   Nagasaki
"徳 島 県" "香 川 県" "愛 媛 県" "高 知 県" "福 岡 県" "佐 賀 県" "長 崎 県"
  Kumamoto      Ooita   Miyazaki  Kagoshima    Okinawa
"熊 本 県" "大 分 県" "宮 崎 県" "鹿児島県" "沖 縄 県"
> ### get some items
> a <- c("A05201","A06102","A06202","F01503","A06205","A06301","A06302","A063
```

```
> X2000$item[a]
                                                A05201
                              "Rate of natural increase  "
                                                A06102
                           "Members per private household  "
                                                A06202
                        "Ratio of family nuclei households  "
                                                F01503
                          "Ratio of dual-income households  "
                                                A06205
                           "Ratio of one-person households  "
                                                A06301
"Ratio of households with members65 years old and over "
                                                A06302
                          "Ratio of aged-couple households  "
                                                A06304
                   "Ratio of aged-single person households  "
                                                A06601
                     "Rate of marriages (per 1,000 persons)  "
```

```
                                                A06602
                     "Rate of divorces (per 1,000 persons)  "
> X2000$jitem[a]
                          A05201                                  A06102
               "自 然 増 加 率 "             "一 般 世 帯 の 平 均 人 員 "
                          A06202                                  F01503
           "核 家 族 世 帯 割 合 "           "共 働 き 世 帯 割 合 "
                          A06205                                  A06301
             "単 独 世 帯 割 合 "         "65歳以上の親族のいる世帯割合 "
                          A06302                                  A06304
          "高齢夫婦のみの世帯の割合 "        "高 齢 単 身 世 帯 の 割 合 "
                          A06601                                  A06602
"婚   姻   率 （人口千人当たり）" "離   婚   率 （人口千人当たり）"
> na <- paste(seq(along=a),a,X2000$item[a])
> na
 [1] "1 A05201 Rate of natural increase  "
 [2] "2 A06102 Members per private household  "
 [3] "3 A06202 Ratio of family nuclei households  "
 [4] "4 F01503 Ratio of dual-income households  "
```

```
 [5] "5 A06205 Ratio of one-person households  "
 [6] "6 A06301 Ratio of households with members65 years old and over "
 [7] "7 A06302 Ratio of aged-couple households  "
 [8] "8 A06304 Ratio of aged-single person households  "
 [9] "9 A06601 Rate of marriages (per 1,000 persons)  "
[10] "10 A06602 Rate of divorces (per 1,000 persons)  "
> jna <- paste(seq(along=a),a,X2000$jitem[a])
> jna
 [1] "1 A05201 自 然 増 加 率 "
 [2] "2 A06102 一 般 世 帯 の 平 均 人 員 "
 [3] "3 A06202 核 家 族 世 帯 割 合 "
 [4] "4 F01503 共 働 き 世 帯 割 合 "
 [5] "5 A06205 単 独 世 帯 割 合 "
 [6] "6 A06301 65歳以上の親族のいる世帯割合 "
 [7] "7 A06302 高齢夫婦のみの世帯の割合 "
 [8] "8 A06304 高 齢 単 身 世 帯 の 割 合 "
 [9] "9 A06601 婚   姻   率 （人口千人当たり）"
[10] "10 A06602 離   婚   率 （人口千人当たり）"
> x <- X2000$x[,a]
```

```
> x
          A05201 A06102 A06202 F01503 A06205 A06301 A06302 A06304 A06601 A066
Hokkaido    0.04   2.42  60.54  26.54  29.95  30.50   9.90   7.39   5.77   2.
Aomori     -0.02   2.86  54.20  34.38  24.08  38.99   7.45   6.61   5.24   1.
Iwate      -0.07   2.92  50.87  38.82  24.47  42.42   7.87   6.05   5.14   1.
Miyagi      0.18   2.80  51.96  31.88  28.59  33.04   6.42   4.54   5.79   1.
Akita      -0.25   3.00  50.48  39.55  21.24  47.77   9.15   6.71   4.69   1.
Yamagata   -0.12   3.25  45.79  47.09  19.98  49.75   7.50   5.27   5.40   1.
Fukushima   0.06   3.05  52.12  39.53  22.60  41.70   7.58   5.65   5.44   1.
Ibaraki     0.16   2.99  58.28  35.84  21.42  33.95   6.35   4.31   5.78   1.
Tochigi     0.13   2.97  56.47  37.59  22.42  34.95   6.28   4.69   5.87   1.
Gumma       0.12   2.88  60.07  36.35  21.78  35.61   7.95   5.49   5.73   1.
Saitama     0.36   2.78  65.46  30.89  23.15  25.10   5.89   3.94   6.19   2.
Chiba       0.27   2.70  62.55  29.57  25.45  26.75   6.36   4.51   6.30   2.
Tokyo       0.11   2.21  52.15  22.09  40.85  25.44   6.69   7.23   6.87   2.
Kanagawa    0.36   2.53  62.04  25.04  29.54  24.74   6.81   5.04   6.89   2.
Niigata    -0.03   3.07  51.07  43.22  21.69  43.77   7.82   5.27   5.03   1.
Toyama     -0.01   3.09  52.30  46.09  19.93  43.47   7.89   5.59   5.51   1.
Ishikawa    0.12   2.83  53.17  40.23  25.98  36.29   7.64   5.81   5.86   1.
```

```
Fukui       0.13   3.14  50.72  46.69  20.94  43.41   7.67   5.73   5.48   1.
Yamanashi   0.08   2.84  57.42  36.04  24.17  38.14   8.61   6.19   5.70   1.
Nagano      0.06   2.89  55.17  41.54  23.13  41.74   9.41   6.03   5.70   1.
Gifu        0.15   3.07  56.74  39.64  19.74  38.46   7.79   5.09   5.59   1.
Shizuoka    0.18   2.91  56.87  38.15  22.91  35.33   6.89   4.83   5.94   1.
Aichi       0.40   2.75  59.79  32.91  26.23  28.08   6.66   4.89   6.59   1.
Mie         0.11   2.88  59.40  36.87  21.73  37.49   9.17   6.65   5.72   1.
Shiga       0.35   3.02  57.50  36.76  22.22  33.67   6.65   4.48   6.24   1.
Kyoto       0.12   2.55  57.65  27.97  30.86  31.42   8.10   7.49   5.96   1.
Osaka       0.30   2.51  61.90  23.78  29.78  27.21   7.30   7.38   6.68   2.
Hyogo       0.22   2.69  63.21  26.94  24.95  32.23   8.54   7.43   6.23   2.
Nara        0.18   2.93  64.94  27.21  19.13  33.77   8.31   5.91   5.56   1.
Wakayama   -0.06   2.77  61.98  30.71  21.97  41.08  10.63   9.54   5.35   1.
Tottori    -0.08   3.00  51.83  43.23  22.69  44.73   8.44   7.33   5.24   1.
Shimane    -0.24   2.90  50.97  42.89  24.02  48.06  10.46   8.24   4.67   1.
Okayama     0.07   2.77  57.42  35.14  24.98  37.73   9.70   7.27   5.60   1.
Hiroshima   0.12   2.57  59.94  32.03  28.02  32.87   9.36   7.73   5.90   1.
Yamaguchi  -0.15   2.56  59.83  32.46  26.75  39.33  11.35   9.65   5.15   1.
Tokushima  -0.11   2.78  55.68  35.88  24.40  40.95   9.61   8.08   5.07   1.
```

```
Kagawa      0.03   2.75  58.53  36.35  23.81  38.88   9.95   7.59   5.63   1.
Ehime      -0.08   2.59  60.33  31.24  26.30  38.15  11.03   9.06   5.12   1.
Kochi      -0.25   2.47  57.67  33.12  29.85  40.21  10.98  11.16   5.00   2.
Fukuoka     0.14   2.57  57.86  26.51  30.24  31.10   7.88   7.48   5.94   2.
Saga        0.07   3.08  55.06  39.49  20.96  42.83   8.27   6.99   5.19   1.
Nagasaki    0.02   2.71  59.92  31.00  25.30  39.10   9.84   9.18   5.12   1.
Kumamoto    0.02   2.81  56.19  34.98  25.04  40.22   9.52   7.96   5.15   1.
Ooita      -0.06   2.64  58.01  32.47  26.42  39.43  10.79   8.93   5.08   1.
Miyazaki    0.07   2.61  62.18  35.51  25.74  36.93  11.13   9.11   5.32   2.
Kagoshima  -0.13   2.43  62.44  29.85  30.12  38.01  12.66  12.39   5.09   1.
Okinawa     0.67   2.91  64.54  25.70  24.26  27.92   5.39   6.22   6.47   2.
> dim(x)
[1] 47 10
> # load "mybiplot", "mylsfit", "mypca", "myplot", "mysvd", "psinit"
> source("~shimo/class/gakubu200209/myfunc20020919.R")
>
```

主成分分析

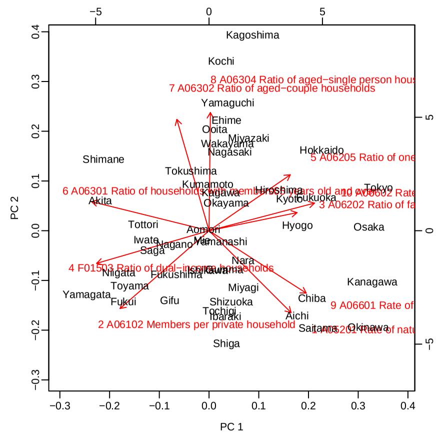
主成分分析 ＝ PCA (principal component analysis)

- 多変量解析の定番
- データの変動をできるだけ少数個の変換された変量で説明
- 主成分＝変換された変量
- バイプロットによって結果を視覚的に示す

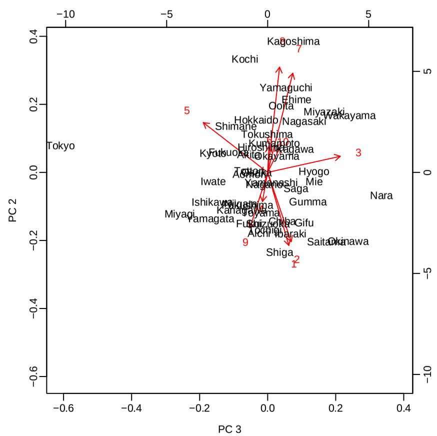
PCAの関数

```
mypca <- function(dat) {
  s <- mysvd(dat)
  x <- s$u %*% diag(s$d)
  y <- s$v %*% diag(s$d)
  list(x=x,y=y,d=s$d,u=s$u,v=s$v)
}

> p <- mypca(scale(x))
> mybiplot(p$u,p$y)
> mybiplot(p$u,p$y,choi=3:2)
```

1 A05201 自然増加率
2 A06102 一般世帯の平均人員
3 A06202 核家族世帯割合
4 F01503 共働き世帯割合
5 A06205 単独世帯割合
6 A06301 65歳以上親族割合
7 A06302 高齢夫婦のみ世帯割合
8 A06304 高齢単身世帯割合
9 A06601 婚姻率
10 A06602 離婚率



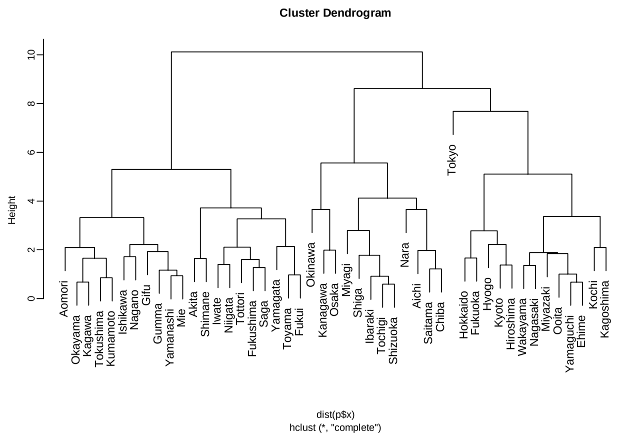
1 A05201 自然増加率
2 A06102 一般世帯の平均人員
3 A06202 核家族世帯割合
4 F01503 共働き世帯割合
5 A06205 単独世帯割合
6 A06301 65歳以上親族割合
7 A06302 高齢夫婦のみ世帯割合
8 A06304 高齢単身世帯割合
9 A06601 婚姻率
10 A06602 離婚率

クラスター分析

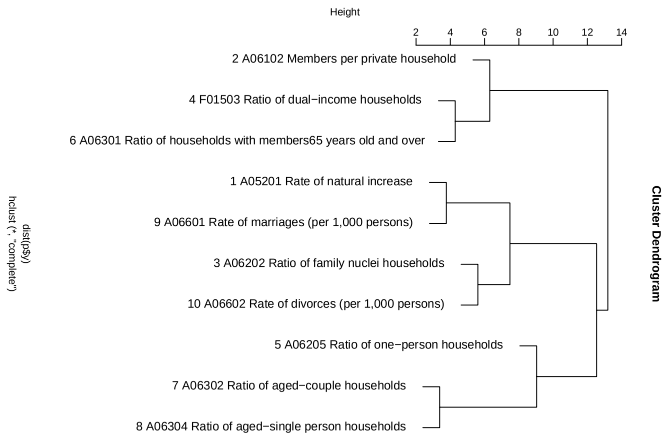
- 対象の自動分類，「教師なし」の分類
- 特徴ベクトルなどから対象間の「距離」を定義
- 距離に従って，似たもの同士の群（クラスター）に分類
- 階層的クラスタリング，樹状図

Rでのクラスター分析

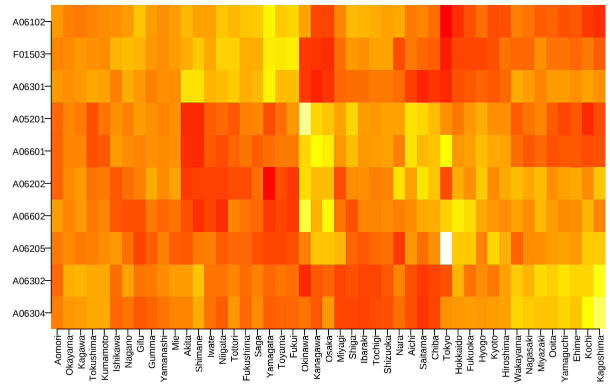
```
> library(mva)  # load multivariante analysis library
> hx <- hclust(dist(p$x))
> hy <- hclust(dist(p$y))
> # show clustering
> plot(hx,cex=1.2)
> plot(hy,labels=na,cex=0.9)
> # show matrix
> image(seq(along=hx$order),seq(along=hy$order),
+ scale(x)[hx$order,rev(hy$order)],
+ col=heat.colors(60),axes=F,xlab="",ylab="")
> axis(1,seq(along=hx$order),rownames(p$x)[hx$order],las=2)
> axis(2,seq(along=hy$order),rownames(p$y)[rev(hy$order)],las=2)
```



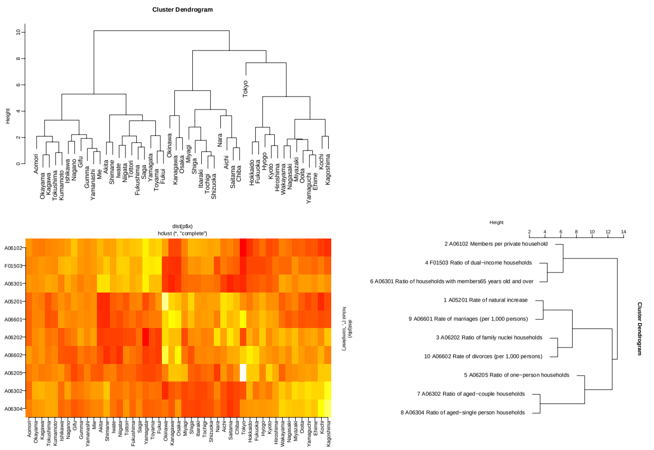
20



21



22



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回帰分析

- データ解析で最も利用頻度の高い分析法
- 重回帰 ＝ multiple regression
- 従属変数yと独立変数$x_1, x_2, \ldots, x_m$の関係を推定

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_m x_m + \epsilon$$

- 係数β_iがyとx_iの関係を表す

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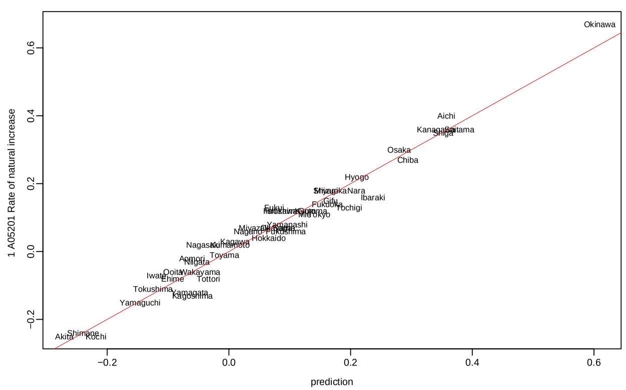
重回帰分析の関数

```
mylsfit <- function(x,y) {
  ...
  sx <- mysvd(x)
  coef <- sx$v %*% (1/sx$d * (t(sx$u) %*% y))
  ...
  ypred <- x %*% coef
  resid <- y - ypred
  ...
  list(coefficients=coef,residuals=resid,pred=ypred,...)
}

> f <- mylsfit(x[,-1],x[,1])
> myplot(f$pred,x[,1],xlab="prediction",ylab=na[1],cex=0.8)
> abline(0,1,col=2,lwd=0.5)
```

25



26

```
> round(f$tsummary,3)
, , = Y

            Estimate Std.Err t-value Pr(>|t|)
  Intercept   -7.887   1.334  -5.913    0.000
  A06102       1.691   0.192   8.808    0.000
  A06202       0.024   0.010   2.553    0.015
  F01503       0.003   0.003   0.978    0.334
  A06205       0.056   0.013   4.359    0.000
  A06301      -0.022   0.009  -2.335    0.025
  A06302       0.051   0.017   2.992    0.005
  A06304      -0.010   0.016  -0.599    0.553
  A06601       0.107   0.027   3.984    0.000
  A06602       0.108   0.043   2.521    0.016
```

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サンプルセッション２

```
> ### randomly selecting items
> a0 <- X2000$code[grep("^.$",X2000$clab)]  # indices
> a0
 [1] "A01101"   "A01601"   "A0160101" "A0160102" "A0160103" "A01201"
 [7] "A01202"   "A01302"   "A01401"   "A01402"   "A02101"   "A02102"
[13] "A02103"   "A02104"   "A03101"   "A03102"   "A03103"   "A03401"
[19] "A03402"   "A03403"   "A03404"   "A0410301" "A0410302" "A0410401"
[25] "A0410402" "A0410501" "A0410502" "A0410601" "A0410602" "A0410701"
[31] "A0410702" "A0410801" "A0410802" "A0430701" "A0430702" "A0440501"
[37] "A0440502" "A0440601" "A0440602" "A05101"   "A05201"   "A05202"
[43] "A05203"   "A05204"   "A0520401" "A0520402" "A05205"   "A05218"
[49] "A0521901" "A0521902" "A05301"   "A05302"   "A05303"   "A05304"
[55] "A05305"   "A0610101" "A06102"   "A06202"   "F01503"   "A06205"
[61] "A06301"   "A06302"   "A06304"   "A06601"   "A06602"   "B01101"
[67] "B01202"   "B01205"   "B01204"   "B01301"   "B01401"   "B0140101"
[73] "B0140102" "B0140103" "B02101"   "B02102"   "B02103"   "B02201"
[79] "B02401"   "B02402"   "B02301"   "B02303"   "B02304"   "C01301"
```

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```
 [85] "C01101"   "C01105"   "C01106"   "C01107"   "C02102"   "C02103"
 [91] "C02201"   "C02205"   "C03201"   "C03205"   "C03303"   "C0330303"
 [97] "C03304"   "C0330408" "C0410101" "C04105"   "C04106"   "C0410701"
[103] "C04401"   "C04404"   "C04505"   "C04507"   "C04601"   "C0460101"
[109] "C04602"   "L04201"   "L04203"   "L04101"   "L04102"   "L04104"
[115] "L04105"   "L04106"   "L04107"   "L04108"   "L04109"   "L04110"
[121] "L04111"   "L04112"   "L04113"   "L04302"   "L04304"   "D0110101"
[127] "D01102"   "D0120101" "D0130201" "D01401"   "D0140201" "D0140301"
[133] "D0210101" "D0210201" "D0210301" "D0220103" "D02202"   "D02204"
[139] "D02206"   "D02207"   "D0310301" "D0310401" "D0310501" "D0310601"
[145] "D0310701" "D0310801" "D0310901" "D0311001" "D0311101" "D0311201"
[151] "D03113"   "D03114"   "D0311501" "D0312301" "D0320101" "D0320201"
[157] "D0320301" "D0330103" "D0330203" "D0330303" "D0330403" "D0330503"
[163] "D0330603" "D0330703" "D0331103" "D03312"   "D03313"   "D0331403"
[169] "D0332003" "D0332103" "D0331503" "D0331603" "D0331703" "D0331803"
[175] "D0331903" "E0110101" "E0110102" "E0110103" "E0110104" "E0110105"
[181] "E0110201" "E0110202" "E0110203" "E01303"   "E01304"   "E01305"
[187] "E0210101" "E0210102" "E0210103" "E02601"   "E02602"   "E02603"
[193] "E02701"   "E02702"   "E02703"   "E0410201" "E0410202" "E0510301"
```

```
[199] "E0510302" "E0510303" "E0510304" "E0510305" "E05203"   "E05204"
[205] "E05205"   "E0610101" "E0610102" "E0610201" "E0610202" "E0620401"
[211] "E0620402" "E0620403" "E08101"   "E08102"   "E08201"   "E08202"
[217] "E0910101" "E0910102" "E0910402" "E09211"   "E09212"   "I0821101"
[223] "I0821102" "E09213"   "E09214"   "E09401"   "E09402"   "E0940302"
[229] "E09501"   "E09502"   "E09503"   "E09504"   "F0110101" "F0110102"
[235] "F01201"   "F01202"   "F01203"   "F01301"   "F0130101" "F0130102"
[241] "F02301"   "F02501"   "F0260101" "F02701"   "F02702"   "F03101"
[247] "F03102"   "F03103"   "F03104"   "F0320101" "F03303"   "F03302"
[253] "F03301"   "F03304"   "F03401"   "F03403"   "F03402"   "F0350101"
[259] "F0350201" "F03601"   "F03602"   "F04101"   "F04102"   "F04103"
[265] "F04104"   "F05101"   "F0610101" "F0610102" "F0620101" "F0620102"
[271] "F06204"   "F0620301" "F0620302" "F0620303" "F0620304" "G01101"
[277] "G01104"   "G01107"   "G01109"   "G01115"   "G01202"   "G01311"
[283] "G01313"   "G01314"   "G01315"   "G01316"   "G01317"   "G03201"
[289] "G03203"   "G0320501" "G03207"   "G04101"   "G04211"   "G04306"
[295] "G04307"   "G05102"   "G0430501" "H01301"   "H01302"   "H0130202"
[301] "H01204"   "H01601"   "H01603"   "H01401"   "H01402"   "H01403"
[307] "H02104"   "H0210301" "H0210302" "H0210701" "H0210703" "H02101"
```

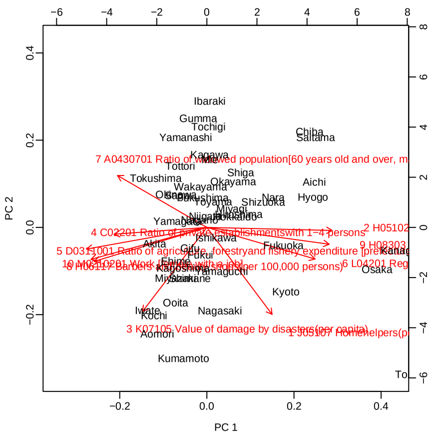
```
[313] "H0210101" "H0210102" "H0220301" "H0220302" "H0210201" "H0210202"
[319] "H02302"   "H02303"   "H02601"   "H04101"   "H04102"   "H04301"
[325] "H05102"   "H05201"   "H05304"   "H05306"   "H0540101" "H05503"
[331] "H05504"   "H05601"   "H06101"   "H06103"   "H06105"   "H06107"
[337] "H06109"   "H06111"   "H06113"   "H0611302" "H06125"   "H06117"
[343] "H06119"   "H06121"   "H06302"   "H06309"   "H06305"   "H06306"
[349] "H06307"   "H06401"   "H06402"   "H06406"   "H06408"   "H06412"
[355] "H06501"   "H0650101" "H0650102" "H03101"   "H07201"   "H0720202"
[361] "H0720201" "H0720204" "H0720203" "H0720205" "H0720206" "H08101"
[367] "H08301"   "H08302"   "H08303"   "H08304"   "I04105"   "I04104"
[373] "I04102"   "I04103"   "I0420102" "I0420103" "I0420202" "I0420203"
[379] "I05101"   "I0520101" "I0520102" "I0520201" "I0520202" "I0520501"
[385] "I0520502" "I06101"   "I06102"   "I06103"   "I06104"   "I06105"
[391] "I06106"   "I06201"   "I07101"   "I07102"   "I07103"   "I07104"
[397] "I07105"   "I07201"   "I0210101" "I0210102" "I0210103" "I0210104"
[403] "I0210105" "I0210106" "I0210201" "I0210202" "I0210203" "I0210204"
[409] "I0210205" "I0210206" "I0910103" "I0910105" "I0910106" "I0910107"
[415] "I0910203" "I0910205" "I0920101" "I0920201" "I0920301" "I0930201"
[421] "I0930301" "I09401"   "I09402"   "I0950102" "I0950103" "I0950104"
```

```
[427] "I10101"   "I10102"   "I10103"   "I10104"   "I10105"   "I10201"
[433] "I10202"   "I10203"   "I10204"   "I10205"   "I11101"   "I11102"
[439] "I11201"   "I12201"   "I13102"   "I13207"   "I13201"   "I13402"
[445] "I14101"   "I14102"   "I14201"   "I14202"   "J01101"   "J01107"
[451] "J0110803" "J0110804" "J0110902" "J01200"   "J02101"   "J02201"
[457] "J02204"   "J02202"   "J02203"   "J02301"   "J02401"   "J02501"
[463] "J03101"   "J03201"   "J03202"   "J03203"   "J03301"   "J03401"
[469] "J03501"   "J04101"   "J04102"   "J04201"   "J04202"   "J04203"
[475] "J04204"   "J04301"   "J04302"   "J04401"   "J04402"   "J05101"
[481] "J05102"   "J05103"   "J05107"   "J05201"   "J05202"   "J05203"
[487] "J05206"   "J05204"   "J05207"   "J0610101" "J0610102" "I15101"
[493] "I15102"   "I15103"   "I15202"   "I1520301" "I1520302" "I1520401"
[499] "I1520402" "F07101"   "F07102"   "F08101"   "F08102"   "F08201"
[505] "F08202"   "K01102"   "K01104"   "K01105"   "K01107"   "K01301"
[511] "K01302"   "K01401"   "K01402"   "K02101"   "K02103"   "K02203"
[517] "K02205"   "K02301"   "K02303"   "K02306"   "K03102"   "K03104"
[523] "K03112"   "K04102"   "K04101"   "K04105"   "K04106"   "K04107"
[529] "K04201"   "K04202"   "K04301"   "K05102"   "K05103"   "K06101"
[535] "K06104"   "K06201"   "K06204"   "K06401"   "K06402"   "K06403"
```

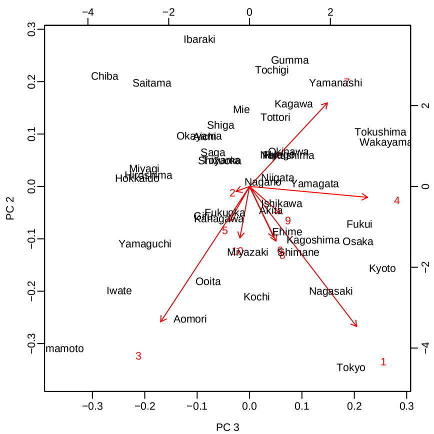
```
[541] "K06405"   "K06301"   "K06304"   "K06501"   "K06503"   "K07105"
[547] "K08101"   "K09201"   "K10101"   "K10105"   "K10107"   "K10201"
[553] "K10203"   "K10301"   "K10304"   "K10305"   "K10401"   "K10403"
[559] "K10501"   "K10502"   "K10503"   "L01201"   "L01204"   "L02602"
[565] "L02201"   "L02401"   "L02402"   "L02403"   "L02404"   "L02405"
[571] "L02406"   "L02407"   "L02408"   "L02409"   "L02410"   "L02734"
[577] "L02735"   "L02736"   "L01100"   "L0110101" "L0110102" "L02601"
[583] "L02101"   "L02301"   "L03201"   "L03212"   "L03213"   "L03214"
[589] "L03401"   "L03412"   "L03602"   "L03603"   "L03604"   "L03606"
[595] "L03607"   "M01101"   "M01102"   "M0120106" "M0120206" "M0120107"
[601] "M0120207" "M0130106" "M0130206" "M0130107" "M0130207" "M0210101"
[607] "M0210201" "M0310101" "M0310201" "M0310102" "M0310202" "M0330101"
[613] "M0330201" "M0330102" "M0330202"
> a <- sample(a0,10)  # randomly select 10 items
> a
 [1] "I07104"   "K06401"   "E0610202" "F07102"   "E09502"   "D03113"
 [7] "L01100"   "J02301"   "D0331803" "I0950103"
> a <- sample(a0,10)  # randomly select 10 items again
> a
```

```
 [1] "J05107"   "H05102"   "K07105"   "C02201"   "D0311001" "L04201"
 [7] "A0430701" "H06117"   "H08303"   "M0210201"
> na <- paste(seq(along=a),a,X2000$item[a])
> na
 [1] "1 J05107 Homehelpers(per 100,000 persons) "
 [2] "2 H05102 Ratio of households coveredby city gas supply system "
 [3] "3 K07105 Value of damage by disasters(per capita) "
 [4] "4 C02201 Ratio of private establishmentswith 1-4 persons "
 [5] "5 D0311001 Ratio of agriculture, forestryand fishery expenditure [pref
 [6] "6 L04201 Regional difference index of consumerprices [general : ku-area
 [7] "7 A0430701 Ratio of widowed population[60 years old and over, male] "
 [8] "8 H06117 Barbers and beauty shops(per 100,000 persons) "
 [9] "9 H08303 Neighborhood parksper inhabitable area 100k "
[10] "10 M0210201 Work [female with a job]  "
> jna <- paste(seq(along=a),a,X2000$jitem[a])
> jna
 [1] "1 J05107 訪問介護員（ホームヘルパー）数（人口10万人当たり） "
 [2] "2 H05102 都市ガス供給区域内世帯比率  "
 [3] "3 K07105 災 害 被 害 額（人口１人当たり） "
```

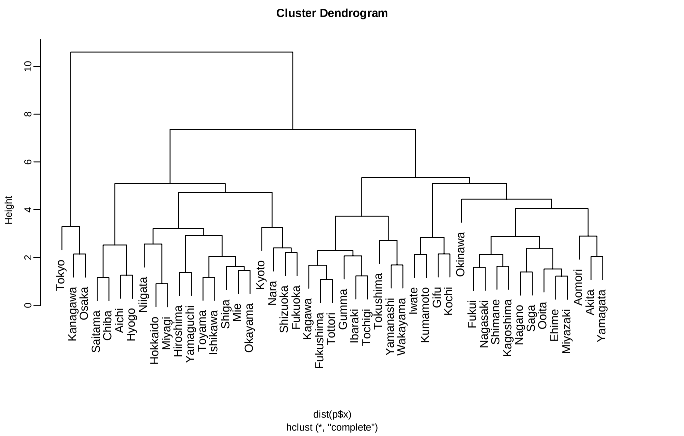
```
 [4] "4 C02201 従業者１～４人の事業所割合［民　営］ "
 [5] "5 D0311001 農 林 水 産 業 費 割 合［県財政］ "
 [6] "6 L04201 消費者物価地域差指数［総合：東京都区部＝100］ "
 [7] "7 A0430701 死 別 者 割 合［60歳以上・男］ "
 [8] "8 H06117 理 容 ・ 美 容 所 数（人口10万人当たり） "
 [9] "9 H08303 近 隣 公 園 数（可住地面積100k 当たり） "
[10] "10 M0210201 仕 事 の 平 均 時 間［有業者・女］ "
> x <- X2000$x[,a]
> dim(x)
[1] 47 10
>
```

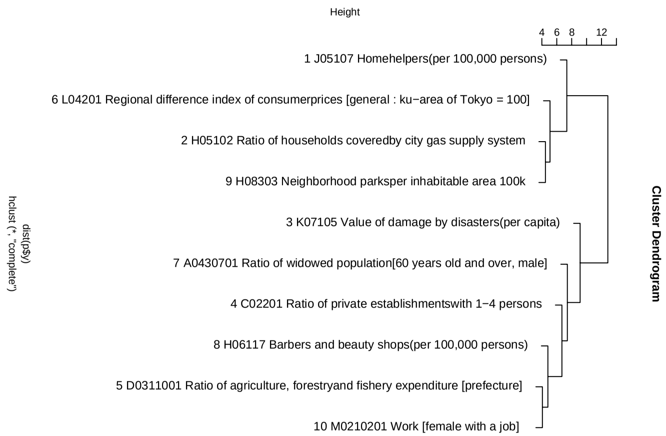


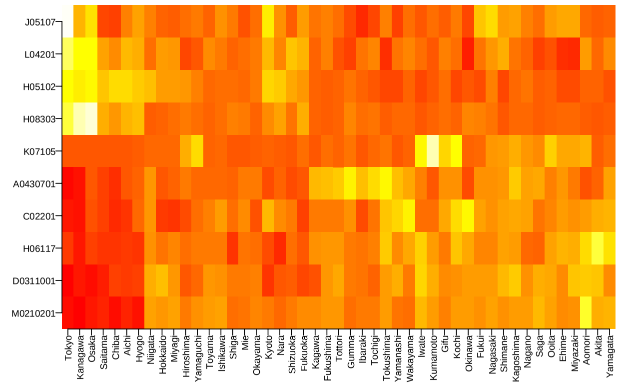
1 J05107 訪問介護員数／10万人
2 H05102 都市ガス供給率
3 K07105 災害被害額/人口
4 C02201 従業者1～4人の事業所
5 D0311001 農林水産業費割合
6 L04201 消費者物価地域差指数
7 A0430701 死別者割合60歳以上男
8 H06117 理容・美容所数/10万人
9 H08303 近隣公園数/可住地面積
10 M0210201 仕事時間 有業者・女

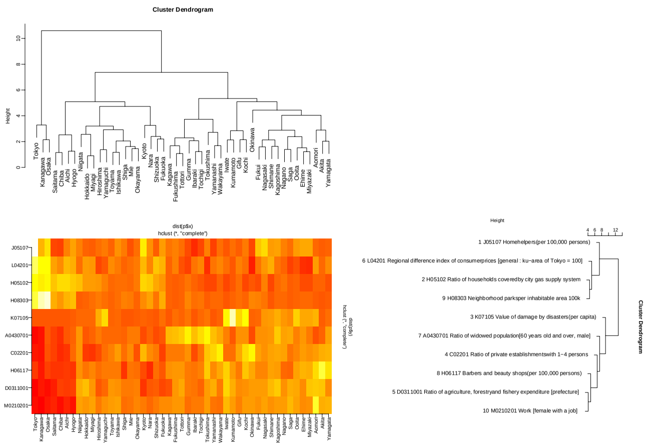


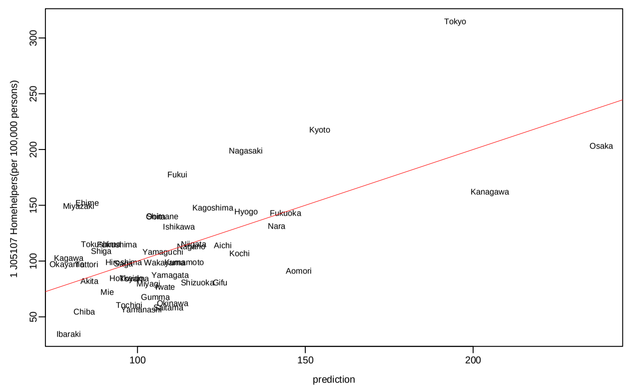
1 J05107 訪問介護員数／10万人
2 H05102 都市ガス供給率
3 K07105 災害被害額/人口
4 C02201 従業者1～4人の事業所
5 D0311001 農林水産業費割合
6 L04201 消費者物価地域差指数
7 A0430701 死別者割合60歳以上男
8 H06117 理容・美容所数/10万人
9 H08303 近隣公園数/可住地面積
10 M0210201 仕事時間 有業者・女












```
> round(f$tsummary,3)
, , = Y

           Estimate Std.Err t-value Pr(>|t|)
 Intercept -1092.573 522.218  -2.092    0.043
 H05102        0.458   0.600   0.764    0.450
 K07105        0.001   0.000   1.259    0.216
 C02201        4.757   3.484   1.365    0.180
 D0311001      0.411   2.963   0.139    0.891
 L04201        5.493   4.361   1.259    0.216
 A0430701      6.486  13.400   0.484    0.631
 H06117       -0.048   0.170  -0.283    0.778
 H08303        7.267   2.901   2.505    0.017
 M0210201     53.139  40.318   1.318    0.196
```


サンプルセッション３

```
> ### values
> ##  character, numeric, and NA types
> "hello"
[1] "hello"
> 123/456
[1] 0.2697368
> sqrt(3/4)
[1] 0.8660254
> sin(pi/3)
[1] 0.8660254
> 1==2
[1] FALSE
> 1==1
[1] TRUE
> 1/0   # infinity
[1] Inf
> sqrt(-1)   # not a number
```

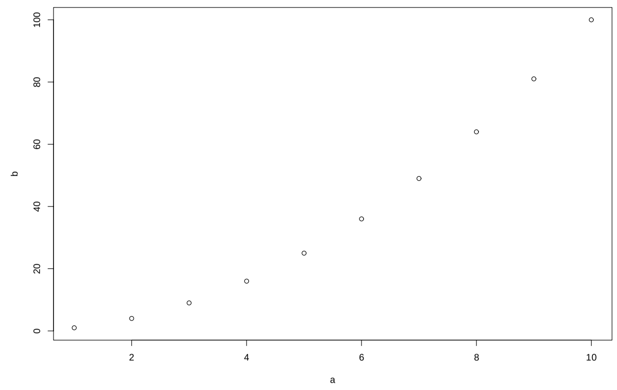


```
[1] NaN
Warning message:
NaNs produced in: sqrt(-1)
> sin(NA)   # not available
[1] NA
> ## vector
> c(1,3,2,4)
[1] 1 3 2 4
> 10:20
 [1] 10 11 12 13 14 15 16 17 18 19 20
> 30:20
 [1] 30 29 28 27 26 25 24 23 22 21 20
> seq(0,10,0.1)   # sequence from 0 to 10 increasing by 0.1
  [1]  0.0  0.1  0.2  0.3  0.4  0.5  0.6  0.7  0.8  0.9  1.0  1.1  1.2  1.3
 [16]  1.5  1.6  1.7  1.8  1.9  2.0  2.1  2.2  2.3  2.4  2.5  2.6  2.7  2.8
 [31]  3.0  3.1  3.2  3.3  3.4  3.5  3.6  3.7  3.8  3.9  4.0  4.1  4.2  4.3
 [46]  4.5  4.6  4.7  4.8  4.9  5.0  5.1  5.2  5.3  5.4  5.5  5.6  5.7  5.8
 [61]  6.0  6.1  6.2  6.3  6.4  6.5  6.6  6.7  6.8  6.9  7.0  7.1  7.2  7.3
 [76]  7.5  7.6  7.7  7.8  7.9  8.0  8.1  8.2  8.3  8.4  8.5  8.6  8.7  8.8
```

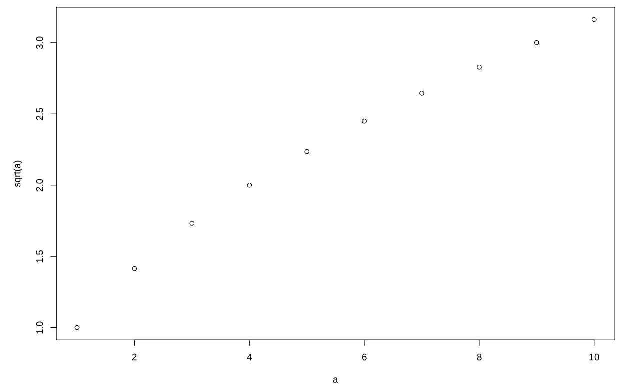
```
 [91]  9.0  9.1  9.2  9.3  9.4  9.5  9.6  9.7  9.8  9.9 10.0
> a <- 10:20
> length(a)   # length of vector
[1] 11
> seq(along=a)
 [1]  1  2  3  4  5  6  7  8  9 10 11
> seq(from=1,to=length(a))
 [1]  1  2  3  4  5  6  7  8  9 10 11
> 1:length(a)
 [1]  1  2  3  4  5  6  7  8  9 10 11
> help(seq)  # show the help message for the function "seq"
> rep(3,10) # replicate elements
 [1] 3 3 3 3 3 3 3 3 3 3
> rep(c(3,4),c(10,20))
 [1] 3 3 3 3 3 3 3 3 3 3 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4 4
> abc <- c("abc","def","ghi","hello")
> rep(abc,1:4)
 [1] "abc"   "def"   "def"   "ghi"   "ghi"   "ghi"   "hello" "hello" "hello"
[10] "hello"
```

```
> help(rep)
> ### variables
> ## simple assignment
> a <- 1
> a
[1] 1
> a <- 1:10
> a
 [1]  1  2  3  4  5  6  7  8  9 10
> a^2
 [1]   1   4   9  16  25  36  49  64  81 100
> b <- a*a
> b
 [1]   1   4   9  16  25  36  49  64  81 100
```

```
> plot(a,b)
```



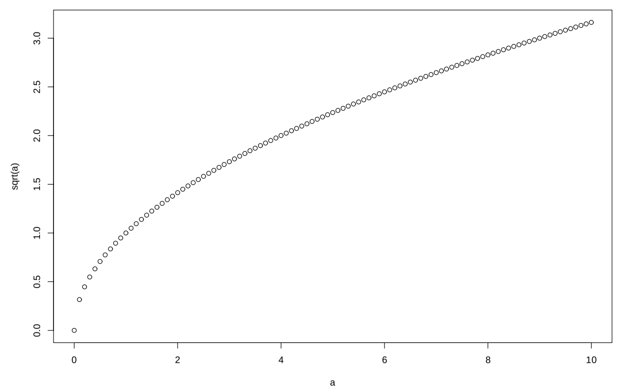

```
> plot(a,sqrt(a))
```



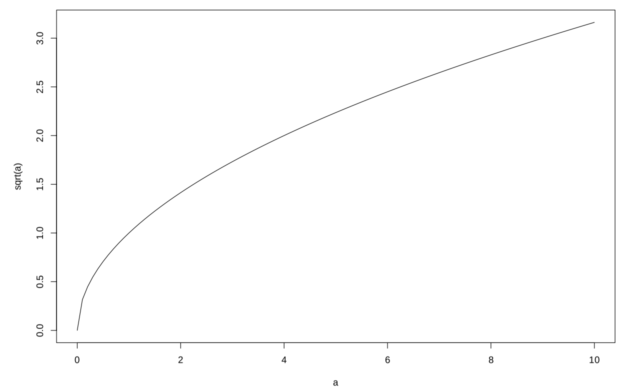

```
> a <- seq(0,10,0.1)
> plot(a,sqrt(a))
> plot(a,sqrt(a),type="l")
```



```
> plot(a,sqrt(a))
```




```
> plot(a,sqrt(a),type="l")
```




```
> abc <- c("abc","def","ghi","hello")
> abc
[1] "abc"   "def"   "ghi"   "hello"
> ## output postscript file
> options(papersize="a4")
> a <- 1:10
> b <- a*a
> postscript("ex01pt1.eps")
> plot(a,b)
> dev.off()
X11
  2
> postscript("ex01pt2.eps")
> plot(a,sqrt(a))
> dev.off()
X11
  2
> a <- seq(0,10,0.1)
> plot(a,sqrt(a))
```



```
> postscript("ex01pt3.eps")
> plot(a,sqrt(a))
> dev.off()
X11
  2
> postscript("ex01pt4.eps")
> plot(a,sqrt(a),type="l")
> dev.off()
X11
  2
> ## extract elements
> abc
[1] "abc"   "def"   "ghi"   "hello"
> abc[4]
[1] "hello"
> abc[1:3]
[1] "abc" "def" "ghi"
> abc[-1]
[1] "def"   "ghi"   "hello"
```

```
> abc[5]
[1] NA
> a <- 101:110
> a
 [1] 101 102 103 104 105 106 107 108 109 110
> a[1]
[1] 101
> a[10]
[1] 110
> a[11]
[1] NA
> a[-1]
[1] 102 103 104 105 106 107 108 109 110
> a[-(1:5)]
[1] 106 107 108 109 110
> a %% 2  # modulo by 2
 [1] 1 0 1 0 1 0 1 0 1 0
> a %% 2 == 0  # even numbers
 [1] FALSE  TRUE FALSE  TRUE FALSE  TRUE FALSE  TRUE FALSE  TRUE
```

```
> a[ a%%2==0 ]
[1] 102 104 106 108 110
> a[ a%%2==1 ]
[1] 101 103 105 107 109
> a >= 105
 [1] FALSE FALSE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE  TRUE
> a[ a>=105 ]
[1] 105 106 107 108 109 110
> ## matrix
> a <- matrix(1:6,3,2)  # matrix of size 3 x 2 with elements 1:6
> a
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
> dim(a)  # dimensions
[1] 3 2
> t(a)  # matrix transpose
     [,1] [,2] [,3]
```

```
[1,]    1    2    3
[2,]    4    5    6
> t(a) %*% a  # multiplication
     [,1] [,2]
[1,]   14   32
[2,]   32   77
> a %*% t(a)
     [,1] [,2] [,3]
[1,]   17   22   27
[2,]   22   29   36
[3,]   27   36   45
> a <- matrix(1:4,2,2)  # matrix of size 2 x 2 with elements 1:4
> a
     [,1] [,2]
[1,]    1    3
[2,]    2    4
> b <- solve(a)  # inverse matrix
> b
     [,1] [,2]
```

```
[1,]   -2  1.5
[2,]    1 -0.5
> a %*% b  # should be identity matrix
             [,1]          [,2]
[1,] 1.000000e+00 -5.551115e-17
[2,] 4.440892e-16  1.000000e-00
> round(a%*%b, 6)  # show results with 6 digits
     [,1] [,2]
[1,]    1    0
[2,]    0    1
> b %*% a
     [,1]         [,2]
[1,]    1 4.440892e-16
[2,]    0 1.000000e-00
> a * a  # element-wize multiplication
     [,1] [,2]
[1,]    1    9
[2,]    4   16
> a %*% a  # matrix multiplication
```

```
     [,1] [,2]
[1,]    7   15
[2,]   10   22
> sin(a)  # element-wise sin()
          [,1]       [,2]
[1,] 0.8414710  0.1411200
[2,] 0.9092974 -0.7568025
> a %% 2 == 0
      [,1]  [,2]
[1,] FALSE FALSE
[2,]  TRUE  TRUE
> a[a %% 2 == 0]  # result becomes a vector
[1] 2 4
> ## more on matrix
> a <- matrix(1:20,4)  # matrix of size 4 x 5
> a
     [,1] [,2] [,3] [,4] [,5]
[1,]    1    5    9   13   17
[2,]    2    6   10   14   18
```

```
[3,]    3    7   11   15   19
[4,]    4    8   12   16   20
> a[3,]  # the third row
[1]  3  7 11 15 19
> a[,3]  # the third column
[1]  9 10 11 12
> a[2:3,]  # the second and third rows
     [,1] [,2] [,3] [,4] [,5]
[1,]    2    6   10   14   18
[2,]    3    7   11   15   19
> a[,2:3]  # the second and third columns
     [,1] [,2]
[1,]    5    9
[2,]    6   10
[3,]    7   11
[4,]    8   12
> a[3,,drop=F]  # the third row as matrix
     [,1] [,2] [,3] [,4] [,5]
[1,]    3    7   11   15   19
```

```
> a[,3,drop=F]  # the third column as matrix
     [,1]
[1,]    9
[2,]   10
[3,]   11
[4,]   12
> ### names and dimnames
> ## vector
> a <- 10:15
> a
[1] 10 11 12 13 14 15
> names(a) <- c("ten","eleven","twelve","thirteen","fourteen","fifteen")
> a
     ten   eleven   twelve thirteen fourteen  fifteen
      10       11       12       13       14       15
> names(a)
[1] "ten"      "eleven"   "twelve"   "thirteen" "fourteen" "fifteen"
> a[2]
eleven
```

```
    11
> a["eleven"]
eleven
    11
> a[2:3]
eleven twelve
    11     12
> a[c("eleven","twelve")]
eleven twelve
    11     12
> b <- names(a)
> b[a>=13]
[1] "thirteen" "fourteen" "fifteen"
> b[a%%2==0]
[1] "ten"      "twelve"   "fourteen"
> ## matrix
> a <- matrix(1:6,3)  # matrix of size 3 x 2
> a
     [,1] [,2]
```

```
[1,]    1    4
[2,]    2    5
[3,]    3    6
> rownames(a) <- c("one","two","three")
> a
      [,1] [,2]
one      1    4
two      2    5
three    3    6
> colnames(a) <- c("ichi","ni")
> a
      ichi ni
one      1  4
two      2  5
three    3  6
> rownames(a)
[1] "one"   "two"   "three"
> colnames(a)
[1] "ichi" "ni"
```

```
> dimnames(a)
[[1]]
[1] "one"   "two"   "three"

[[2]]
[1] "ichi" "ni"

> a[,"ni"]
  one   two three
    4     5     6
> a["two",]
ichi   ni
   2    5
> ### list
> a <- list(1:10,abc)
> a
[[1]]
 [1]  1  2  3  4  5  6  7  8  9 10
```

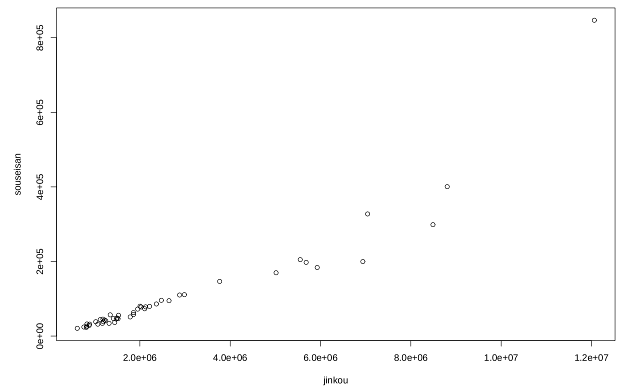
```
[[2]]
[1] "abc"   "def"   "ghi"   "hello"

> a[[1]]
 [1]  1  2  3  4  5  6  7  8  9 10
> a[[2]]
[1] "abc"   "def"   "ghi"   "hello"
> a <- list(suji=1:10,moji=abc)
> a
$suji
 [1]  1  2  3  4  5  6  7  8  9 10

$moji
[1] "abc"   "def"   "ghi"   "hello"

> a$suji
 [1]  1  2  3  4  5  6  7  8  9 10
> a$moji
[1] "abc"   "def"   "ghi"   "hello"
```

```
> ### simple analysis
> ## load a sample dataset
> source("~shimo/class/gakubu200209/data20020919c.R")
> x
            jinkou souseisan
Hokkaido   5683062    197473
Aomori     1475728     45620
Iwate      1416180     46949
Miyagi     2365320     86155
Akita      1189279     38414
Yamagata   1244147     41119
Fukushima  2126935     78345
Ibaraki    2985676    110819
Tochigi    2004817     79962
Gumma      2024852     77960
Saitama    6938006    199636
Chiba      5926285    183721
Tokyo     12064101    846809
Kanagawa   8489974    298661
```

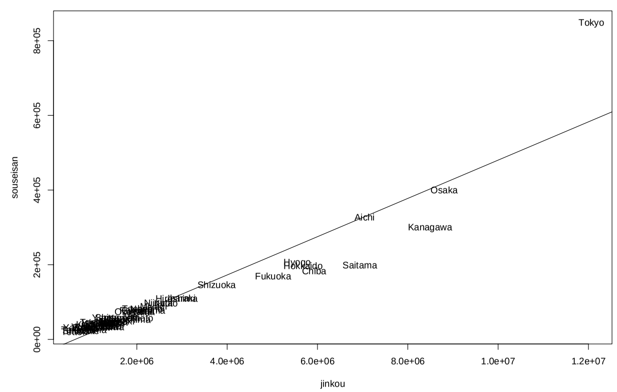
```
Niigata    2475733     95874
Toyama     1120851     44087
Ishikawa   1180977     45230
Fukui       828944     32426
Yamanashi   888172     31981
Nagano     2215168     79508
Gifu       2107700     73078
Shizuoka   3767393    146616
Aichi      7043300    327476
Mie        1857339     62717
Shiga      1342832     56815
Kyoto      2644391     94863
Osaka      8805081    400519
Hyogo      5550574    204939
Nara       1442795     36523
Wakayama   1069912     31854
Tottori     613289     20817
Shimane     761503     24100
Okayama    1950828     72200
```

```
Hiroshima  2878915    110162
Yamaguchi  1527964     55796
Tokushima   824108     26357
Kagawa     1022890     38295
Ehime      1493092     48146
Kochi       813949     23417
Fukuoka    5015699    169834
Saga        876654     28484
Nagasaki   1516523     46426
Kumamoto   1859344     57580
Ooita      1221140     42965
Miyazaki   1170007     34026
Kagoshima  1786194     51166
Okinawa    1318220     34249
> x["Tokyo",]
   jinkou souseisan
 12064101    846809
> x[,"jinkou"]
 Hokkaido    Aomori     Iwate    Miyagi     Akita  Yamagata Fukushima   Ibara
```

```
  5683062   1475728   1416180   2365320   1189279   1244147   2126935   29856
  Tochigi     Gumma   Saitama     Chiba     Tokyo  Kanagawa   Niigata    Toya
  2004817   2024852   6938006   5926285  12064101   8489974   2475733   11208
 Ishikawa     Fukui Yamanashi    Nagano      Gifu  Shizuoka     Aichi       M
  1180977    828944    888172   2215168   2107700   3767393   7043300   18573
    Shiga     Kyoto     Osaka     Hyogo      Nara  Wakayama   Tottori   Shima
  1342832   2644391   8805081   5550574   1442795   1069912    613289    7615
  Okayama Hiroshima Yamaguchi Tokushima    Kagawa     Ehime     Kochi   Fukuo
  1950828   2878915   1527964    824108   1022890   1493092    813949   50156
     Saga  Nagasaki  Kumamoto     Ooita  Miyazaki Kagoshima   Okinawa
   876654   1516523   1859344   1221140   1170007   1786194   1318220
> ## plot and fitting
> plot(x)  # simple plot
```




```
> plot(x,type="n")  # draw only frame
> text(x,rownames(x)) # draw labels
> f <- lsfit(x[,1],x[,2])  # least square fitting (kaiki-bunseki)
> abline(f)  # draw a fitted line
```

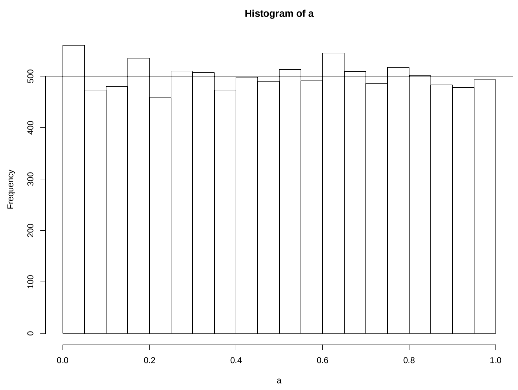




```
> ## calculate statistics
> mean(x[,1])
[1] 2700550
> mean(x[,2])
[1] 105961.0
> apply(x,2,mean)
   jinkou souseisan
2700549.9  105961.0
> ## output postscript file
> postscript("ex01rg1.eps")
> plot(x)
> dev.off()
X11
  2
> postscript("ex01rg2.eps")
> plot(x,type="n")  # draw only frame
> text(x,rownames(x)) # draw labels
> abline(f)  # draw a fitted line
> dev.off()
```

```
> ### random number generation
> a <- runif(100)  # uniform distribution on (0,1)
> a
  [1] 0.33772072 0.95523453 0.11471802 0.45899514 0.25807340 0.91897002
  [7] 0.19894305 0.71841781 0.17071827 0.58036916 0.72244387 0.30885956
 [13] 0.39961291 0.44603197 0.49604300 0.08504009 0.02123887 0.71410722
 [19] 0.42955228 0.44309812 0.64121792 0.95145627 0.38858641 0.96265811
 [25] 0.29707709 0.04824197 0.29456821 0.45555714 0.43653072 0.09194056
 [31] 0.96184772 0.23232472 0.99816295 0.87468042 0.59191003 0.58080336
 [37] 0.75491096 0.15443375 0.13984498 0.51942845 0.68094018 0.91656951
 [43] 0.87344172 0.28951874 0.20323800 0.44015944 0.20591796 0.80711408
 [49] 0.30058366 0.70400184 0.15151447 0.36760816 0.87091817 0.90298059
 [55] 0.36557006 0.70513375 0.93172830 0.04053871 0.78096573 0.33618138
 [61] 0.17551581 0.49283572 0.47098055 0.85567305 0.42323136 0.42056184
 [67] 0.45873132 0.84085186 0.67309793 0.14937437 0.37588200 0.61308521
 [73] 0.27323279 0.15935226 0.07312308 0.26750706 0.31644778 0.50176397
 [79] 0.55026224 0.37149845 0.94189514 0.10848281 0.73368034 0.22186991
 [85] 0.45946215 0.80568116 0.41801127 0.46940970 0.71094321 0.91322983
 [91] 0.35198930 0.65997991 0.74573909 0.17367779 0.03160446 0.35358868
```

```
 [97] 0.39337573 0.75346727 0.02309114 0.91162517
> hist(a)
> a <- runif(1000)
> hist(a)
> a <- runif(10000)
> mean(a)
[1] 0.5010653
> var(a)
[1] 0.08278935
> a <- runif(10000)
> mean(a)
[1] 0.4979175
> var(a)
[1] 0.08332883
> hist(a)
> abline(h=500)
> postscript("ex01unif.eps")
> hist(a)
> abline(h=500)
```

```
> dev.off()
X11
  2
```




```
> a <- rnorm(100)  # normal distribution with mean 0 and varianc 1
> a
  [1] -0.82691765 -2.02067099  0.19400892 -0.30382863 -0.31811388 -0.77346330
  [7] -0.40153550  2.41079419  0.60562417 -0.97393404 -1.23733634  0.85196384
 [13] -0.60534823 -0.77889770 -0.07444445  2.66534621 -0.83451795  0.45235685
 [19] -0.10990285  1.08580316 -0.74960909  0.40406038  0.60829232  1.45375506
 [25]  0.75997487 -1.20344286 -0.85792115 -0.15464927  0.15831217  0.08548434
 [31]  0.50799391 -1.80017291  0.88274744 -1.15015568  0.01921664  2.05726484
 [37]  0.37508515 -0.49540912 -0.92401419  0.38382362  0.27878916 -1.00021783
 [43] -0.63664893  0.69261984 -0.32744108  0.01033082 -0.50170459  1.24632212
 [49]  1.52279633 -0.49338017  0.68571754 -0.70039005 -0.25592276 -1.85568359
 [55]  0.99690176  0.98597080  0.51932234  2.18836775  0.12552985  0.46521986
 [61] -1.33403257 -0.89277524  1.32653428 -0.35091993 -0.37484179  0.40620331
 [67]  1.42748708  0.65026413  0.42211847  1.34728761 -0.30578058  0.53137451
 [73]  0.15892649 -0.35528093  1.53916414  1.65100974  0.70355433  0.56355801
 [79] -0.24340207 -0.44164793  0.73611704  1.18361392 -0.87211264  1.08447142
 [85] -0.57204720  1.17112253 -0.50147376 -0.32345874  2.00594036  0.68166394
 [91] -0.65396266  0.24280340  0.89660829 -0.19244041  0.91239919  0.13789878
 [97] -1.45605476 -1.66931721 -0.66200807 -2.32467900
```



```
> hist(a)
> a <- rnorm(1000)
> hist(a)
> a <- rnorm(10000)
> hist(a)
> mean(a)
[1] -0.005828347
> var(a)
[1] 0.992512
> b <- seq(-4,4,length=100)
> lines(b,dnorm(b)*0.5*10000)
> postscript("ex01norm.eps")
> hist(a)
> lines(b,dnorm(b)*0.5*10000)
> dev.off()
X11
  2
```


```
> ### function
> foo <- function(x) x*x
> foo
function(x) x*x
> foo(5)
[1] 25
> foo(1:10)
 [1]   1   4   9  16  25  36  49  64  81 100
> goo <- function(x,y) x*y
> goo(3,5)
[1] 15
> goo(1:10,2)
 [1]  2  4  6  8 10 12 14 16 18 20
> goo <- function(x,y=2) x*y
> goo(1:10,2)
 [1]  2  4  6  8 10 12 14 16 18 20
> goo(1:10)
 [1]  2  4  6  8 10 12 14 16 18 20
> foo <- function(x) {  # dont type the following "+" prompt marks
```



```
+ if(x > 0) y <- log(x)
+ else y <- log(-x)
+ y
+ }
> foo
function(x) {
if(x > 0) y <- log(x)
else y <- log(-x)
y
}
> foo(10)
[1] 2.302585
> foo(-5)
[1] 1.609438
> foo <- function(x) if(x>0) log(x) else log(-x)
> foo(-5)
[1] 1.609438
> foo <- function(x) log(abs(x))
> foo(-5)
```

```
[1] 1.609438
> ## end
> q()
Save workspace image? [y/n/c]: y

Process R finished at Fri Sep 20 00:47:40 2002
```