Class 8: PCA Mini Project

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It is important to consider scalling your data before analysis such as PCA. For example:

head(mtcars)

```
mpg cyl disp hp drat
                                          wt qsec vs am gear carb
Mazda RX4
                 21.0
                           160 110 3.90 2.620 16.46
                                                    0
Mazda RX4 Wag
                 21.0
                           160 110 3.90 2.875 17.02
                                                    0
Datsun 710
                 22.8
                        4 108 93 3.85 2.320 18.61
                                                                 1
Hornet 4 Drive
                 21.4
                        6
                           258 110 3.08 3.215 19.44 1 0
                                                                 1
                           360 175 3.15 3.440 17.02 0 0
                                                            3
                                                                 2
Hornet Sportabout 18.7
                        8
Valiant
                 18.1
                           225 105 2.76 3.460 20.22 1 0
                                                            3
```

apply(mtcars, 2, sd)

```
wt
      mpg
                   cyl
                               disp
                                             hp
                                                        drat
6.0269481
            1.7859216 123.9386938
                                     68.5628685
                                                   0.5346787
                                                                0.9784574
     qsec
                                           gear
                                                        carb
            0.5040161
                                                   1.6152000
1.7869432
                         0.4989909
                                      0.7378041
```

```
x<- scale(mtcars)
head(x)</pre>
```

```
mpgcyldisphpdratMazda RX40.1508848-0.1049878-0.57061982-0.53509280.5675137Mazda RX4 Wag0.1508848-0.1049878-0.57061982-0.53509280.5675137Datsun 7100.4495434-1.2248578-0.99018209-0.78304050.4739996Hornet 4 Drive0.2172534-0.10498780.22009369-0.5350928-0.9661175Hornet Sportabout-0.23073451.01488211.043081230.4129422-0.8351978
```

```
Valiant
                 -0.3302874 -0.1049878 -0.04616698 -0.6080186 -1.5646078
                           wt
                                    qsec
                                                vs
                                                            am
                                                                     gear
Mazda RX4
                 -0.610399567 -0.7771651 -0.8680278 1.1899014 0.4235542
Mazda RX4 Wag
                 -0.349785269 -0.4637808 -0.8680278 1.1899014 0.4235542
Datsun 710
                 -0.917004624 0.4260068 1.1160357 1.1899014 0.4235542
Hornet 4 Drive
                 -0.002299538 0.8904872 1.1160357 -0.8141431 -0.9318192
Hornet Sportabout 0.227654255 -0.4637808 -0.8680278 -0.8141431 -0.9318192
Valiant
                  0.248094592 1.3269868 1.1160357 -0.8141431 -0.9318192
                       carb
Mazda RX4
                  0.7352031
Mazda RX4 Wag
                  0.7352031
Datsun 710
                 -1.1221521
Hornet 4 Drive
                 -1.1221521
Hornet Sportabout -0.5030337
Valiant
                 -1.1221521
```

round(colMeans(x),2)

Key-point: It is usually always a good idea to scale your data before to PCA...

```
fna.data <- "WisconsinCancer.csv"
wisc.df <- read.csv(fna.data, row.names=1)
head(wisc.df)</pre>
```

	diagnosis	radius_mean	texture_mean	perimeter_mean	area_mean	
842302	M	17.99	10.38	122.80	1001.0	
842517	M	20.57	17.77	132.90	1326.0	
84300903	M	19.69	21.25	130.00	1203.0	
84348301	М	11.42	20.38	77.58	386.1	
84358402	М	20.29	14.34	135.10	1297.0	
843786	М	12.45	15.70	82.57	477.1	
	smoothness	_mean compac	ctness_mean co	oncavity_mean co	oncave.poin	ts_mean
842302	0.3	11840	0.27760	0.3001		0.14710
842517	0.0	08474	0.07864	0.0869		0.07017
84300903	0.3	10960	0.15990	0.1974		0.12790
84348301	0.3	14250	0.28390	0.2414		0.10520
84358402	0.3	10030	0.13280	0.1980		0.10430
843786	0.3	12780	0.17000	0.1578		0.08089

```
symmetry mean fractal dimension mean radius se texture se perimeter se
842302
                0.2419
                                        0.07871
                                                   1.0950
                                                               0.9053
                                                                              8.589
                                        0.05667
842517
                0.1812
                                                   0.5435
                                                               0.7339
                                                                              3.398
84300903
                0.2069
                                        0.05999
                                                   0.7456
                                                               0.7869
                                                                              4.585
84348301
                0.2597
                                        0.09744
                                                   0.4956
                                                               1.1560
                                                                              3.445
84358402
                0.1809
                                        0.05883
                                                   0.7572
                                                               0.7813
                                                                              5.438
843786
                0.2087
                                        0.07613
                                                   0.3345
                                                               0.8902
                                                                              2.217
         area_se smoothness_se compactness_se concavity_se concave.points_se
842302
          153.40
                       0.006399
                                        0.04904
                                                     0.05373
                                                                         0.01587
842517
           74.08
                       0.005225
                                                     0.01860
                                                                         0.01340
                                        0.01308
84300903
           94.03
                       0.006150
                                                                         0.02058
                                        0.04006
                                                     0.03832
84348301
           27.23
                       0.009110
                                        0.07458
                                                                         0.01867
                                                     0.05661
           94.44
84358402
                       0.011490
                                        0.02461
                                                     0.05688
                                                                         0.01885
843786
           27.19
                       0.007510
                                        0.03345
                                                                         0.01137
                                                     0.03672
         symmetry_se fractal_dimension_se radius_worst texture_worst
842302
             0.03003
                                  0.006193
                                                   25.38
                                                                  17.33
842517
             0.01389
                                  0.003532
                                                   24.99
                                                                  23.41
                                                   23.57
84300903
             0.02250
                                  0.004571
                                                                  25.53
84348301
             0.05963
                                  0.009208
                                                   14.91
                                                                  26.50
84358402
             0.01756
                                  0.005115
                                                   22.54
                                                                  16.67
843786
             0.02165
                                  0.005082
                                                   15.47
                                                                  23.75
         perimeter worst area worst smoothness worst compactness worst
                              2019.0
                                                0.1622
842302
                  184.60
                                                                   0.6656
842517
                   158.80
                              1956.0
                                                0.1238
                                                                   0.1866
84300903
                   152.50
                              1709.0
                                                0.1444
                                                                   0.4245
                               567.7
                                                0.2098
84348301
                   98.87
                                                                   0.8663
84358402
                   152.20
                              1575.0
                                                0.1374
                                                                   0.2050
843786
                   103.40
                               741.6
                                                0.1791
                                                                   0.5249
         concavity_worst concave.points_worst symmetry_worst
842302
                  0.7119
                                         0.2654
                                                         0.4601
842517
                  0.2416
                                         0.1860
                                                         0.2750
84300903
                  0.4504
                                         0.2430
                                                         0.3613
84348301
                  0.6869
                                         0.2575
                                                         0.6638
84358402
                  0.4000
                                         0.1625
                                                         0.2364
843786
                  0.5355
                                         0.1741
                                                         0.3985
         fractal dimension worst
842302
                          0.11890
842517
                          0.08902
84300903
                          0.08758
84348301
                          0.17300
84358402
                          0.07678
843786
                          0.12440
```

```
diagnosis<-wisc.df[,1]
table(diagnosis)</pre>
```

diagnosis B M 357 212

essentially the expert answer that we will compare our analysis results to:

```
# We can use -1 here to remove the first column
wisc.data<- wisc.df[,-1]
head(wisc.data)</pre>
```

	radius_mean te	xture_mean	perimete	er_mean	area_mean	smoothne	ess_mean
842302	17.99	10.38	-	122.80	1001.0		0.11840
842517	20.57	17.77		132.90	1326.0		0.08474
84300903	19.69	21.25		130.00	1203.0		0.10960
84348301	11.42	20.38		77.58	386.1		0.14250
84358402	20.29	14.34		135.10	1297.0		0.10030
843786	12.45	15.70		82.57	477.1		0.12780
	compactness_me	an concavit	ty_mean o	concave.	points_mea	an symmet	cry_mean
842302	0.277	60	0.3001		0.147	LO	0.2419
842517	0.078	64	0.0869		0.070	17	0.1812
84300903	0.159	90	0.1974		0.1279	90	0.2069
84348301	0.283	90	0.2414		0.1052	20	0.2597
84358402	0.132	80	0.1980		0.1043	30	0.1809
843786	0.170	00	0.1578		0.0808	39	0.2087
	fractal_dimens	ion_mean ra	adius_se	texture	_se perime	eter_se a	area_se
842302		0.07871	1.0950	0.9	053	8.589	153.40
842517		0.05667	0.5435	0.7	'339	3.398	74.08
84300903		0.05999	0.7456	0.7	'869	4.585	94.03
84348301		0.09744	0.4956	1.1	.560	3.445	27.23
84358402		0.05883	0.7572	0.7	'813	5.438	94.44
843786		0.07613	0.3345	0.8	3902	2.217	27.19
	smoothness_se	-	_	cavity_s	se concave	points_s	se .
842302	0.006399	0.04	1904	0.0537	'3	0.0158	37
842517	0.005225	0.03	1308	0.0186	50	0.0134	10
84300903	0.006150	0.04	1006	0.0383	32	0.0205	58
84348301	0.009110	0.07	7458	0.0566	31	0.0186	37
84358402	0.011490	0.02	2461	0.0568	88	0.0188	35
843786	0.007510	0.03	3345	0.0367	′2	0.0113	37

```
symmetry_se fractal_dimension_se radius_worst texture_worst
842302
             0.03003
                                   0.006193
                                                    25.38
                                                                   17.33
842517
             0.01389
                                   0.003532
                                                    24.99
                                                                   23.41
84300903
             0.02250
                                                    23.57
                                                                   25.53
                                   0.004571
84348301
             0.05963
                                   0.009208
                                                    14.91
                                                                   26.50
84358402
                                                    22.54
             0.01756
                                   0.005115
                                                                   16.67
843786
             0.02165
                                   0.005082
                                                    15.47
                                                                   23.75
         perimeter_worst area_worst smoothness_worst compactness_worst
842302
                              2019.0
                                                 0.1622
                   184.60
                                                                    0.6656
842517
                   158.80
                              1956.0
                                                 0.1238
                                                                    0.1866
84300903
                   152.50
                              1709.0
                                                 0.1444
                                                                    0.4245
84348301
                    98.87
                               567.7
                                                 0.2098
                                                                    0.8663
84358402
                   152.20
                              1575.0
                                                 0.1374
                                                                    0.2050
843786
                   103.40
                               741.6
                                                 0.1791
                                                                    0.5249
         concavity_worst concave.points_worst symmetry_worst
842302
                   0.7119
                                         0.2654
                                                         0.4601
842517
                   0.2416
                                         0.1860
                                                         0.2750
84300903
                   0.4504
                                         0.2430
                                                         0.3613
84348301
                   0.6869
                                         0.2575
                                                         0.6638
84358402
                   0.4000
                                         0.1625
                                                         0.2364
                                                         0.3985
843786
                   0.5355
                                         0.1741
         fractal_dimension_worst
842302
                          0.11890
842517
                          0.08902
84300903
                          0.08758
84348301
                          0.17300
                          0.07678
84358402
843786
                          0.12440
```

diagnosis <- c (diagnosis)

Exploratory data analysis

Q1. How many observations are in this dataset?

```
num_observations <- length(rownames(data))
print(num_observations)</pre>
```

[1] 0

Q2. How many of the observations have a malignant diagnosis?

Q3. How many variables/features in the data are suffixed with _mean?

```
length(grep("_mean", colnames(wisc.data)) )
```

[1] 10

Principal Component Analysis

```
wisc.pr<-prcomp(wisc.data, scale=T)
summary(wisc.pr)</pre>
```

Importance of components:

```
PC2
                          PC1
                                         PC3
                                                 PC4
                                                          PC5
                                                                  PC6
                                                                          PC7
Standard deviation
                       3.6444 2.3857 1.67867 1.40735 1.28403 1.09880 0.82172
Proportion of Variance 0.4427 0.1897 0.09393 0.06602 0.05496 0.04025 0.02251
Cumulative Proportion 0.4427 0.6324 0.72636 0.79239 0.84734 0.88759 0.91010
                           PC8
                                  PC9
                                         PC10
                                                PC11
                                                         PC12
                                                                 PC13
                                                                         PC14
Standard deviation
                       0.69037 0.6457 0.59219 0.5421 0.51104 0.49128 0.39624
Proportion of Variance 0.01589 0.0139 0.01169 0.0098 0.00871 0.00805 0.00523
Cumulative Proportion 0.92598 0.9399 0.95157 0.9614 0.97007 0.97812 0.98335
                          PC15
                                  PC16
                                          PC17
                                                  PC18
                                                           PC19
                                                                   PC20
Standard deviation
                       0.30681 0.28260 0.24372 0.22939 0.22244 0.17652 0.1731
Proportion of Variance 0.00314 0.00266 0.00198 0.00175 0.00165 0.00104 0.0010
Cumulative Proportion 0.98649 0.98915 0.99113 0.99288 0.99453 0.99557 0.9966
                          PC22
                                  PC23
                                         PC24
                                                 PC25
                                                          PC26
                                                                  PC27
                                                                          PC28
Standard deviation
                       0.16565 0.15602 0.1344 0.12442 0.09043 0.08307 0.03987
Proportion of Variance 0.00091 0.00081 0.0006 0.00052 0.00027 0.00023 0.00005
Cumulative Proportion 0.99749 0.99830 0.9989 0.99942 0.99969 0.99992 0.99997
                          PC29
                                  PC30
Standard deviation
                       0.02736 0.01153
Proportion of Variance 0.00002 0.00000
Cumulative Proportion 1.00000 1.00000
```

Main "PC score plot", "PC1 vs PC2 plot"

See what is in our PCA result object:

```
attributes(wisc.pr)
```

\$names

[1] "sdev" "rotation" "center" "scale" "x"

\$class

[1] "prcomp"

head

function (x, ...)
UseMethod("head")

<bytecode: 0x7fd1386151d8>
<environment: namespace:utils>

wisc.pr\$x

	PC1	PC2	PC3	PC4	PC5
842302	-9.18475521	-1.946870030	-1.122178766	3.630536408	1.1940594778
842517	-2.38570263	3.764859063	-0.528827374	1.117280773	-0.6212283647
84300903	-5.72885549	1.074228589	-0.551262540	0.911280840	0.1769302185
84348301	-7.11669126	-10.266555635	-3.229947535	0.152412923	2.9582754313
84358402	-3.93184247	1.946358977	1.388544953	2.938054169	-0.5462667446
843786	-2.37815462	-3.946456430	-2.932296681	0.940209586	1.0551135428
844359	-2.23691506	2.687666414	-1.638471247	0.149208600	-0.0403240371
84458202	-2.14141428	-2.338186649	-0.871180715	-0.126931171	1.4261817833
844981	-3.17213315	-3.388831138	-3.117243065	-0.600768440	1.5209521144
84501001	-6.34616284	-7.720380945	-4.338098744	-3.372234369	-1.7087596141
845636	0.80970132	2.656937673	-0.488400053	-1.671096176	-0.2755690974
84610002	-2.64876984	-0.066509405	-1.525113359	0.051216497	-0.3316592904
846226	-8.17783882	-2.698602007	5.725193241	-1.111278747	-1.0425531111
846381	-0.34182514	0.967428026	1.715661982	-0.594479872	-0.4675990720
84667401	-4.33856172	-4.856809832	-2.813639832	-1.453278303	-1.2889287269
84799002	-4.07207318	-2.974443983	-3.122526655	-2.455909915	0.4079831402
848406	-0.22985277	1.563382114	-0.801813642	-0.650010973	0.4942761390
84862001	-4.41412695	-1.417423150	-2.268323145	-0.186108659	1.4226094459
849014	-4.94435304	4.110716528	-0.314472408	-0.088128974	0.0566653163
8510426	1.23597583	0.188049490	-0.592761930	1.594942716	0.4417655273
8510653	1.57677384	-0.572304625	-1.799863016	1.124286473	0.3949222435
8510824	3.55420904	-1.661487969	0.450790799	2.071941593	0.4903150736
8511133	-4.72904972	-3.302058265	-1.465247427	2.039355666	0.0261970715
851509	-4.20482441	5.123858059	-0.751740573	-0.861951843	0.4705538779
852552	-4.94528075	1.542395143	-1.711687827	0.046718059	1.7377012054

```
852631
                       -2.016835734 -0.028984132 2.585675482 2.0375470912
           -7.09232236
852763
           -3.50717666
                       -2.169715994 -3.891122637 -1.294620549
                                                               0.0681580703
852781
                         1.874902631 2.579478032 0.128371462
           -3.06136021
                                                                0.1165625639
852973
                       -0.536769860 -2.759197831 -1.896718595
           -4.00374127
                                                                0.5252107652
853201
           -1.71380176
                         1.522365502 0.146058578 1.909706071 -0.5356519265
853401
           -6.05411853
                         0.756511800 -0.348932376 -1.063281958
                                                               0.7454493340
853612
           -2.89968469
                        -4.001774373 -2.998823809 -0.325030387
                                                                0.8546038749
85382601
           -4.55077848
                        -0.337239419 -0.753637681 -0.699714306
                                                                1.5471839770
854002
           -4.98621538
                         1.131593223 -2.575118337 -1.216191663 -0.6693259394
854039
           -2.98271631
                        -0.757756497 -3.490690279 0.054212589 -0.1669530505
854253
           -2.76393718
                         0.354044421 -1.895295337 -0.533786198 0.8832432812
                        -0.912393466 -1.574383382 -1.042249570 -0.4143571251
854268
           -1.29505925
                         1.412230504 1.730784885 -0.564945456 -0.0802687991
854941
            3.74601730
855133
            0.99719148
                         3.348346731 4.301788720 -0.560716245 0.4639645611
855138
           -0.76459136
                        -0.885464837 -2.702540362 -0.274538185 -0.8097169787
            2.14906252
                         1.922300194 -1.179446370 -1.112219391 -0.4480774771
855167
855563
            0.09324934
                        -2.258764532 -1.903051997 -1.441039161 1.7038647386
855625
                        -2.016898441 2.139343894 -1.068304028 -0.7972299505
           -9.08001023
                        -0.984064148 -2.308702241 -0.276582144
                                                                0.6399478981
856106
           -0.98958304
85638502
           0.29328849
                         0.136978564 -3.299029123 -1.008898141
                                                                0.0224910920
857010
           -5.37620991
                         0.134758404 -1.677366657 1.506369463 -0.1518645822
85713702
            4.57790860
                        -1.482915508 0.042037623 0.295968708
                                                               0.7132249498
85715
           -1.69851237
                        -2.350203862 -3.075383081 -0.065962912
                                                                1.0555376469
857155
            2.13456708
                        -0.095745364 -1.491099878 1.120077655
                                                                0.0679774156
857156
            1.56610099
                         1.207370855 -0.368834570 -1.474331566 -0.1725985690
857343
            3.53979091
                         1.281368110 1.017315805 -0.607621596
                                                                0.2194428358
857373
            3.15503795
                         1.687473796 -0.495857416 0.193841543 -1.4386516886
857374
            3.44745515
                         0.497780720 -0.152383875
                                                  0.574980496
                                                               0.0522688899
857392
           -3.29964761
                         1.129943574 0.825666100
                                                  0.981853085
                                                                1.1942122234
857438
            0.67402621
                         2.114549137 -1.394992302 -1.042221635 -0.2416042153
85759902
            2.85564577
                        -0.152588874 0.428557855
                                                 0.482635650
                                                               1.5092086632
857637
           -4.64465207
                         2.308301508 -0.728168145 0.639379104
                                                                1.1573061797
                        -0.971261438 -1.942179421 -0.736670095
857793
           -2.17494916
                                                                0.3954358798
                         1.786070097 1.278807604 0.115464169
                                                                0.5258196576
857810
            3.71818738
858477
            4.13232693
                       -2.401679261 -1.241865694 2.046545722
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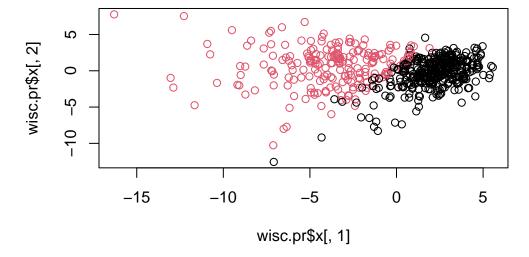
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9113514
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9113538
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911384
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912558
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912600
913063
         -0.0107779990 3.093484e-03 1.413849e-01 -6.100949e-03 1.202071e-03
```

```
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                                                    1.970595e-02 -1.498247e-02
914862
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          -0.0963197757 9.104160e-02 -2.312398e-02 3.386630e-02 -1.529871e-02
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91505
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915143
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915186
915276
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91544001
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           0.0189855035 - 9.752934e - 02 - 6.505096e - 03 - 2.312757e - 03 - 1.589520e - 02
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916838
           0.0550042618 - 1.724436e - 01 - 9.894992e - 02 - 7.051032e - 02 7.208234e - 03
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                                                                  1.086353e-02
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91762702
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                                                    1.344440e-02 2.051314e-03
917896
          -0.1061345671 4.966193e-03 -6.582652e-03 4.193781e-02
                                                                  7.898565e-03
917897
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                                                                  1.449954e-03
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91813701
91813702
           0.0181336410
                        4.282084e-02 3.040698e-02 1.508284e-02 -7.330015e-03
          -0.0934720894 -5.020254e-02 4.171083e-02 -7.809330e-03 -9.193665e-05
918192
```

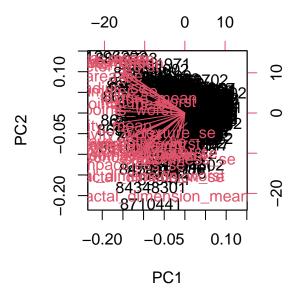
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918465
91858
           0.0424242869 9.025177e-03 -1.623234e-02 6.269355e-03 -8.871060e-04
           0.0931826121 -3.654002e-02 4.324270e-03 4.165806e-03 -1.106227e-03
91903901
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                        1.658681e-02 1.150422e-02 -1.563064e-02 -6.663151e-03
91903902
91930402
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                        1.259825e-02 -9.518713e-03 9.373100e-03 -3.095154e-03
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919555
           0.1536070303 -3.265112e-02 2.996697e-02 8.171708e-03 -3.458037e-02
91979701 -0.0487762627 5.821042e-02 1.015633e-02 2.035367e-02 9.738559e-03
           0.0329233687 -1.804282e-02 -2.169062e-02 -2.378939e-02 8.893677e-03
919812
921092
           0.1468627182 7.253893e-02 -8.746899e-03 -1.161071e-02 9.286171e-03
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           0.0313546289 -4.161718e-02 -2.705643e-03 9.706143e-03 3.657914e-03
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923169
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923465
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                        3.418774e-02 6.937288e-05 -2.145122e-02 -4.134624e-03
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923780
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924084
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924342
          0.0044220903 4.297202e-03 -9.650436e-03 -1.615592e-02 -1.435061e-03
924632
           0.0024994349 - 7.130661e - 02   4.473723e - 02   1.560585e - 02   1.385123e - 03
           0.0938320141 3.896512e-02 -1.164274e-02 -1.431460e-03 6.878081e-03
924934
924964
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925292
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926125
          -0.0729289516
                        1.450989e-01 -3.945551e-02 7.014761e-02
                                                                  7.638391e-03
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                        1.590577e-01 9.843968e-03 7.112909e-03
                                                                  1.413613e-03
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                                                                  1.041027e-02
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          -0.1980178555 -2.738532e-02 -6.802653e-02 -8.408929e-02 2.376191e-02
927241
92751
           0.3468098821 1.272691e-01 -9.507513e-03 -6.085956e-02 1.945846e-02
```

```
#plot(wisc.pr$x)
```



```
pca_result <- prcomp(wisc.data, scale = TRUE)

#create a biplot
biplot(pca_result)</pre>
```

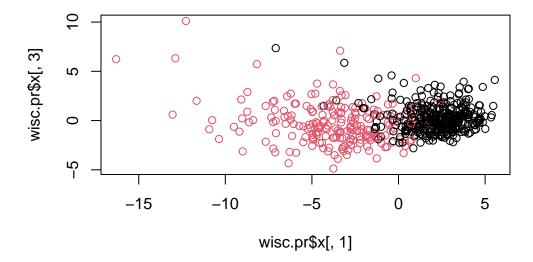


#something that stands out are the overlapping in the plot. It is hard to understand because

Q7. What stands out to you about this plot? Is it easy or difficult to understand? Why?

Each dot represents a patient. It is hard to understand because there is no visible relationship in the plot.

- Q4. From your results, what proportion of the original variance is captured by the first principal components (PC1)?
- Q5. How many principal components (PCs) are required to describe at least 70% of the original variance in the data?
- Q6. How many principal components (PCs) are required to describe at least 90% of the original variance in the data?
- Q7. What stands out to you about this plot? Is it easy or difficult to understand? Why?
- Q8. Generate a similar plot for principal components 1 and 3. What do you notice about these plots?



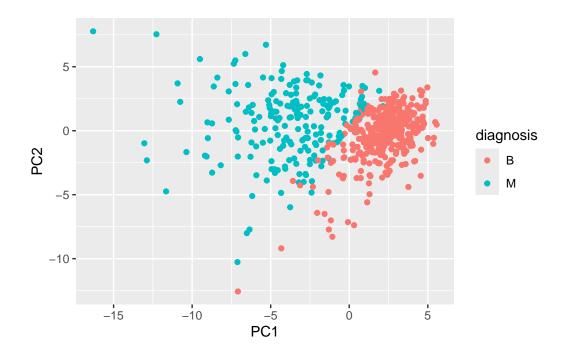
These plots are quite similar but show a different principal component.

Q9. For the first principal component, what is the component of the loading vector (i.e. wisc.pr\$rotation[,1]) for the feature concave.points_mean?

```
df <- as.data.frame(wisc.pr$x)
df$diagnosis <- diagnosis

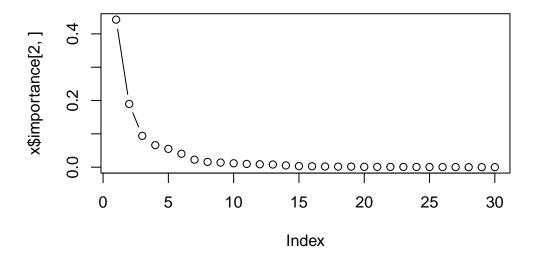
library(ggplot2)

ggplot(df) +
   aes(PC1, PC2, col = diagnosis) + # Use 'diagnosis' to color points
   geom_point()</pre>
```



- Q10. What is the minimum number of principal components required to explain 80% of the variance of the data?
- Q11. Using the plot() and abline() functions, what is the height at which the clustering model has 4 clusters?
- Q12. Can you find a better cluster vs diagnoses match by cutting into a different number of clusters between 2 and 10?
- Q13. Which method gives your favorite results for the same data.dist dataset? Explain your reasoning.

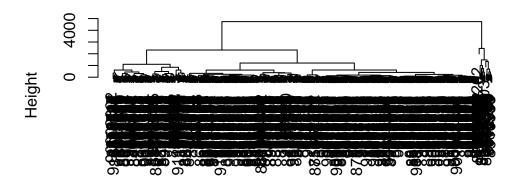
```
x<- summary(wisc.pr)
plot(x$importance[2,], typ="b")</pre>
```



Clustering

```
d<- dist(wisc.data)
hc.raw<-hclust(d)
plot(hc.raw)</pre>
```

Cluster Dendrogram



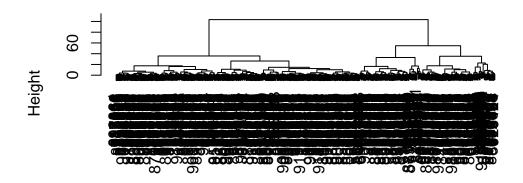
d hclust (*, "complete")

Combine PCA and clustering

Our PCA results were in wisc.prx

```
#distance matrix from PCA result
d <-dist(wisc.pr$x[,1:3])
hc<- hclust(d, method="ward.D2")
plot(hc)</pre>
```

Cluster Dendrogram

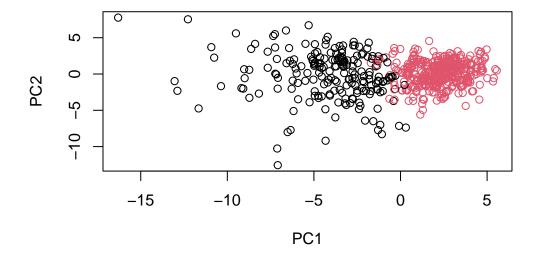


d hclust (*, "ward.D2")

Cutree into two groups/branches/clusters...

```
grps<- cutree(hc, k=2)</pre>
```

plot(wisc.pr\$x, col=grps)



Compare my clustering result(my grps) to the expert diagnosis

table(diagnosis)

diagnosis

B M

357 212

table(grps)

grps

1 2

203 366

table(diagnosis,grps)

grp

diagnosis 1 2

B 24 333

M 179 33

B= benign M=malignant

Individual 2.