R Notebook

## Example: To predict whether the value of number of rings either as a continuous value or classification problem —-

## Step 1: Collecting data (Import CSV File) —-

## The dataset is loaded into R.

abl <- read.csv("abalonedata.csv", stringsAsFactors = FALSE)

## Step 2: Exploring and preparing the data —-

## The dataset is explored and prepared for analysis.

## The str() function is used to gather data about the dataset.One can see the names and number of variables and level of observations for each variable.

str(abl)

## 'data.frame': 4177 obs. of 8 variables:  
## $ length : num 0.455 0.35 0.53 0.44 0.33 0.425 0.53 0.545 0.475 0.55 ...  
## $ diameter : num 0.365 0.265 0.42 0.365 0.255 0.3 0.415 0.425 0.37 0.44 ...  
## $ height : num 0.095 0.09 0.135 0.125 0.08 0.095 0.15 0.125 0.125 0.15 ...  
## $ wholeweight : num 0.514 0.226 0.677 0.516 0.205 ...  
## $ shuckedweight: num 0.2245 0.0995 0.2565 0.2155 0.0895 ...  
## $ visceraweight: num 0.101 0.0485 0.1415 0.114 0.0395 ...  
## $ shellweight : num 0.15 0.07 0.21 0.155 0.055 0.12 0.33 0.26 0.165 0.32 ...  
## $ rings : int 15 7 9 10 7 8 20 16 9 19 ...

## There is no data missing for abalone dataset after the clean-up.

abl[abl==""] <- NA  
abl <- na.omit(abl)

## Here we assign column names for the variables.

colnames(abl) <- c('length', 'diameter', 'height', 'wholeWwight', 'shuckedweight','visceraWeight', 'shellweight', 'rings')

## We use summary() function to observe characteristics of the dataset.

summary(abl)

## length diameter height wholeWwight   
## Min. :0.075 Min. :0.0550 Min. :0.0000 Min. :0.0020   
## 1st Qu.:0.450 1st Qu.:0.3500 1st Qu.:0.1150 1st Qu.:0.4415   
## Median :0.545 Median :0.4250 Median :0.1400 Median :0.7995   
## Mean :0.524 Mean :0.4079 Mean :0.1395 Mean :0.8287   
## 3rd Qu.:0.615 3rd Qu.:0.4800 3rd Qu.:0.1650 3rd Qu.:1.1530   
## Max. :0.815 Max. :0.6500 Max. :1.1300 Max. :2.8255   
## shuckedweight visceraWeight shellweight rings   
## Min. :0.0010 Min. :0.0005 Min. :0.0015 Min. : 1.000   
## 1st Qu.:0.1860 1st Qu.:0.0935 1st Qu.:0.1300 1st Qu.: 8.000   
## Median :0.3360 Median :0.1710 Median :0.2340 Median : 9.000   
## Mean :0.3594 Mean :0.1806 Mean :0.2388 Mean : 9.934   
## 3rd Qu.:0.5020 3rd Qu.:0.2530 3rd Qu.:0.3290 3rd Qu.:11.000   
## Max. :1.4880 Max. :0.7600 Max. :1.0050 Max. :29.000

## We use sapply() function to observe the type of variables

sapply(abl, class)

## length diameter height wholeWwight shuckedweight   
## "numeric" "numeric" "numeric" "numeric" "numeric"   
## visceraWeight shellweight rings   
## "numeric" "numeric" "integer"

## We implement the ANOVA model to find out value of coefficients with respect to shellweight and value of R-squared.As we can see, the value of adjusted R-Squared is 0.5268, which signifies that the regression data is not very much accurate.

modelFit <- lm(rings ~ ., data = abl)   
modelFit2 <- lm(rings ~ shellweight, data = abl)   
anova(modelFit, modelFit2, test="Chisq")

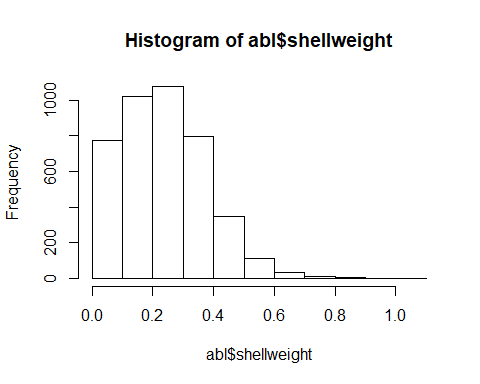
## Analysis of Variance Table  
##   
## Model 1: rings ~ length + diameter + height + wholeWwight + shuckedweight +   
## visceraWeight + shellweight  
## Model 2: rings ~ shellweight  
## Res.Df RSS Df Sum of Sq Pr(>Chi)   
## 1 4169 20506   
## 2 4175 26313 -6 -5807.5 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

summary(modelFit)

##   
## Call:  
## lm(formula = rings ~ ., data = abl)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -11.1632 -1.3613 -0.3885 0.9054 13.7440   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.9852 0.2691 11.092 < 2e-16 \*\*\*  
## length -1.5719 1.8248 -0.861 0.389   
## diameter 13.3609 2.2371 5.972 2.53e-09 \*\*\*  
## height 11.8261 1.5481 7.639 2.70e-14 \*\*\*  
## wholeWwight 9.2474 0.7326 12.622 < 2e-16 \*\*\*  
## shuckedweight -20.2139 0.8233 -24.552 < 2e-16 \*\*\*  
## visceraWeight -9.8297 1.3040 -7.538 5.82e-14 \*\*\*  
## shellweight 8.5762 1.1367 7.545 5.54e-14 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 2.218 on 4169 degrees of freedom  
## Multiple R-squared: 0.5276, Adjusted R-squared: 0.5268   
## F-statistic: 665.2 on 7 and 4169 DF, p-value: < 2.2e-16

## We plot a histogram to find out the frequency of particular weights of the shell. We observe that shells of weight around 0.3 are the highest in number.

hist(abl$shellweight)



## Step 3: Training a model on the data —-

## Standardize the data frame by each observation to get a standardized list back

Rings\_a <- abl[1:4000,]  
Rings\_b <- as.data.frame(lapply(Rings\_a, scale))  
print("Seed is set to generate random numbers in a sequence.")

## [1] "Seed is set to generate random numbers in a sequence."

set.seed(2345)  
Rings\_cluster <- kmeans(Rings\_a,4)

## Step 4: Evaluating model performance —-

## Step 4 of the data analysis process is evaluating the model’s performance.

## We just check the overall size of the cluster and then find out the centers of the clusters generated. We get 4 clusters of sizes as mentioned below in the output.

# look at the size of the clusters  
Rings\_cluster$size

## [1] 1037 364 1788 811

# look at the cluster centers  
Rings\_cluster$centers

## length diameter height wholeWwight shuckedweight visceraWeight  
## 1 0.5891225 0.4631051 0.16116201 1.1048780 0.4700140 0.24264899  
## 2 0.5916896 0.4692445 0.17001374 1.1577610 0.4331332 0.24124176  
## 3 0.5400867 0.4199609 0.14195190 0.8356186 0.3765106 0.18355537  
## 4 0.3675154 0.2777250 0.09167694 0.2907540 0.1331350 0.06272626  
## shellweight rings  
## 1 0.32008582 11.999036  
## 2 0.37419368 17.313187  
## 3 0.23347343 9.038591  
## 4 0.08259803 6.114673

## k-means clustering is done with k=3 after standardizing data where the 1st arguement is the dataset and the 2nd arguement is the k parameter

## Clusplot is used as 2D representation of cluster results even when they represent of 92.6% of total variance.

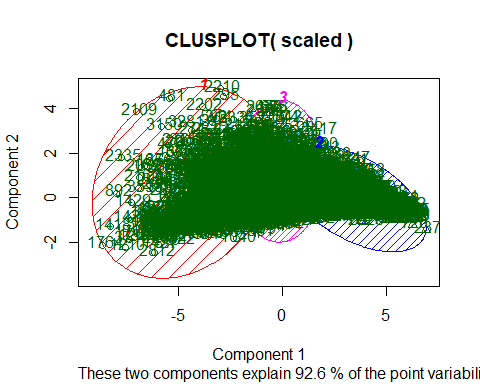
scaled=scale(abl)  
k\_cluster=kmeans(scaled,3)  
k\_cluster

## K-means clustering with 3 clusters of sizes 1227, 1177, 1773  
##   
## Cluster means:  
## length diameter height wholeWwight shuckedweight visceraWeight  
## 1 1.0343234 1.040219 0.9792794 1.21871272 1.175052 1.19554726  
## 2 -1.2786312 -1.279790 -1.1222893 -1.13841966 -1.084902 -1.11668868  
## 3 0.1330142 0.129703 0.0673202 -0.08767094 -0.092983 -0.08606537  
## shellweight rings  
## 1 1.17376211 0.6209137  
## 2 -1.12936206 -0.8593091  
## 3 -0.06257584 0.1407477  
##   
## Clustering vector:  
## 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15   
## 3 2 3 3 2 2 3 3 3 3 3 2 3 3 2   
## 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30   
## 3 2 2 2 2 2 2 3 3 1 3 3 3 3 3   
## 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45   
## 3 1 1 1 1 2 1 2 3 2 2 3 2 2 2   
## 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60   
## 2 3 2 2 3 3 2 3 3 2 3 2 3 2 3   
## 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75   
## 2 3 3 2 3 2 3 1 3 2 3 2 1 1 1   
## 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90   
## 3 3 3 3 1 3 1 3 1 3 1 1 3 3 3   
## 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105   
## 3 3 1 1 1 1 3 3 3 3 2 3 3 3 1   
## 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120   
## 3 3 3 3 2 3 2 2 2 3 3 3 2 3 2   
## 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135   
## 2 2 3 2 2 2 2 2 1 1 1 2 2 2 2   
## 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150   
## 2 2 2 2 2 3 3 1 3 3 3 3 2 2 2   
## 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165   
## 1 1 1 3 3 3 1 1 3 3 1 1 1 1 1   
## 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180   
## 1 1 1 1 1 1 3 3 3 2 2 2 2 2 3   
## 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195   
## 3 1 3 3 1 1 1 1 1 3 1 1 3 2 3   
## 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210   
## 3 3 1 3 3 2 3 3 3 2 3 2 2 3 2   
## 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225   
## 3 2 2 3 3 3 2 2 3 2 2 3 3 3 2   
## 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240   
## 3 2 2 3 3 3 3 1 2 3 2 2 2 2 2   
## 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255   
## 3 2 2 2 2 2 2 2 2 2 2 1 3 1 1   
## 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270   
## 3 1 3 1 1 3 3 3 2 2 3 3 2 3 3   
## 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285   
## 1 1 1 1 1 1 1 1 1 3 3 2 2 3 3   
## 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300   
## 3 3 3 2 3 3 1 1 1 1 2 2 2 3 2   
## 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315   
## 2 3 2 2 3 2 2 1 3 3 1 3 1 1 1   
## 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330   
## 2 1 2 3 2 2 2 2 2 2 2 2 3 2 2   
## 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345   
## 3 2 2 2 1 1 1 1 1 1 1 1 1 3 3   
## 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360   
## 3 3 2 2 1 1 3 3 3 1 1 1 1 1 1   
## 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375   
## 1 3 1 1 1 1 3 3 1 1 1 1 1 1 1   
## 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390   
## 1 1 3 3 1 1 3 3 3 3 2 3 3 3 3   
## 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405   
## 2 3 3 2 2 2 3 3 3 3 3 3 2 3 2   
## 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420   
## 3 2 3 3 3 1 3 3 3 1 3 1 1 1 3   
## 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435   
## 1 3 3 2 2 3 1 1 3 3 3 1 3 3 2   
## 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450   
## 3 2 2 2 3 2 2 3 2 2 3 3 3 1 3   
## 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465   
## 1 1 1 3 1 3 1 2 2 3 2 3 2 2 2   
## 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480   
## 2 1 1 1 1 3 3 2 3 3 3 2 1 1 1   
## 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495   
## 1 3 3 3 3 3 3 1 3 3 3 3 1 1 1   
## 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510   
## 3 1 1 1 3 3 1 1 1 1 1 3 1 3 3   
## 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525   
## 1 3 3 2 2 2 2 2 2 2 2 2 2 2 2   
## 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540   
## 2 2 3 3 2 3 3 3 2 3 3 3 2 2 2   
## 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555   
## 3 2 2 2 2 2 2 2 3 3 1 3 3 3 3   
## 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570   
## 3 3 1 1 3 2 3 3 3 3 2 3 2 2 2   
## 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585   
## 3 3 1 3 3 1 3 3 3 1 1 3 1 3 2   
## 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600   
## 3 3 3 3 2 3 2 3 1 3 3 3 3 3 3   
## 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615   
## 3 2 2 3 3 3 2 3 2 2 3 2 2 3 3   
## 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630   
## 3 3 2 2 2 2 3 3 3 3 3 2 2 3 2   
## 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645   
## 3 2 3 3 2 2 2 2 3 3 2 1 3 2 2   
## 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660   
## 2 2 3 3 2 2 2 3 2 2 2 3 1 1 3   
## 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675   
## 1 3 2 2 3 2 3 3 3 3 3 3 3 3 3   
## 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690   
## 3 3 3 3 2 2 3 2 3 3 3 3 3 3 3   
## 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705   
## 3 2 2 2 2 2 2 2 3 2 2 3 2 2 2   
## 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735   
## 2 3 1 3 2 3 2 3 3 3 3 3 3 3 3   
## 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750   
## 3 3 3 3 2 3 2 3 3 3 3 1 3 3 1   
## 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765   
## 3 3 1 3 1 1 1 1 3 3 3 3 3 1 1   
## 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780   
## 3 3 2 3 3 3 3 2 3 3 3 3 3 3 3   
## 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795   
## 3 3 3 2 2 3 3 3 3 3 3 3 3 3 3   
## 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810   
## 3 3 2 3 2 3 2 2 2 3 2 2 3 2 3   
## 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825   
## 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840   
## 2 2 2 2 2 2 2 2 2 2 3 3 3 3 2   
## 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870   
## 3 3 3 3 1 3 3 1 1 1 1 1 1 1 1   
## 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900   
## 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2   
## 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960   
## 3 3 3 2 3 3 2 3 2 3 3 3 3 3 3   
## 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990   
## 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3   
## 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005   
## 3 3 3 3 3 3 1 3 3 3 3 1 3 3 1   
## 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1036 1037 1038 1039 1040 1041 1042 1043 1044 1045 1046 1047 1048 1049 1050   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1051 1052 1053 1054 1055 1056 1057 1058 1059 1060 1061 1062 1063 1064 1065   
## 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2   
## 1066 1067 1068 1069 1070 1071 1072 1073 1074 1075 1076 1077 1078 1079 1080   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1081 1082 1083 1084 1085 1086 1087 1088 1089 1090 1091 1092 1093 1094 1095   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1096 1097 1098 1099 1100 1101 1102 1103 1104 1105 1106 1107 1108 1109 1110   
## 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1111 1112 1113 1114 1115 1116 1117 1118 1119 1120 1121 1122 1123 1124 1125   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1126 1127 1128 1129 1130 1131 1132 1133 1134 1135 1136 1137 1138 1139 1140   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1141 1142 1143 1144 1145 1146 1147 1148 1149 1150 1151 1152 1153 1154 1155   
## 3 3 3 3 3 1 3 3 3 3 3 3 3 3 1   
## 1156 1157 1158 1159 1160 1161 1162 1163 1164 1165 1166 1167 1168 1169 1170   
## 3 3 1 3 1 3 3 1 3 3 3 3 3 3 1   
## 1171 1172 1173 1174 1175 1176 1177 1178 1179 1180 1181 1182 1183 1184 1185   
## 1 1 3 1 3 1 1 1 1 1 1 1 1 1 1   
## 1186 1187 1188 1189 1190 1191 1192 1193 1194 1195 1196 1197 1198 1199 1200   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1201 1202 1203 1204 1205 1206 1207 1208 1209 1210 1211 1212 1213 1214 1215   
## 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2   
## 1216 1217 1218 1219 1220 1221 1222 1223 1224 1225 1226 1227 1228 1229 1230   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1231 1232 1233 1234 1235 1236 1237 1238 1239 1240 1241 1242 1243 1244 1245   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1246 1247 1248 1249 1250 1251 1252 1253 1254 1255 1256 1257 1258 1259 1260   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1261 1262 1263 1264 1265 1266 1267 1268 1269 1270 1271 1272 1273 1274 1275   
## 2 2 2 2 2 2 2 2 2 2 3 2 2 2 2   
## 1276 1277 1278 1279 1280 1281 1282 1283 1284 1285 1286 1287 1288 1289 1290   
## 3 2 2 3 3 3 3 3 3 3 3 3 3 3 3   
## 1291 1292 1293 1294 1295 1296 1297 1298 1299 1300 1301 1302 1303 1304 1305   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1306 1307 1308 1309 1310 1311 1312 1313 1314 1315 1316 1317 1318 1319 1320   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1321 1322 1323 1324 1325 1326 1327 1328 1329 1330 1331 1332 1333 1334 1335   
## 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3   
## 1336 1337 1338 1339 1340 1341 1342 1343 1344 1345 1346 1347 1348 1349 1350   
## 3 3 1 3 3 3 1 3 3 1 3 3 3 1 3   
## 1351 1352 1353 1354 1355 1356 1357 1358 1359 1360 1361 1362 1363 1364 1365   
## 3 3 1 3 3 3 3 3 1 3 3 3 3 3 1   
## 1366 1367 1368 1369 1370 1371 1372 1373 1374 1375 1376 1377 1378 1379 1380   
## 3 3 1 3 3 3 1 3 1 1 3 1 1 1 1   
## 1381 1382 1383 1384 1385 1386 1387 1388 1389 1390 1391 1392 1393 1394 1395   
## 3 1 1 1 1 1 3 3 1 1 1 1 1 3 1   
## 1396 1397 1398 1399 1400 1401 1402 1403 1404 1405 1406 1407 1408 1409 1410   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1411 1412 1413 1414 1415 1416 1417 1418 1419 1420 1421 1422 1423 1424 1425   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1426 1427 1428 1429 1430 1431 1432 1433 1434 1435 1436 1437 1438 1439 1440   
## 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2   
## 1441 1442 1443 1444 1445 1446 1447 1448 1449 1450 1451 1452 1453 1454 1455   
## 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2   
## 1456 1457 1458 1459 1460 1461 1462 1463 1464 1465 1466 1467 1468 1469 1470   
## 3 2 2 3 2 3 3 3 3 3 3 3 3 3 3   
## 1471 1472 1473 1474 1475 1476 1477 1478 1479 1480 1481 1482 1483 1484 1485   
## 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3   
## 1486 1487 1488 1489 1490 1491 1492 1493 1494 1495 1496 1497 1498 1499 1500   
## 3 3 3 1 3 1 1 1 3 3 3 3 1 1 3   
## 1501 1502 1503 1504 1505 1506 1507 1508 1509 1510 1511 1512 1513 1514 1515   
## 1 3 1 1 1 1 1 1 1 1 1 1 1 3 1   
## 1516 1517 1518 1519 1520 1521 1522 1523 1524 1525 1526 1527 1528 1529 1530   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1531 1532 1533 1534 1535 1536 1537 1538 1539 1540 1541 1542 1543 1544 1545   
## 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1546 1547 1548 1549 1550 1551 1552 1553 1554 1555 1556 1557 1558 1559 1560   
## 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2   
## 1561 1562 1563 1564 1565 1566 1567 1568 1569 1570 1571 1572 1573 1574 1575   
## 2 2 2 2 2 2 2 2 2 3 2 3 3 3 3   
## 1576 1577 1578 1579 1580 1581 1582 1583 1584 1585 1586 1587 1588 1589 1590   
## 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1591 1592 1593 1594 1595 1596 1597 1598 1599 1600 1601 1602 1603 1604 1605   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1606 1607 1608 1609 1610 1611 1612 1613 1614 1615 1616 1617 1618 1619 1620   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1621 1622 1623 1624 1625 1626 1627 1628 1629 1630 1631 1632 1633 1634 1635   
## 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3   
## 1636 1637 1638 1639 1640 1641 1642 1643 1644 1645 1646 1647 1648 1649 1650   
## 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3   
## 1651 1652 1653 1654 1655 1656 1657 1658 1659 1660 1661 1662 1663 1664 1665   
## 3 3 3 3 3 3 3 3 3 1 3 1 3 3 3   
## 1666 1667 1668 1669 1670 1671 1672 1673 1674 1675 1676 1677 1678 1679 1680   
## 3 3 1 3 3 1 3 3 3 1 1 3 1 1 1   
## 1681 1682 1683 1684 1685 1686 1687 1688 1689 1690 1691 1692 1693 1694 1695   
## 1 1 1 1 3 3 1 3 1 1 1 1 1 3 1   
## 1696 1697 1698 1699 1700 1701 1702 1703 1704 1705 1706 1707 1708 1709 1710   
## 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1   
## 1711 1712 1713 1714 1715 1716 1717 1718 1719 1720 1721 1722 1723 1724 1725   
## 1 1 1 1 1 1 1 1 1 1 1 1 3 1 1   
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## 4066 4067 4068 4069 4070 4071 4072 4073 4074 4075 4076 4077 4078 4079 4080   
## 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3   
## 4081 4082 4083 4084 4085 4086 4087 4088 4089 4090 4091 4092 4093 4094 4095   
## 3 3 3 3 1 1 3 3 3 3 1 1 1 1 1   
## 4096 4097 4098 4099 4100 4101 4102 4103 4104 4105 4106 4107 4108 4109 4110   
## 3 1 1 1 1 1 1 1 1 1 1 1 2 2 3   
## 4111 4112 4113 4114 4115 4116 4117 4118 4119 4120 4121 4122 4123 4124 4125   
## 1 3 1 3 3 3 1 1 1 2 2 2 2 3 3   
## 4126 4127 4128 4129 4130 4131 4132 4133 4134 4135 4136 4137 4138 4139 4140   
## 3 3 3 3 3 3 3 3 3 3 1 3 1 1 1   
## 4141 4142 4143 4144 4145 4146 4147 4148 4149 4150 4151 4152 4153 4154 4155   
## 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2   
## 4156 4157 4158 4159 4160 4161 4162 4163 4164 4165 4166 4167 4168 4169 4170   
## 2 2 3 2 3 3 3 2 2 2 2 3 3 3 3   
## 4171 4172 4173 4174 4175 4176 4177   
## 3 3 3 3 1 1 1   
##   
## Within cluster sum of squares by cluster:  
## [1] 4563.610 2105.546 3251.249  
## (between\_SS / total\_SS = 70.3 %)  
##   
## Available components:  
##   
## [1] "cluster" "centers" "totss" "withinss"   
## [5] "tot.withinss" "betweenss" "size" "iter"   
## [9] "ifault"

library("cluster")

## Warning: package 'cluster' was built under R version 3.4.4

clusplot(scaled, k\_cluster$cluster, color=TRUE, shade=TRUE,   
 labels=2, lines=0)



## We select option 2 in MClust list of plots. The classification plot shows the linear trend between the columns. In some cases, exponential linear trend is also depicted.

## Step 5: Improving model performance —-

## This step involves improving the model performance to get better results.

# apply the cluster IDs to the original data frame

abl$cluster <- k\_cluster$cluster  
abl$cluster

## [1] 3 2 3 3 2 2 3 3 3 3 3 2 3 3 2 3 2 2 2 2 2 2 3 3 1 3 3 3 3 3 3 1 1 1  
## [35] 1 2 1 2 3 2 2 3 2 2 2 2 3 2 2 3 3 2 3 3 2 3 2 3 2 3 2 3 3 2 3 2 3 1  
## [69] 3 2 3 2 1 1 1 3 3 3 3 1 3 1 3 1 3 1 1 3 3 3 3 3 1 1 1 1 3 3 3 3 2 3  
## [103] 3 3 1 3 3 3 3 2 3 2 2 2 3 3 3 2 3 2 2 2 3 2 2 2 2 2 1 1 1 2 2 2 2 2  
## [137] 2 2 2 2 3 3 1 3 3 3 3 2 2 2 1 1 1 3 3 3 1 1 3 3 1 1 1 1 1 1 1 1 1 1  
## [171] 1 3 3 3 2 2 2 2 2 3 3 1 3 3 1 1 1 1 1 3 1 1 3 2 3 3 3 1 3 3 2 3 3 3  
## [205] 2 3 2 2 3 2 3 2 2 3 3 3 2 2 3 2 2 3 3 3 2 3 2 2 3 3 3 3 1 2 3 2 2 2  
## [239] 2 2 3 2 2 2 2 2 2 2 2 2 2 1 3 1 1 3 1 3 1 1 3 3 3 2 2 3 3 2 3 3 1 1  
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## [409] 3 3 1 3 3 3 1 3 1 1 1 3 1 3 3 2 2 3 1 1 3 3 3 1 3 3 2 3 2 2 2 3 2 2  
## [443] 3 2 2 3 3 3 1 3 1 1 1 3 1 3 1 2 2 3 2 3 2 2 2 2 1 1 1 1 3 3 2 3 3 3  
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## [579] 3 1 1 3 1 3 2 3 3 3 3 2 3 2 3 1 3 3 3 3 3 3 3 2 2 3 3 3 2 3 2 2 3 2  
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## [715] 2 2 2 2 2 2 2 3 1 3 2 3 2 3 3 3 3 3 3 3 3 3 3 3 3 2 3 2 3 3 3 3 1 3  
## [749] 3 1 3 3 1 3 1 1 1 1 3 3 3 3 3 1 1 3 3 2 3 3 3 3 2 3 3 3 3 3 3 3 3 3  
## [783] 3 2 2 3 3 3 3 3 3 3 3 3 3 3 3 2 3 2 3 2 2 2 3 2 2 3 2 3 3 3 2 2 2 2  
## [817] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 3 2 3 3 3 3 3 3 3 3 3 3  
## [851] 3 3 3 3 3 3 3 3 3 1 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  
## [885] 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2  
## [919] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3 2 3 3 2  
## [953] 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3  
## [987] 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 1 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  
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## [1089] 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
## [1123] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 1 3  
## [1157] 3 1 3 1 3 3 1 3 3 3 3 3 3 1 1 1 3 1 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  
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## [1259] 2 2 2 2 2 2 2 2 2 2 2 2 3 2 2 2 2 3 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
## [1293] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3  
## [1327] 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 1 3 3 1 3 3 3 1 3 3 3 1 3 3 3 3 3 1 3  
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## [1633] 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3 1 3 3 3 3  
## [1667] 3 1 3 3 1 3 3 3 1 1 3 1 1 1 1 1 1 1 3 3 1 3 1 1 1 1 1 3 1 1 1 1 1 1  
## [1701] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 1  
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## [1871] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
## [1905] 3 3 3 3 3 3 3 3 3 3 3 3 1 3 1 3 3 1 3 1 3 1 3 3 1 1 3 1 3 1 1 3 3 1  
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## [1973] 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2  
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## [2041] 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
## [2075] 3 3 1 3 1 3 1 1 1 1 1 1 1 1 1 1 1 3 3 3 2 2 3 2 2 2 2 3 2 2 3 3 3 1  
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## [2143] 2 3 2 2 3 3 2 2 2 1 2 2 3 1 1 1 3 1 1 1 1 3 2 3 2 2 2 2 2 2 2 3 1 3  
## [2177] 1 1 1 1 1 3 3 3 2 2 3 3 3 3 3 1 1 2 2 2 2 2 2 1 1 1 3 1 2 2 2 2 1 1  
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## [2313] 2 3 3 3 3 3 3 3 2 3 3 2 1 2 2 3 3 3 2 3 3 1 1 1 3 3 1 1 3 2 2 2 1 1  
## [2347] 3 3 3 2 3 3 1 1 1 3 1 3 1 1 3 3 1 1 1 1 1 1 1 3 2 2 2 3 2 2 2 3 2 2  
## [2381] 2 2 3 3 2 3 3 3 3 2 3 2 2 2 1 1 3 1 3 3 2 3 3 2 3 1 3 1 1 3 3 3 2 3  
## [2415] 2 2 3 2 3 3 2 3 3 2 2 3 3 2 3 2 3 1 1 1 1 3 3 2 3 2 3 3 3 3 3 3 3 2  
## [2449] 2 2 2 2 2 2 2 2 2 2 2 1 3 3 2 3 3 3 2 3 2 3 1 1 1 1 1 3 1 3 3 3 3 2  
## [2483] 3 3 3 2 3 1 3 3 2 3 3 2 2 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 3 3 3  
## [2517] 3 3 3 3 3 3 3 3 1 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2  
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## [2585] 3 3 3 3 3 3 3 3 3 1 3 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  
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## [2755] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 1 3 1 1 3  
## [2789] 3 3 1 3 1 1 3 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2  
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## [2891] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 1 1 3 3 1 3 3 1  
## [2925] 1 3 3 1 3 1 1 3 3 1 3 1 1 1 1 3 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1  
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## [3027] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 1 3 3 3 3 1 3 1 3 1  
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## [3095] 3 3 3 3 3 3 3 3 1 1 1 2 2 2 2 2 2 2 2 2 2 2 3 2 3 3 3 3 3 3 3 1 1 1  
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## [3197] 2 2 3 3 3 2 1 1 1 2 2 3 2 3 3 1 1 3 1 1 1 2 1 1 3 2 3 3 1 2 2 3 2 1  
## [3231] 3 2 3 1 1 1 2 1 1 1 3 1 1 1 1 1 3 1 3 2 2 3 3 2 2 2 3 3 2 1 3 1 1 3  
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## [3401] 3 3 3 2 2 2 2 2 2 2 2 2 3 3 2 3 3 3 1 3 1 3 3 1 1 1 1 1 2 2 2 2 2 2  
## [3435] 2 2 2 2 2 2 2 2 3 2 3 3 3 3 3 3 3 3 3 3 3 3 1 1 3 1 1 1 1 1 1 1 1 1  
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## [3639] 2 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
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## [3809] 3 3 3 3 1 2 2 2 2 3 3 3 3 3 1 3 1 1 1 1 1 1 3 3 3 3 2 2 2 2 2 3 3 3  
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## [3911] 3 2 3 3 3 3 3 1 1 3 2 2 3 2 3 2 3 3 1 1 1 3 3 2 2 3 3 3 2 3 3 3 3 1  
## [3945] 3 2 3 3 3 3 3 3 2 3 3 3 3 3 1 1 1 1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2  
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## [4013] 3 1 1 1 1 1 1 1 1 1 1 2 2 2 2 2 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3  
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## [4081] 3 3 3 3 1 1 3 3 3 3 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 1 2 2 3 1 3 1 3  
## [4115] 3 3 1 1 1 2 2 2 2 3 3 3 3 3 3 3 3 3 3 3 3 1 3 1 1 1 1 1 1 1 1 1 1 1  
## [4149] 1 2 2 2 2 2 2 2 2 3 2 3 3 3 2 2 2 2 3 3 3 3 3 3 3 3 1 1 1

# look at the first three records  
abl[1:5, c("length", "diameter", "height")]

## length diameter height  
## 1 0.455 0.365 0.095  
## 2 0.350 0.265 0.090  
## 3 0.530 0.420 0.135  
## 4 0.440 0.365 0.125  
## 5 0.330 0.255 0.080

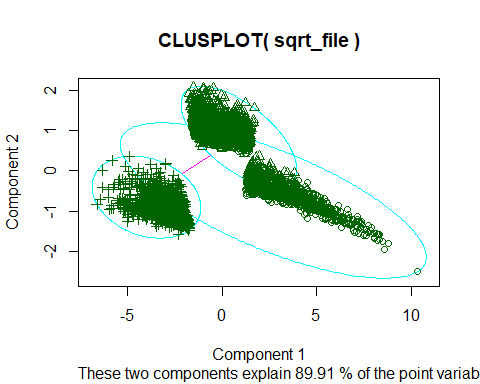
# mean shellweight by cluster  
aggregate(data = abl, shellweight ~ cluster, mean)

## cluster shellweight  
## 1 1 0.40222168  
## 2 2 0.08162065  
## 3 3 0.23012014

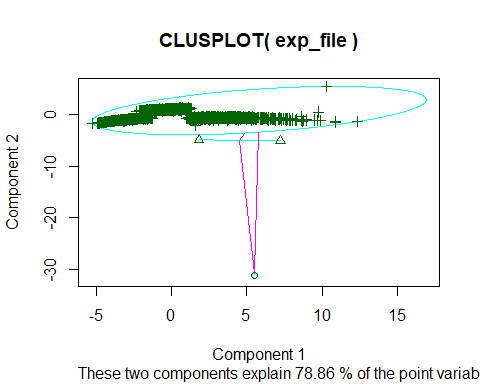
# mean number of rings by cluster  
aggregate(data = abl, rings ~ cluster, mean)

## cluster rings  
## 1 1 11.935615  
## 2 2 7.163127  
## 3 3 10.387479

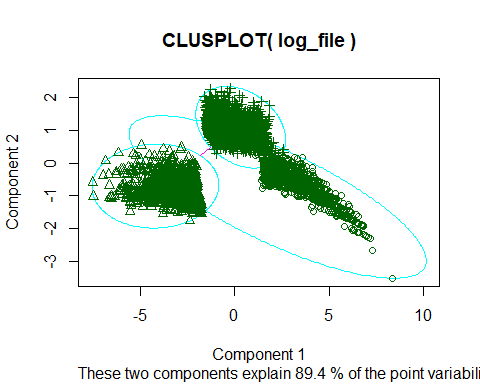
sqrt\_file <- abl\*\*0.5  
km <- kmeans(sqrt\_file, centers=3, nstart=20)  
clusplot(sqrt\_file, km$cluster)



exp\_file <- exp(abl)  
km <- kmeans(exp\_file, centers=3, nstart=20)  
clusplot(exp\_file, km$cluster)



log\_file <- log10(abl+1)  
km <- kmeans(log\_file, centers=3, nstart=20)  
clusplot(log\_file, km$cluster)



sq\_file <- abl\*\*2  
km <- kmeans(sq\_file, centers=3, nstart=20)  
clusplot(sq\_file, km$cluster)

