wine quality prediction\_multiple regression

## R Markdown

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When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document. You can embed an R code chunk like this:

Import to R the following file:

winequality <- read.csv(file = "http://archive.ics.uci.edu/ml/machine-learning-databases/wine-quality/winequality-white.csv", header = TRUE, sep = ";")

Divide the data to training and testing groups.

wine\_split <- sample(nrow(winequality), floor(nrow(winequality)\*0.7))  
train <- winequality[wine\_split,]  
test <- winequality[-wine\_split,]

Use the multiple Regression algorithm to predict the quality of wine using its attributes.

model\_lm <- lm(quality ~ ., data = train)  
summary(model\_lm)

##   
## Call:  
## lm(formula = quality ~ ., data = train)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -3.7111 -0.4921 -0.0434 0.4547 3.0579   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 1.983e+02 2.658e+01 7.462 1.07e-13 \*\*\*  
## fixed.acidity 1.226e-01 2.691e-02 4.556 5.39e-06 \*\*\*  
## volatile.acidity -1.841e+00 1.332e-01 -13.821 < 2e-16 \*\*\*  
## citric.acid -4.291e-02 1.124e-01 -0.382 0.70254   
## residual.sugar 9.811e-02 1.007e-02 9.742 < 2e-16 \*\*\*  
## chlorides -1.613e-01 6.191e-01 -0.260 0.79450   
## free.sulfur.dioxide 3.254e-03 9.895e-04 3.289 0.00102 \*\*   
## total.sulfur.dioxide -2.003e-04 4.511e-04 -0.444 0.65696   
## density -1.989e+02 2.693e+01 -7.386 1.90e-13 \*\*\*  
## pH 7.781e-01 1.320e-01 5.894 4.13e-09 \*\*\*  
## sulphates 6.278e-01 1.194e-01 5.259 1.54e-07 \*\*\*  
## alcohol 1.373e-01 3.380e-02 4.061 4.99e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.7391 on 3416 degrees of freedom  
## Multiple R-squared: 0.286, Adjusted R-squared: 0.2837   
## F-statistic: 124.4 on 11 and 3416 DF, p-value: < 2.2e-16

Now we can use backward elimination method

library(MASS)   
stepB <- stepAIC(model\_lm, direction= "backward", trace=TRUE)

## Start: AIC=-2060.37  
## quality ~ fixed.acidity + volatile.acidity + citric.acid + residual.sugar +   
## chlorides + free.sulfur.dioxide + total.sulfur.dioxide +   
## density + pH + sulphates + alcohol  
##   
## Df Sum of Sq RSS AIC  
## - chlorides 1 0.037 1866.3 -2062.3  
## - citric.acid 1 0.080 1866.3 -2062.2  
## - total.sulfur.dioxide 1 0.108 1866.4 -2062.2  
## <none> 1866.2 -2060.4  
## - free.sulfur.dioxide 1 5.909 1872.2 -2051.5  
## - alcohol 1 9.011 1875.3 -2045.9  
## - fixed.acidity 1 11.341 1877.6 -2041.6  
## - sulphates 1 15.108 1881.4 -2034.7  
## - pH 1 18.982 1885.2 -2027.7  
## - density 1 29.802 1896.1 -2008.1  
## - residual.sugar 1 51.845 1918.1 -1968.4  
## - volatile.acidity 1 104.357 1970.6 -1875.8  
##   
## Step: AIC=-2062.3  
## quality ~ fixed.acidity + volatile.acidity + citric.acid + residual.sugar +   
## free.sulfur.dioxide + total.sulfur.dioxide + density + pH +   
## sulphates + alcohol  
##   
## Df Sum of Sq RSS AIC  
## - citric.acid 1 0.089 1866.4 -2064.1  
## - total.sulfur.dioxide 1 0.109 1866.4 -2064.1  
## <none> 1866.3 -2062.3  
## - free.sulfur.dioxide 1 5.883 1872.2 -2053.5  
## - alcohol 1 8.985 1875.3 -2047.8  
## - fixed.acidity 1 11.941 1878.2 -2042.4  
## - sulphates 1 15.208 1881.5 -2036.5  
## - pH 1 19.959 1886.2 -2027.8  
## - density 1 31.057 1897.3 -2007.7  
## - residual.sugar 1 54.724 1921.0 -1965.2  
## - volatile.acidity 1 105.785 1972.1 -1875.3  
##   
## Step: AIC=-2064.14  
## quality ~ fixed.acidity + volatile.acidity + residual.sugar +   
## free.sulfur.dioxide + total.sulfur.dioxide + density + pH +   
## sulphates + alcohol  
##   
## Df Sum of Sq RSS AIC  
## - total.sulfur.dioxide 1 0.113 1866.5 -2065.9  
## <none> 1866.4 -2064.1  
## - free.sulfur.dioxide 1 5.824 1872.2 -2055.5  
## - alcohol 1 8.906 1875.3 -2049.8  
## - fixed.acidity 1 11.858 1878.2 -2044.4  
## - sulphates 1 15.138 1881.5 -2038.5  
## - pH 1 20.321 1886.7 -2029.0  
## - density 1 31.412 1897.8 -2008.9  
## - residual.sugar 1 55.106 1921.5 -1966.4  
## - volatile.acidity 1 107.217 1973.6 -1874.7  
##   
## Step: AIC=-2065.93  
## quality ~ fixed.acidity + volatile.acidity + residual.sugar +   
## free.sulfur.dioxide + density + pH + sulphates + alcohol  
##   
## Df Sum of Sq RSS AIC  
## <none> 1866.5 -2065.9  
## - free.sulfur.dioxide 1 7.665 1874.2 -2053.9  
## - alcohol 1 8.793 1875.3 -2051.8  
## - fixed.acidity 1 12.100 1878.6 -2045.8  
## - sulphates 1 15.032 1881.5 -2040.4  
## - pH 1 20.685 1887.2 -2030.2  
## - density 1 34.453 1901.0 -2005.2  
## - residual.sugar 1 58.210 1924.7 -1962.7  
## - volatile.acidity 1 113.032 1979.5 -1866.4

summary(stepB)

##   
## Call:  
## lm(formula = quality ~ fixed.acidity + volatile.acidity + residual.sugar +   
## free.sulfur.dioxide + density + pH + sulphates + alcohol,   
## data = train)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -3.6933 -0.4935 -0.0406 0.4561 3.0602   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 2.031e+02 2.533e+01 8.017 1.48e-15 \*\*\*  
## fixed.acidity 1.236e-01 2.625e-02 4.708 2.60e-06 \*\*\*  
## volatile.acidity -1.848e+00 1.284e-01 -14.389 < 2e-16 \*\*\*  
## residual.sugar 9.971e-02 9.657e-03 10.326 < 2e-16 \*\*\*  
## free.sulfur.dioxide 2.954e-03 7.883e-04 3.747 0.000182 \*\*\*  
## density -2.038e+02 2.565e+01 -7.944 2.63e-15 \*\*\*  
## pH 7.933e-01 1.289e-01 6.155 8.35e-10 \*\*\*  
## sulphates 6.237e-01 1.189e-01 5.247 1.64e-07 \*\*\*  
## alcohol 1.344e-01 3.348e-02 4.013 6.12e-05 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 0.7389 on 3419 degrees of freedom  
## Multiple R-squared: 0.2859, Adjusted R-squared: 0.2842   
## F-statistic: 171.1 on 8 and 3419 DF, p-value: < 2.2e-16

So we end up with using variables: fixed.acidity, volatile.acidity, residual.sugar, free.sulfur.dioxide, density, pH, sulphates, alcohol

new\_model <- lm(quality ~ fixed.acidity + volatile.acidity + residual.sugar +   
 free.sulfur.dioxide + density + pH + sulphates + alcohol, data = train)  
prediction = predict(new\_model, interval="prediction", newdata = test)  
prediction

## fit lwr upr  
## 1 5.542744 4.09188803 6.993600  
## 6 5.816660 4.36640617 7.266915  
## 7 5.446720 3.99742943 6.896010  
## 8 5.542744 4.09188803 6.993600  
## 11 6.227621 4.77724976 7.677992  
## 14 6.743444 5.29221800 8.194669  
## 15 5.675065 4.22310684 7.127023  
## 17 4.981946 3.53104698 6.432845  
## 19 5.801572 4.35202936 7.251115  
## 25 5.182220 3.72951278 6.634928  
## 28 5.867440 4.41774813 7.317131  
## 32 5.955282 4.50197061 7.408594  
## 34 5.644785 4.19398634 7.095583  
## 35 6.162889 4.71132618 7.614452  
## 40 5.668768 4.21765593 7.119879  
## 42 5.418085 3.96747882 6.868690  
## 52 6.160554 4.71089542 7.610214  
## 55 5.318687 3.86823131 6.769142  
## 57 5.965299 4.51540390 7.415194  
## 64 5.466884 4.01736013 6.916408  
## 65 5.674962 4.22567473 7.124249  
## 66 5.123822 3.67356967 6.574074  
## 71 5.410305 3.96067939 6.859931  
## 74 5.175149 3.72370039 6.626598  
## 75 6.027683 4.57812395 7.477243  
## 77 6.717953 5.26774714 8.168158  
## 78 6.239409 4.78951630 7.689302  
## 86 5.175285 3.72477609 6.625795  
## 94 6.711102 5.26097627 8.161228  
## 95 6.350872 4.90091203 7.800832  
## 99 5.678347 4.22355483 7.133140  
## 101 5.679069 4.22919979 7.128938  
## 107 6.132607 4.68089530 7.584320  
## 108 5.916594 4.46620115 7.366987  
## 113 5.468245 4.01805437 6.918436  
## 120 5.472141 4.02247564 6.921806  
## 121 5.622431 4.17285105 7.072012  
## 124 5.417136 3.96674529 6.867526  
## 127 5.704080 4.25456653 7.153594  
## 128 5.832558 4.38268641 7.282430  
## 129 5.944350 4.49489692 7.393804  
## 138 5.185416 3.73570570 6.635127  
## 144 5.738899 4.28812602 7.189671  
## 153 5.302376 3.85229930 6.752453  
## 154 5.957706 4.50807798 7.407334  
## 160 6.093377 4.64224604 7.544507  
## 163 5.628692 4.17906237 7.078322  
## 166 5.989113 4.53912500 7.439101  
## 172 6.060762 4.61074463 7.510779  
## 175 6.055451 4.60463081 7.506270  
## 176 6.318305 4.86814817 7.768462  
## 181 5.384212 3.93434574 6.834078  
## 185 5.725461 4.27525846 7.175664  
## 191 5.413064 3.96341265 6.862716  
## 192 5.600254 4.14886220 7.051646  
## 194 5.886918 4.43675632 7.337080  
## 203 5.358406 3.90726659 6.809546  
## 204 6.825246 5.37426077 8.276232  
## 210 5.250119 3.79836743 6.701871  
## 220 6.019702 4.56980589 7.469599  
## 226 5.751160 4.29948985 7.202830  
## 227 5.832590 4.38209568 7.283083  
## 231 4.768733 3.31546862 6.221996  
## 233 5.486702 4.03634266 6.937061  
## 249 6.065573 4.61522334 7.515923  
## 253 5.145081 3.69526177 6.594900  
## 257 5.879351 4.42956705 7.329135  
## 259 6.277808 4.82833615 7.727279  
## 261 6.134502 4.68460430 7.584400  
## 262 5.597824 4.14689882 7.048749  
## 270 5.171224 3.71902806 6.623421  
## 271 5.369502 3.92021436 6.818790  
## 278 5.708379 4.25773737 7.159021  
## 280 6.557824 5.10751685 8.008131  
## 288 5.666397 4.21654582 7.116248  
## 298 6.295427 4.84386092 7.746993  
## 299 6.022200 4.57215452 7.472246  
## 301 5.817802 4.36730039 7.268303  
## 307 5.365020 3.91535416 6.814685  
## 312 6.341651 4.88881260 7.794489  
## 317 5.982979 4.53368813 7.432270  
## 318 6.022129 4.57287714 7.471380  
## 319 6.324936 4.87419993 7.775672  
## 324 5.923040 4.47376609 7.372313  
## 326 6.135360 4.67857235 7.592147  
## 338 5.631238 4.18136415 7.081113  
## 342 5.363824 3.91313621 6.814511  
## 345 5.757428 4.30649077 7.208366  
## 346 5.829197 4.37917309 7.279221  
## 352 6.229997 4.77997815 7.680016  
## 355 5.377700 3.92763492 6.827766  
## 358 5.358766 3.90687546 6.810657  
## 359 5.664077 4.21160619 7.116547  
## 361 6.269451 4.81926084 7.719641  
## 365 6.298793 4.84818311 7.749404  
## 366 6.621796 5.17132644 8.072266  
## 369 5.835805 4.38610873 7.285501  
## 378 5.752520 4.30266594 7.202375  
## 381 5.752520 4.30266594 7.202375  
## 382 5.603176 4.15352596 7.052826  
## 386 6.454701 5.00367275 7.905729  
## 387 6.234935 4.78377523 7.686094  
## 394 6.526897 5.07698082 7.976814  
## 400 6.484065 5.03447633 7.933654  
## 404 5.649812 4.19946589 7.100159  
## 405 6.845537 5.39523053 8.295843  
## 408 4.927020 3.47582563 6.378215  
## 413 5.993503 4.54394618 7.443061  
## 416 5.911745 4.46045910 7.363032  
## 423 6.033893 4.58474492 7.483042  
## 424 6.033893 4.58474492 7.483042  
## 426 6.043865 4.59471588 7.493014  
## 430 5.623257 4.17376214 7.072752  
## 432 5.256456 3.80651130 6.706401  
## 437 5.503495 4.05373779 6.953252  
## 441 6.301461 4.85203570 7.750886  
## 442 5.832852 4.38246270 7.283241  
## 443 6.936739 5.48573066 8.387748  
## 444 5.253023 3.80211058 6.703936  
## 445 6.673565 5.22080959 8.126320  
## 447 6.368274 4.91708640 7.819462  
## 449 5.595934 4.14499566 7.046871  
## 452 5.756167 4.30658453 7.205750  
## 454 5.819569 4.37001808 7.269120  
## 456 5.583575 4.13265955 7.034491  
## 457 6.677145 5.22692688 8.127362  
## 459 5.513711 4.06261209 6.964810  
## 463 5.712841 4.26275186 7.162930  
## 464 5.259606 3.80945346 6.709758  
## 466 5.425690 3.97527755 6.876102  
## 472 5.473141 4.02235025 6.923932  
## 474 5.866148 4.41597497 7.316322  
## 478 5.742541 4.29293410 7.192147  
## 479 4.609463 3.15708409 6.061842  
## 480 5.927253 4.47695745 7.377549  
## 484 5.177164 3.72677911 6.627549  
## 486 5.849029 4.39843013 7.299628  
## 492 6.600147 5.15009192 8.050202  
## 498 6.624575 5.17475388 8.074396  
## 499 5.543229 4.09240631 6.994052  
## 508 5.777306 4.32617421 7.228437  
## 511 5.743926 4.29352976 7.194322  
## 512 6.102303 4.65228236 7.552323  
## 513 6.130839 4.68159638 7.580082  
## 524 5.850212 4.39975924 7.300665  
## 528 6.561965 5.11216306 8.011766  
## 529 6.253664 4.80298708 7.704342  
## 531 6.123664 4.67195066 7.575378  
## 544 5.927386 4.47776364 7.377008  
## 546 5.935501 4.48511364 7.385888  
## 547 5.795560 4.34531872 7.245801  
## 554 5.663992 4.21457234 7.113412  
## 555 6.300783 4.85070128 7.750865  
## 558 5.312615 3.86233649 6.762894  
## 560 6.519572 5.06792329 7.971221  
## 564 5.675363 4.22434741 7.126379  
## 566 5.791796 4.34233299 7.241258  
## 569 5.594307 4.14360228 7.045011  
## 580 6.466029 5.01559091 7.916468  
## 581 5.166026 3.71497787 6.617074  
## 585 5.762619 4.31280820 7.212431  
## 588 5.927437 4.47750047 7.377374  
## 589 5.986726 4.53691820 7.436533  
## 591 5.284344 3.83315031 6.735538  
## 593 5.303166 3.85356824 6.752763  
## 594 5.356423 3.90500102 6.807845  
## 598 5.942271 4.49320348 7.391338  
## 601 5.210549 3.76057876 6.660520  
## 602 5.742918 4.29231872 7.193517  
## 603 5.356423 3.90500102 6.807845  
## 607 5.601711 4.15137449 7.052048  
## 609 5.856617 4.40610046 7.307133  
## 613 5.288004 3.83809620 6.737912  
## 625 5.159502 3.70930499 6.609699  
## 627 4.830267 3.37845382 6.282080  
## 628 5.412119 3.96262900 6.861609  
## 633 6.002509 4.55287637 7.452141  
## 636 6.242559 4.79235336 7.692764  
## 637 6.225378 4.77573712 7.675018  
## 640 5.889475 4.43920419 7.339745  
## 644 5.749533 4.30000371 7.199062  
## 645 5.754028 4.30445738 7.203599  
## 650 5.550581 4.10092849 7.000234  
## 652 5.550581 4.10092849 7.000234  
## 654 5.730188 4.28031706 7.180059  
## 657 6.086946 4.63624297 7.537648  
## 658 5.501834 4.05221834 6.951450  
## 662 6.856098 5.40484566 8.307350  
## 665 5.913837 4.46402855 7.363646  
## 667 6.716625 5.26603487 8.167214  
## 668 5.913837 4.46402855 7.363646  
## 669 5.890688 4.44077293 7.340603  
## 672 6.190185 4.74086447 7.639506  
## 673 6.899704 5.44771991 8.351688  
## 674 5.807771 4.35795207 7.257589  
## 676 5.314511 3.86485636 6.764166  
## 683 5.555356 4.10531790 7.005395  
## 687 6.034057 4.58478702 7.483327  
## 693 5.551125 4.10132974 7.000920  
## 694 5.479865 4.02991546 6.929815  
## 695 5.895409 4.44472434 7.346093  
## 696 5.695536 4.24578687 7.145284  
## 697 6.184288 4.73480317 7.633772  
## 700 5.685989 4.23601255 7.135966  
## 704 5.558778 4.10920565 7.008351  
## 706 5.946399 4.49537037 7.397428  
## 708 6.040635 4.58837299 7.492898  
## 709 5.843998 4.39361200 7.294383  
## 712 6.241166 4.79065876 7.691674  
## 714 5.789955 4.34033181 7.239578  
## 716 5.996557 4.54599319 7.447121  
## 724 6.254367 4.80466661 7.704066  
## 725 5.948381 4.49804048 7.398721  
## 729 5.960156 4.51008403 7.410227  
## 734 5.585913 4.13606839 7.035757  
## 741 6.227288 4.77658938 7.677986  
## 748 6.240905 4.79073723 7.691073  
## 752 5.997008 4.54617946 7.447836  
## 757 5.591865 4.14131641 7.042414  
## 763 5.610268 4.15949676 7.061039  
## 768 6.057595 4.60763848 7.507552  
## 770 5.950137 4.49935521 7.400918  
## 771 6.053764 4.60308901 7.504439  
## 778 5.600072 4.15057692 7.049566  
## 785 5.600072 4.15057692 7.049566  
## 795 5.247940 3.79774907 6.698131  
## 800 6.297332 4.84714589 7.747518  
## 801 5.399834 3.95023025 6.849438  
## 803 5.259108 3.80891080 6.709304  
## 814 5.683185 4.23215439 7.134216  
## 818 4.829918 3.37887442 6.280961  
## 820 4.829918 3.37887442 6.280961  
## 826 5.749632 4.30041650 7.198848  
## 827 5.874028 4.42454727 7.323509  
## 831 5.679802 4.22453703 7.135066  
## 835 5.679802 4.22453703 7.135066  
## 837 6.369507 4.91988276 7.819132  
## 839 6.369507 4.91988276 7.819132  
## 841 6.244353 4.79440050 7.694306  
## 843 5.431664 3.98115762 6.882170  
## 844 5.839098 4.38890249 7.289294  
## 846 6.198546 4.74872948 7.648363  
## 847 5.678867 4.22827231 7.129462  
## 848 5.766261 4.31401117 7.218510  
## 852 5.533459 4.08304114 6.983876  
## 855 5.916090 4.46232622 7.369853  
## 861 5.986899 4.53556208 7.438237  
## 863 5.669926 4.21928318 7.120569  
## 864 6.375013 4.92563210 7.824394  
## 868 5.535625 4.08443586 6.986813  
## 871 5.120536 3.66949210 6.571579  
## 874 5.453541 3.99863638 6.908446  
## 880 6.709796 5.25784512 8.161747  
## 881 5.795797 4.34623782 7.245356  
## 884 6.275939 4.82656040 7.725317  
## 885 5.872136 4.42246387 7.321809  
## 886 6.453850 5.00341101 7.904289  
## 887 6.088021 4.63871686 7.537325  
## 888 6.125251 4.67510782 7.575394  
## 889 6.088021 4.63871686 7.537325  
## 890 6.125251 4.67510782 7.575394  
## 891 5.714150 4.26375543 7.164545  
## 892 6.129584 4.67945656 7.579712  
## 894 6.327525 4.87775547 7.777295  
## 898 5.574499 4.12483534 7.024164  
## 899 5.775173 4.32524785 7.225098  
## 903 5.437311 3.98708524 6.887538  
## 913 5.517379 4.06757542 6.967182  
## 914 5.301964 3.85038171 6.753546  
## 915 5.069095 3.61827870 6.519912  
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## 4838 6.713046 5.26090394 8.165189  
## 4846 5.263697 3.81327051 6.714124  
## 4851 5.987682 4.53694073 7.438423  
## 4853 6.160398 4.70974527 7.611050  
## 4854 6.307366 4.85690820 7.757825  
## 4856 5.531612 4.08119297 6.982032  
## 4866 6.683464 5.23240398 8.134524  
## 4872 6.571411 5.12091056 8.021911  
## 4875 5.840218 4.38954652 7.290889  
## 4877 6.114726 4.66498045 7.564471  
## 4881 5.658931 4.20872804 7.109135  
## 4883 5.614752 4.16410231 7.065401  
## 4884 5.912494 4.46044376 7.364545  
## 4885 5.690095 4.24001911 7.140171  
## 4891 6.210379 4.76031631 7.660441  
## 4895 5.645586 4.19602051 7.095152