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1 Stepwise Regression (using R

SPSS can be very opaque in determining how particularly statistical routines are carried out. Conversely the statistical programming language R is usually quite clear, once a familiarity with the language has been developed.

For variable selection procedures, R used the AIC criterion. When comparing multiple candidate models, the candidate model with the lowest AIC value is the best model. We will use R output to revise variable selection procedures. Recall that we used the *mtcars* data set. The data was extracted from the 1974 Motor Trend US magazine, and comprises fuel consumption and 10 aspects of automobile design and performance for 32 automobiles (197374 models). For this data, we tried to determine the optimal set of independent variables to predict the dependent variables *mpg* (miles per gallon).

cyl Number of cylinders

disp Displacement (cu.in.)

hp Gross horsepower

drat Rear axle ratio

wt Weight (lb/1000)

qsec 1/4 mile time

vs V/S

am Transmission (0 = automatic, 1 = manual)

gear Number of forward gears

carb Number of carburetors

1.1 Backward Elimination

The initial model contains all of the independent variables. Candidate models, whereby each of the independent variables are individually removed from the model are fitted. The AIC value for each reduced model is computed. The unreduced model is also used for comparison. The AIC values are tabulated to determine which removal results in the lowest AIC value. In this first case, the removal of cyl would reduced the AIC value from 70.898 (see bottom row) to 68.915. Thus the independent variable cyl is removed from the set of IVs.

Start: AIC=70.9

`mpg ~ cyl + disp + hp + drat + wt + qsec + vs + am + gear + carb`

	Df	Sum of Sq	RSS	AIC
- cyl	1	0.0799	147.57	68.915
- vs	1	0.1601	147.66	68.932

```

- carb 1 0.4067 147.90 68.986
- gear 1 1.3531 148.85 69.190
- drat 1 1.6270 149.12 69.249
- disp 1 3.9167 151.41 69.736
- hp 1 6.8399 154.33 70.348
- qsec 1 8.8641 156.36 70.765
<none> 147.49 70.898
- am 1 10.5467 158.04 71.108
- wt 1 27.0144 174.51 74.280

```

In the second phase, the process is repeated. This time removing `vs` results in an AIC value of 66.973. It is then removed from the set of IVs. For this phase, the unreduced model is the model fitted by all independent variables except `cyl`, which was removed in the previous phase.

```

Step: AIC=68.92
mpg ~ disp + hp + drat + wt + qsec + vs + am + gear + carb

      Df Sum of Sq    RSS    AIC
- vs   1    0.2685 147.84 66.973
- carb 1    0.5201 148.09 67.028
- gear 1    1.8211 149.40 67.308
- drat 1    1.9826 149.56 67.342
- disp 1    3.9009 151.47 67.750
- hp   1    7.3632 154.94 68.473
<none>      147.57 68.915
- qsec 1   10.0933 157.67 69.032
- am   1   11.8359 159.41 69.384
- wt   1   27.0280 174.60 72.297

```

this process continues until the removal of an IV will not results in an improvement in AIC. This is indicated by having the `< none >` (i.e unreduced model) having the lowest AIC value. At the end of the output is the optimal model, according to the backward elimination procedure, using the IVs : `am` , `qsec` and `wt`.

```

Step: AIC=61.31
mpg ~ wt + qsec + am

```

```

      Df Sum of Sq    RSS    AIC

```

```

<none>                169.29 61.307
- am      1      26.178 195.46 63.908
- qsec    1     109.034 278.32 75.217
- wt      1     183.347 352.63 82.790

Call:
lm(formula = mpg ~ wt + qsec + am)

Coefficients:
(Intercept)          wt          qsec          am
      9.618      -3.917       1.226       2.936

```

1.2 Stepwise Regression

Stepwise Regression differs from Backward Elimination, in that it allows IVs to be re-introduced. Hence the + signs from the second phase onwards.

```
mpg ~ cyl + disp + hp + drat + wt + qsec + vs + am + gear + carb
```

	Df	Sum of Sq	RSS	AIC
- cyl	1	0.0799	147.57	68.915
- vs	1	0.1601	147.66	68.932
- carb	1	0.4067	147.90	68.986
- gear	1	1.3531	148.85	69.190
- drat	1	1.6270	149.12	69.249
- disp	1	3.9167	151.41	69.736
- hp	1	6.8399	154.33	70.348
- qsec	1	8.8641	156.36	70.765
<none>			147.49	70.898
- am	1	10.5467	158.04	71.108
- wt	1	27.0144	174.51	74.280

Step: AIC=68.92

```
mpg ~ disp + hp + drat + wt + qsec + vs + am + gear + carb
```

	Df	Sum of Sq	RSS	AIC
- vs	1	0.2685	147.84	66.973
- carb	1	0.5201	148.09	67.028
- gear	1	1.8211	149.40	67.308
- drat	1	1.9826	149.56	67.342
- disp	1	3.9009	151.47	67.750
- hp	1	7.3632	154.94	68.473
<none>			147.57	68.915

```

- qsec 1 10.0933 157.67 69.032
- am 1 11.8359 159.41 69.384
+ cyl 1 0.0799 147.49 70.898
- wt 1 27.0280 174.60 72.297

```

Again, the procedure finishes when it is found that the unchanged model has the lowest of all possible AIC values.

```

Step: AIC=61.31
mpg ~ wt + qsec + am

```

	Df	Sum of Sq	RSS	AIC
<none>			169.29	61.307
+ hp	1	9.219	160.07	61.515
+ carb	1	8.036	161.25	61.751
+ disp	1	3.276	166.01	62.682
+ cyl	1	1.501	167.78	63.022
+ drat	1	1.400	167.89	63.042
+ gear	1	0.123	169.16	63.284
+ vs	1	0.000	169.29	63.307
- am	1	26.178	195.46	63.908
- qsec	1	109.034	278.32	75.217
- wt	1	183.347	352.63	82.790

```

Call:
lm(formula = mpg ~ wt + qsec + am)

```

```

Coefficients:
(Intercept)          wt          qsec          am
      9.618       -3.917        1.226        2.936

```