Stopping stepwise: Why stepwise and similar selection methods are bad, and what you should use

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NESUG, November, 2007
Outline

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Garbage in, fake pearls out

Sorting pearls from garbage

Garbage in, total garbage out

Garbage disposal: Some solutions

Summary and further reading
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Summary and further reading
The problem

- Too many IVs in regression
- Not sure which are good
- Need some help in speeding the selection process
- Problem exists in many types of regression
Extent of this talk

- Brief theory on stepwise
- Various example data sets
- No bootstrapping, etc.
- PROC GLMSELECT, lasso and lars
- Only OLS regression
- ‘Stepwise’ used for forward, backward, stepwise etc.
Some theory on why stepwise is bad

- The basic problem - one test vs. many
- The result:
  - Standard errors too small
  - p-values too small
  - Parameter estimates biased away from 0
  - Models too complex
You hope that you never do a regression with all noise.
If you do, you hope that the output says it’s all noise.
100 cases, 50 variables

- For the first test, we ran a regression with 100 subjects and 50 independent variables — all noise
- The defaults in stepwise are SLE = .15, SLS = .15
- The final model included 15 IVs, 5 sig at $p < .05$
- Forward: default SLE = .50, 29 IVs, 5 sig at $p < .05$
- Backward: default SLS = .10, 10 IVs, 8 sig at $p < .05$
1000 cases, 50 variables

- That’s a lot of IVs per subject, but with N = 1000
- The final stepwise model had 10 IVs, again, 5 sig. at $p < .05$
- Forward: 28 IVs, 5 sig. at $p < .05$
- Backward: 8 IVs, 5 sig. at $p < .05$
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- More often, some of your IVs are real and some are noise
- Here, you want to sort the pearls from the garbage
100 cases, 50 + 1 variables

- If we add one IV that is linearly related to the DV, \( r = .32 \)
- Stepwise with the default settings has 4 IVs, including the real one
- Backward: Real one plus 1
- Forward: Real one plus 23
With 1000 cases, 51 IVs, one real, same r
Stepwise: Real variable is included, but so are 9 others, 5 at .05
Forward: Real and 27 others, 5 at .05
Backward: Real and 6 others, all at .05
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Summary and further reading
A single outlier in a perfect world

- Sometimes, you violate assumptions
- Outliers and leverage points happen
- \( N = 100, \) 5 noise IVs, 1 real, 1 outliers
- Forward: real variable included, and 2 others, param est on real was .76 (not 1)
- Stepwise and backward: Only real variable included, but param est now .72 (not 1)
Multiple outliers in that perfect world

► N = 100, 5 noise IVs, 1 real, 2 outliers
► Stepwise and backward: Only real variable included, but param est now .44 (not 1)
► Forward: Real and 2 others, parameter est = .44
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- If you can, the best solution is expert knowledge
- If the key is not the particular IVs and explanation: PLS, multimodel averaging
- If there are a small number of sensible models: AIC or BIC
- Otherwise.....LASSO or LAR
PROC GLMSELECT - introduction

- Experimental PROC in v9
- Download from SAS website
- Implements a variety of model selection schemes
- Has a variety of cross-validation methods
- Not intended to replace PROC GLM or REG, too few options
PROC GLMSELECT <options>;
CLASS variable;
MODEL variable = <effects></options>;
SCORE <DATA = dataset> <OUT = dataset> ;
PROC GLMSELECT statement — key options

- DATA =
- TESTDATA =
- VALDATA =
- PLOTS =
MODEL statement - selection options

- Forward
- Backward
- Stepwise
- Lasso
- LAR
The CHOOSE = criterion option chooses from a list of models based on a criterion

Available criteria are: adjrsq, aic, aicc, bic, cp, cv, press, sbc, validate

CV is residual sum squares based on k-fold CV

VALIDATE is avg. sq. error for validation data
The STOP = criterion option stops the selection process.

Available criteria are: adjrsq, aic aicc, bic, cp cv, press, sbc, sl, validate
MODEL statement - some other options

- HIERARCHY =
- CVDETAILS= AND CVMETHOD=
- STATS =
- STB
Uses of GLMSELECT

- You can combine the options in lots of ways. e.g.
  ```r
  selection = forward(stop = AIC s1e = .2)
  selection = forward(stop = 20 choose = AICC)
  ```
Brief theory of LASSO

- Least Absolute Shrinkage Selection Operator — Developed by Tibshirani (1994)
- Shrinkage method
- Constrains the sum of the absolute regression coefficients
- Center and scale all variables then minimize

$$||y - X\beta||^2 \quad \text{subject to} \quad \sum_{j=1}^{m} |\beta_j| \leq t$$
LASSO with defaults applied to the above problems

- $N = 100$, 50 IVs, all noise . . . none selected
- $N = 1000$, 50 IVs, all noise . . . none selected
- $N = 100$, 50 noise variables, 1 real . . . none selected
- $N = 1000$, 50 noise variables, 1 real . . . only real selected
- $N = 100$, 5 noise variables, 1 real, 1 outlier . . . . . . . param est now .99
- $N = 100$, 5 noise variables, 1 real, 2 outliers . . . . . . . no variables included
Brief theory of LAR

▶ Least Angle Regression - developed by Efron, Hastie, Johnstone & Tibshirani (2004)
▶ All variables are centered, covariates are scaled
▶ Starts with all parameters = 0
▶ Adds parameters based on correlations with current residual
▶ Results on above problems essentially identical with LASSO
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Summary and further reading
In any statistical problem, the key is substantive knowledge.
If that is not available, then methods such as LASSO and LAR are better than standard methods.
Further reading

- On the general problem:
  1. Harrell: Regression modeling strategies
  2. Burnham and Anderson: Model selection and multimodel averaging

- On LASSO and LARS
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