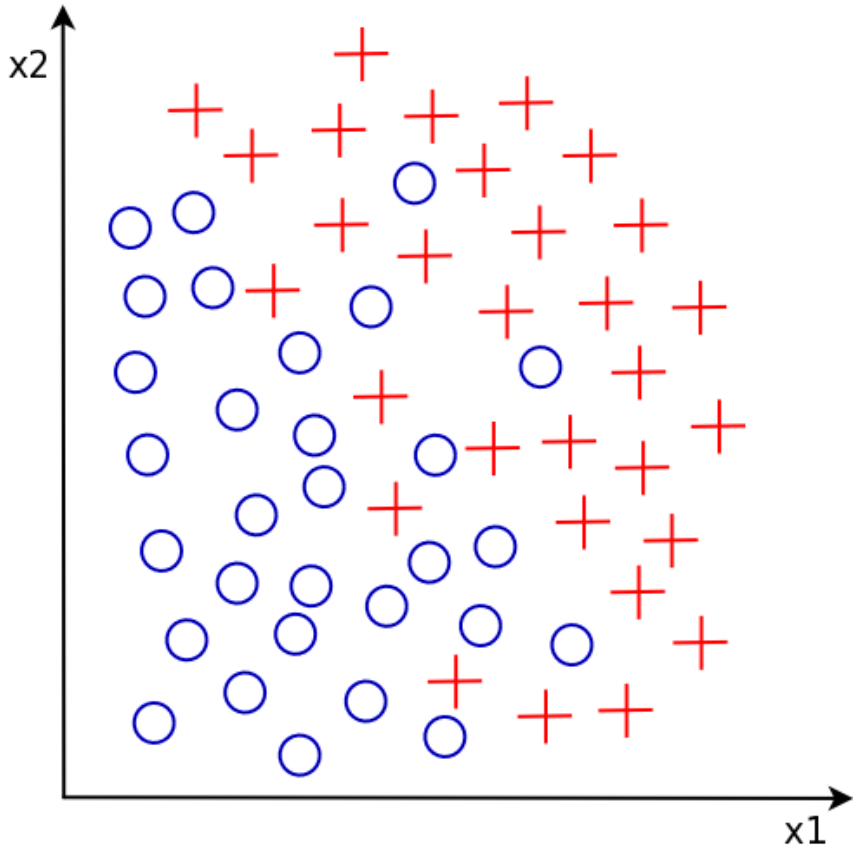
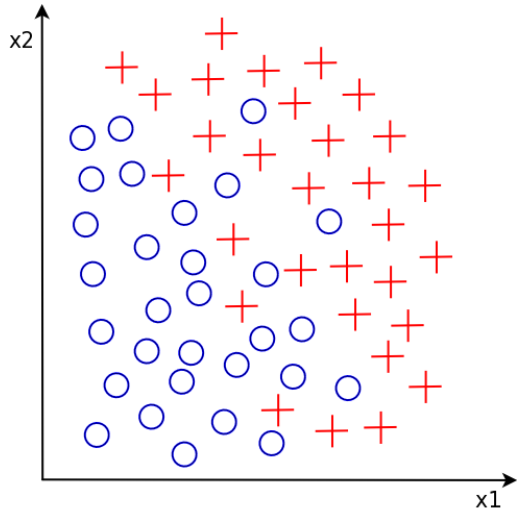
Cross-validation

Classification task

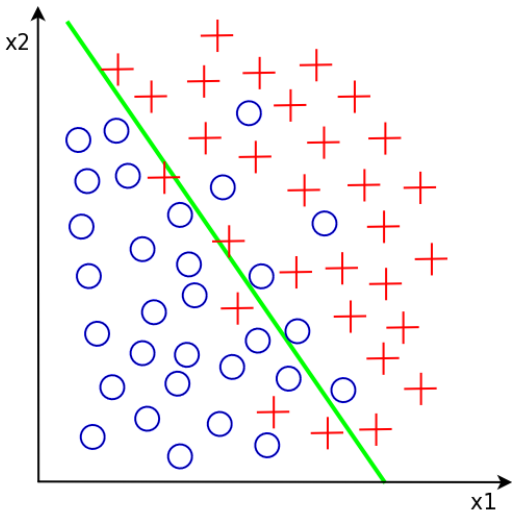


- task: classify future independent observations drawn from the same distribution
- how to choose a (classification) model?

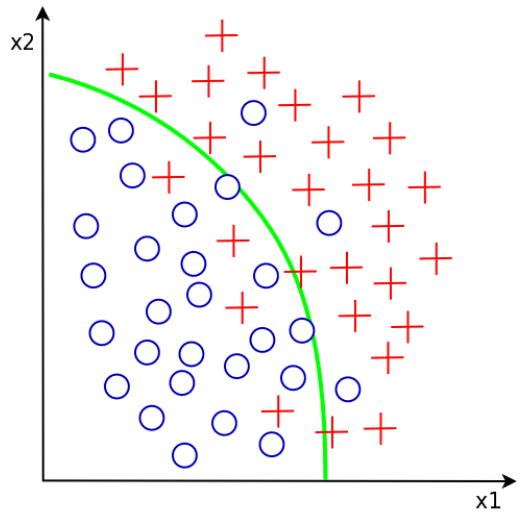
Model selection (1)



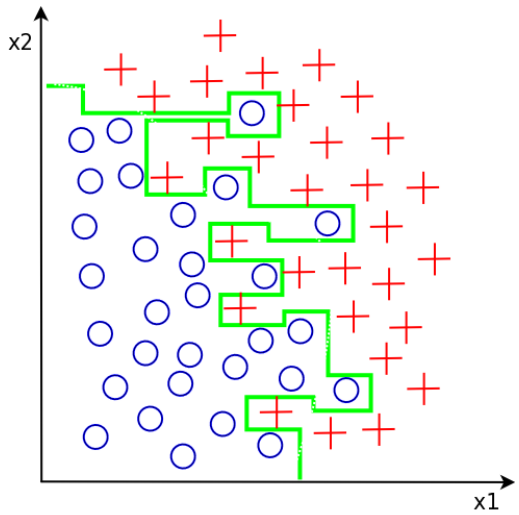
model 1



model 2

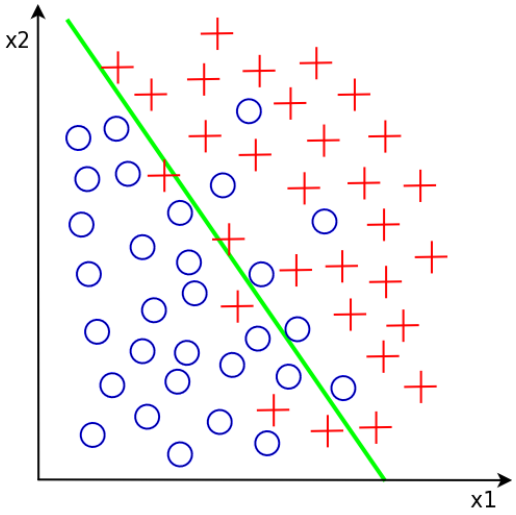


model 3



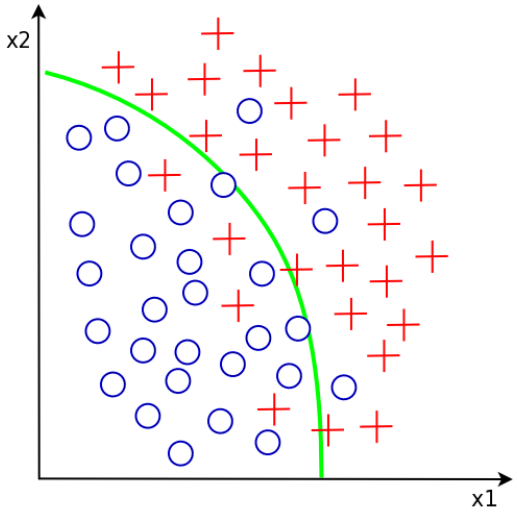
Model selection (2)

model 1



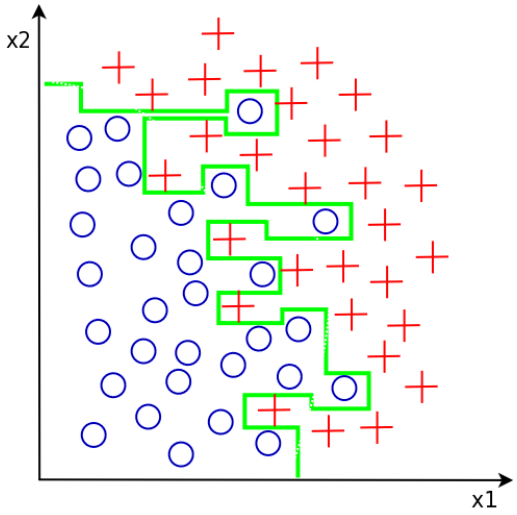
10 missclassifications
2 parameters

model 2



7 missclass.
4 parameters

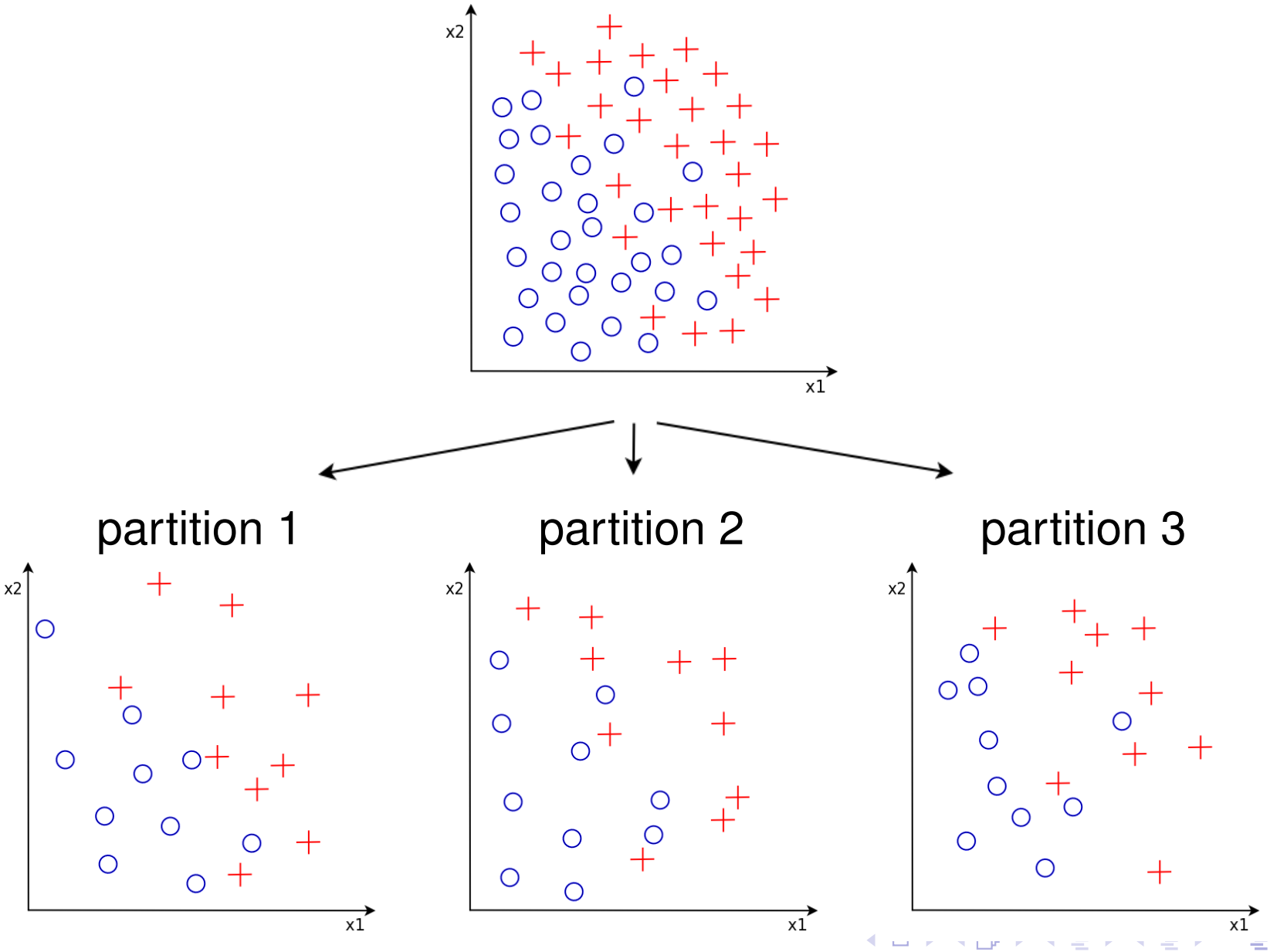
model 3



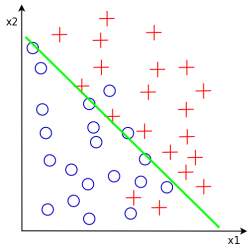
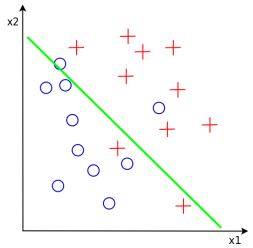
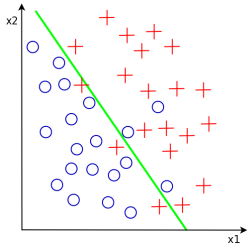
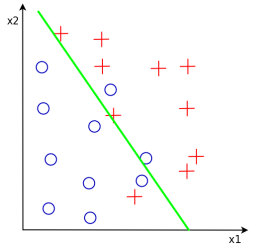
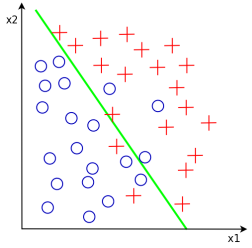
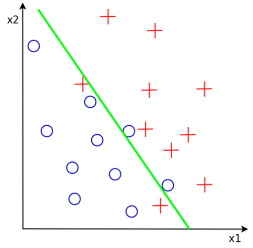
0 missclass.
72 parameters

- which model is the best?

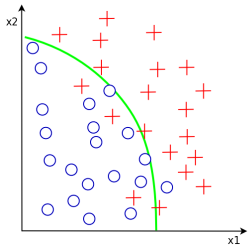
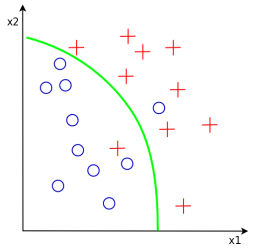
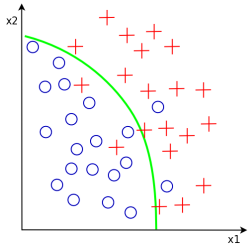
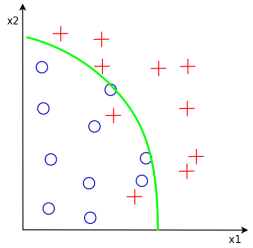
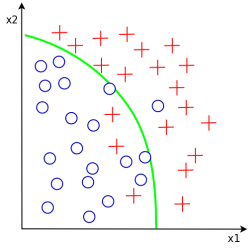
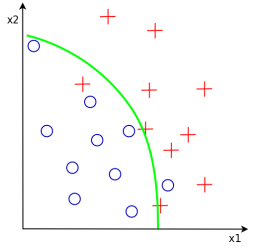
Cross-validation: data splitting



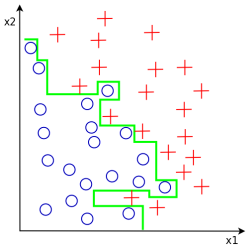
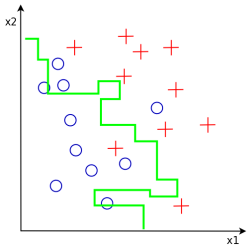
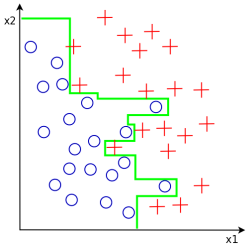
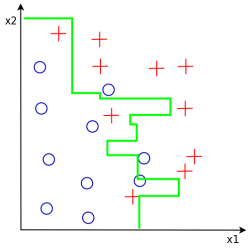
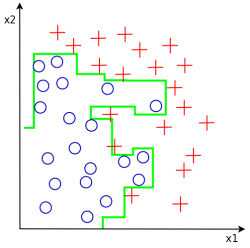
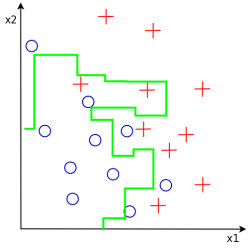
Cross-validating model 1

training set	train error	testing set	test error	**mean test error**
partition 1+2 	4/20	partition 3 	4/10	
partition 1+3 	6/20	partition 2 	3/10	**11/30**
partition 2+3 	5/20	partition 1 	4/10	

Cross-validating model 2

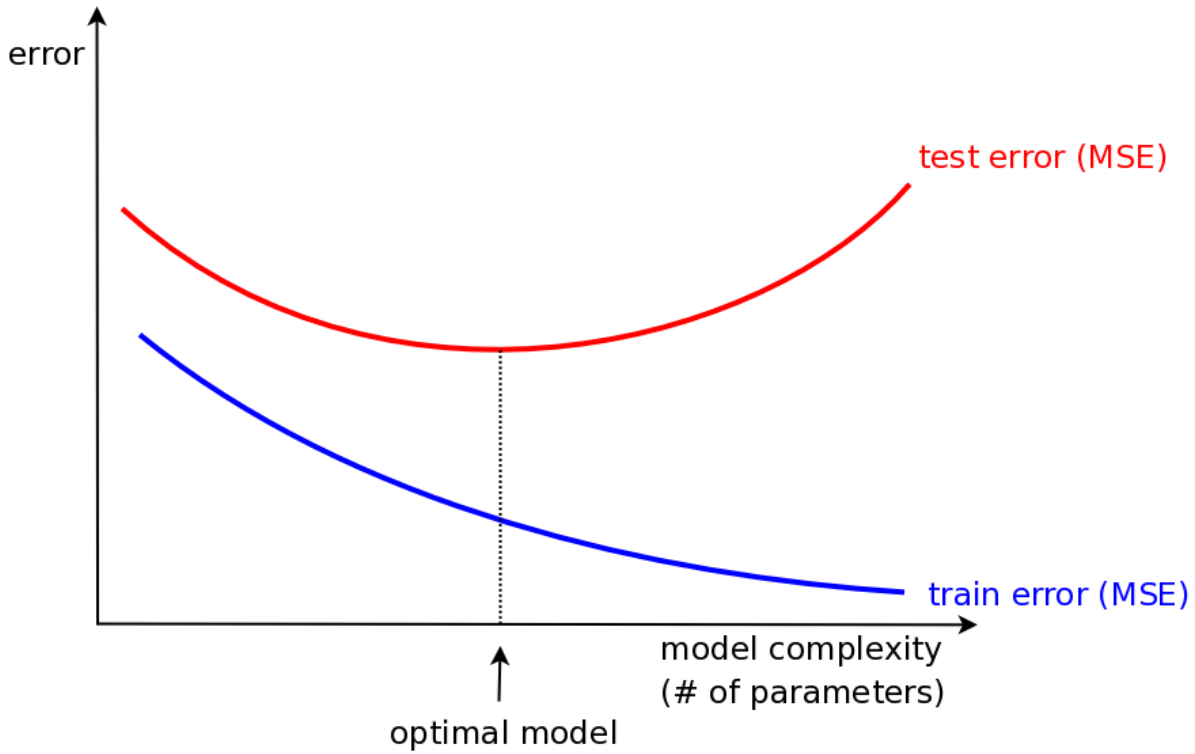
training set	train error	testing set	test error	**mean test error**
partition 1+2 	4/20	partition 3 	2/10	
partition 1+3 	4/20	partition 2 	2/10	**6/30**
partition 2+3 	4/20	partition 1 	2/10	

Cross-validating model 3

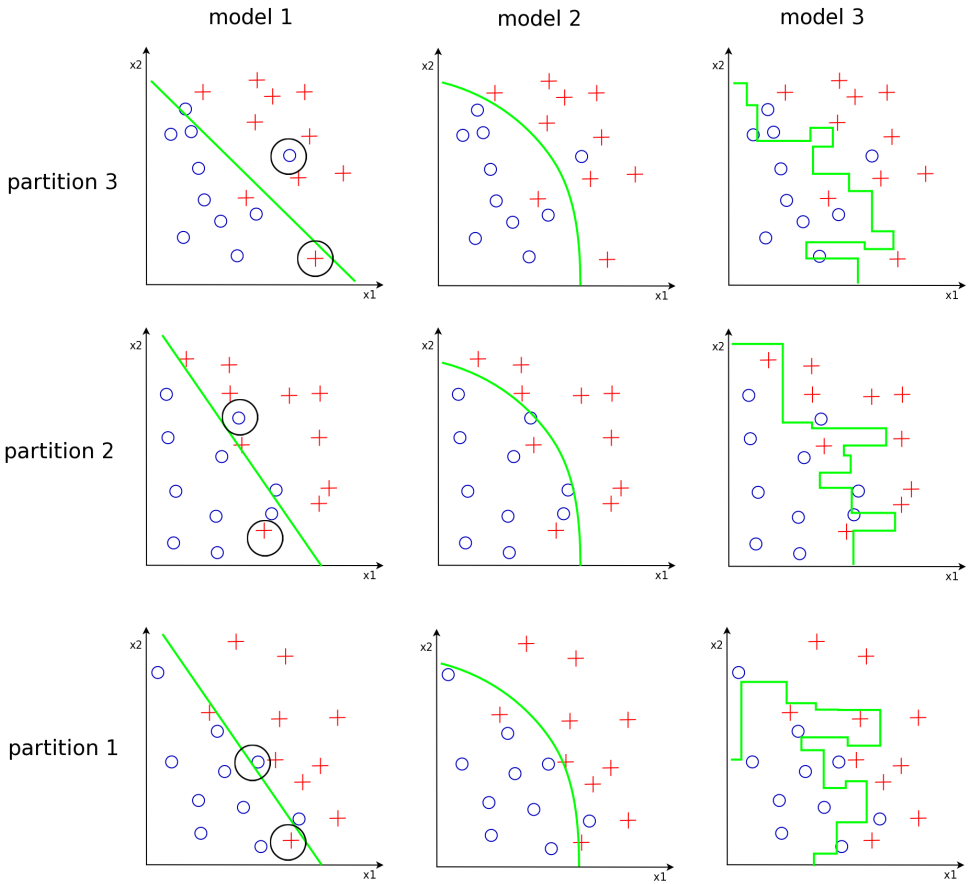
training set	train error	testing set	test error	**mean test error**
partition 1+2 	0	partition 3 	5/10	
partition 1+3 	0	partition 2 	5/10	**16/30**
partition 2+3 	0	partition 1 	6/10	

Cross-validating models
Summary

model	1	2	3
# of parameters	2	4	72
mean train error	15/60	12/60	0
mean test error	11/30	**6/30**	16/30



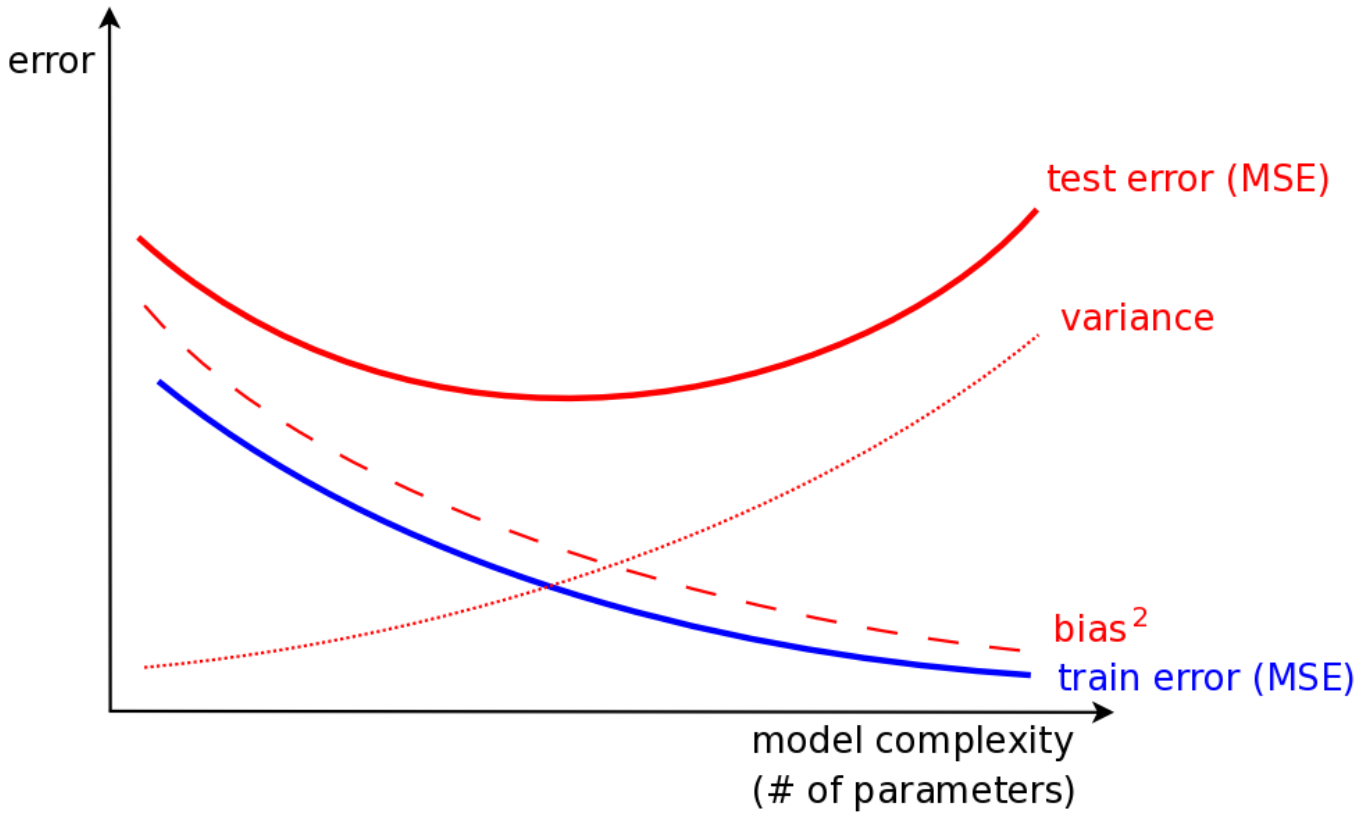
Model comparison
Test set performance



- model 1 is biased
- model 3 is highly variable and overfits the data

Cross-validation: summary

- MSE = bias^2 + variance



- high bias for low-complexity models
- high variance for high-complexity models

Cross-validation: conclusion

- CV can be seen as regularization technique
  - helps to overcome overfitting
  - note some models regularize naturally
    - e.g. nonparametric Bayesian models - see Maneesh's lectures
- CV can be seen as model selection technique