

Biostat 202: Opportunities and Challenges of “Big Data”.

Machine Learning 2:

Classification

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Overview

- Auto-numeric node Modeler Demo
- Classification
- Model evaluation
- Training-test
- Classification methods
 - Logistic Regression
 - K-nearest neighbors
- IBM SPSS Data Modeler examples left for todays lab

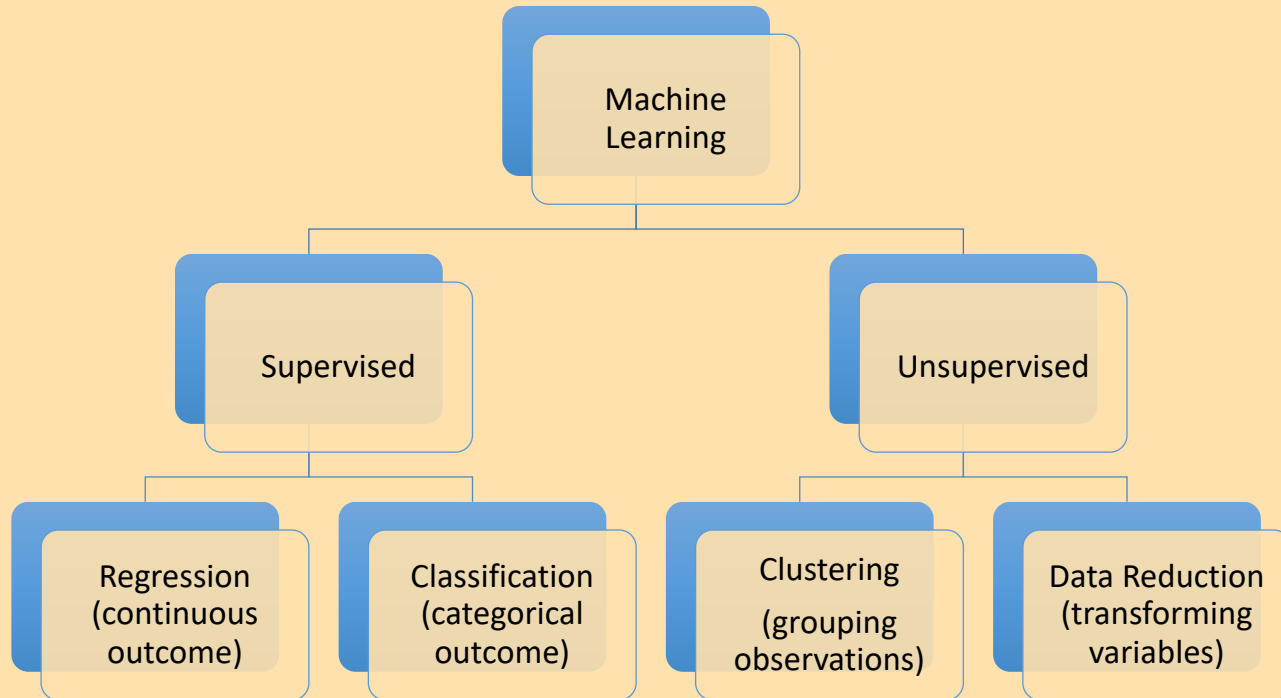
Brain volumes dataset Modeler demo

- Use regional brain volumes to predict age of subject in healthy controls with a range of ages – Target = Age, Predictors = regional volumes + demographic variables
- ROI volumes are the main predictors:
Extract 136 ROIs as predictors for each subject – big data?
- ROIs are defined in terms of anatomical regions and landmarks in the human brain that are common to all individuals – often have specific functional roles

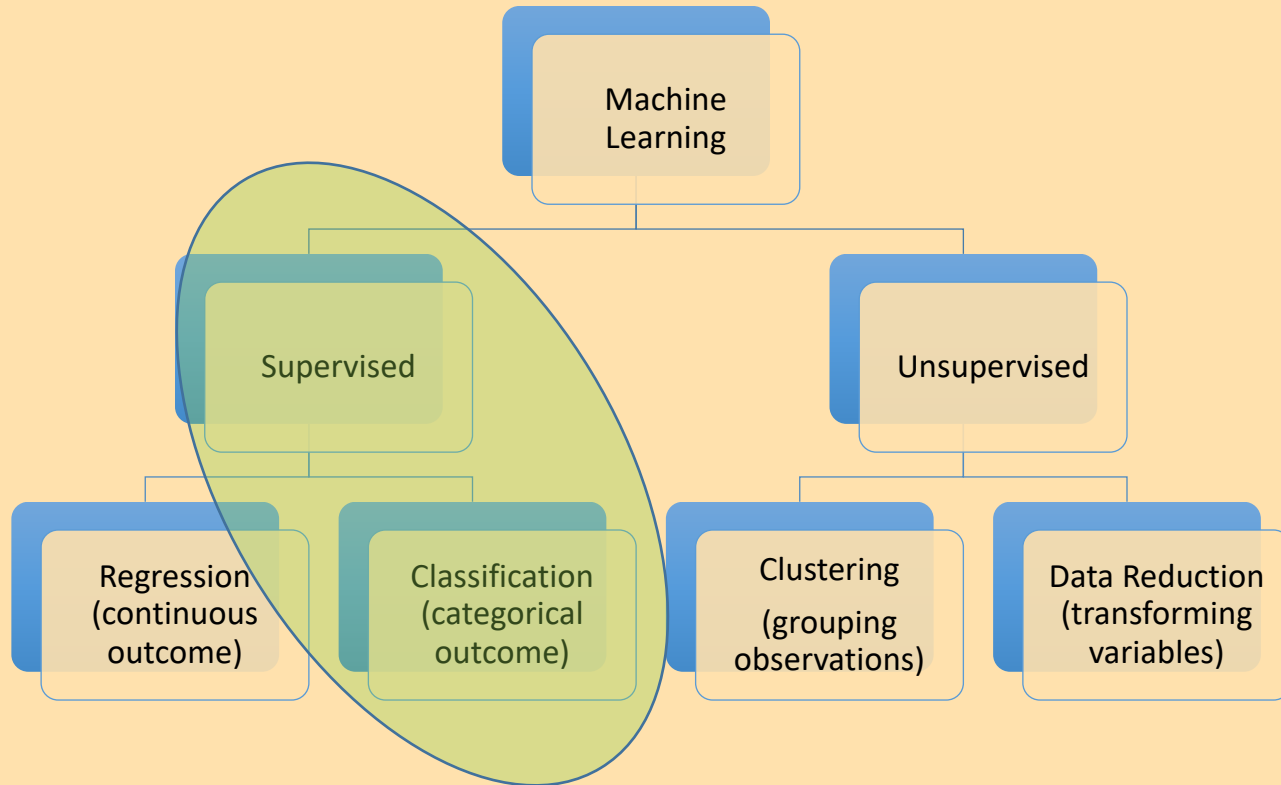


Classification

Supervised vs. unsupervised



Supervised vs. unsupervised



Classification

- Objective – given set of predictors and some training data, generate a rule (classifier) to predict which category a new instance/observation/subject belongs to
- Training data with observed predictors and outcomes (target) used to develop a classifier
- Classifier is applied to new data where the outcome (i.e. target group/class) is unknown
- Let's look at a toy example trying to classify 1st vs. 6th grade girls based on height and weight....

1st grade vs. 6th grade girls: height vs. weight

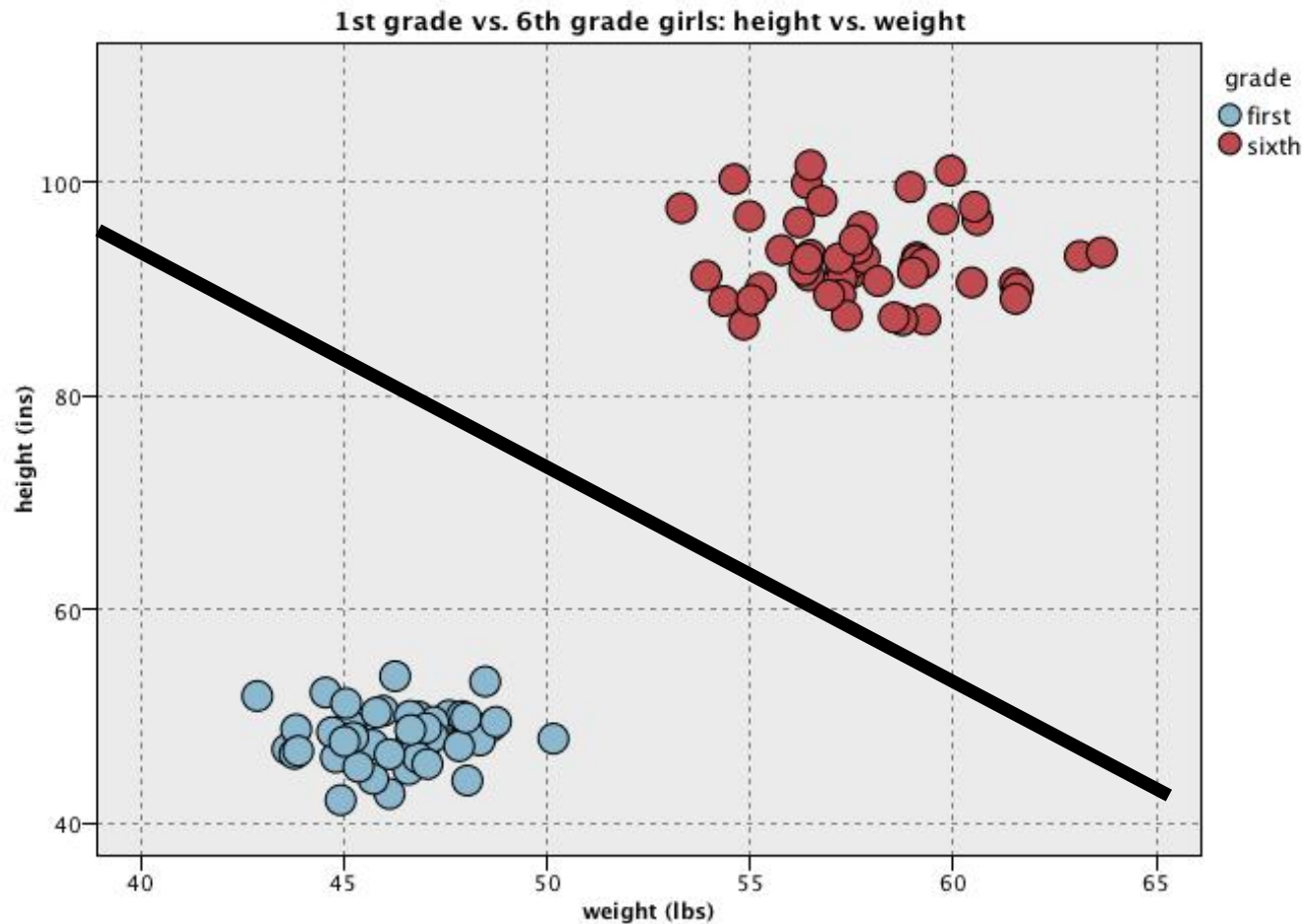
grade

- first
- sixth

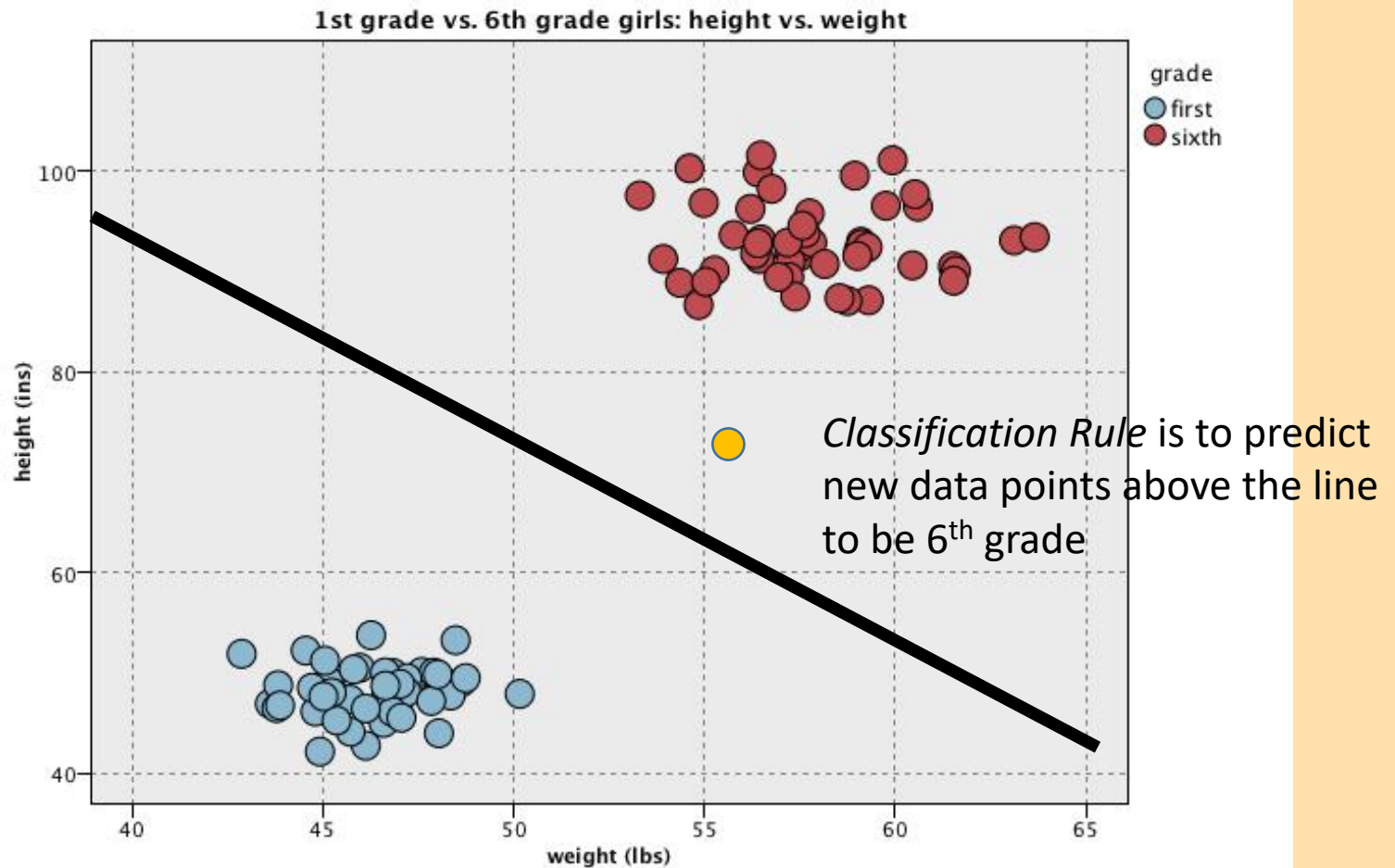
height (ins)

weight (lbs)

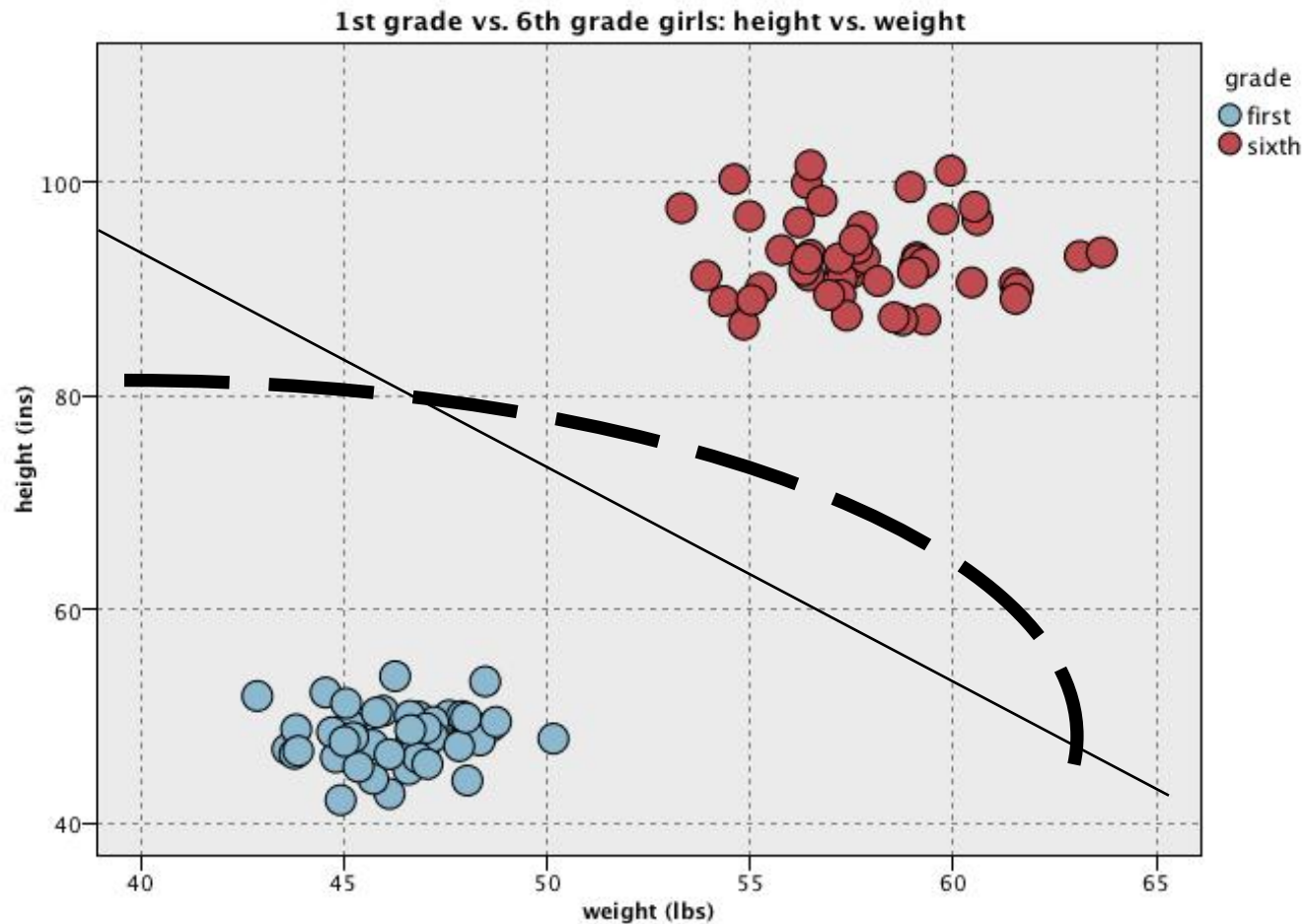
2D Classification example



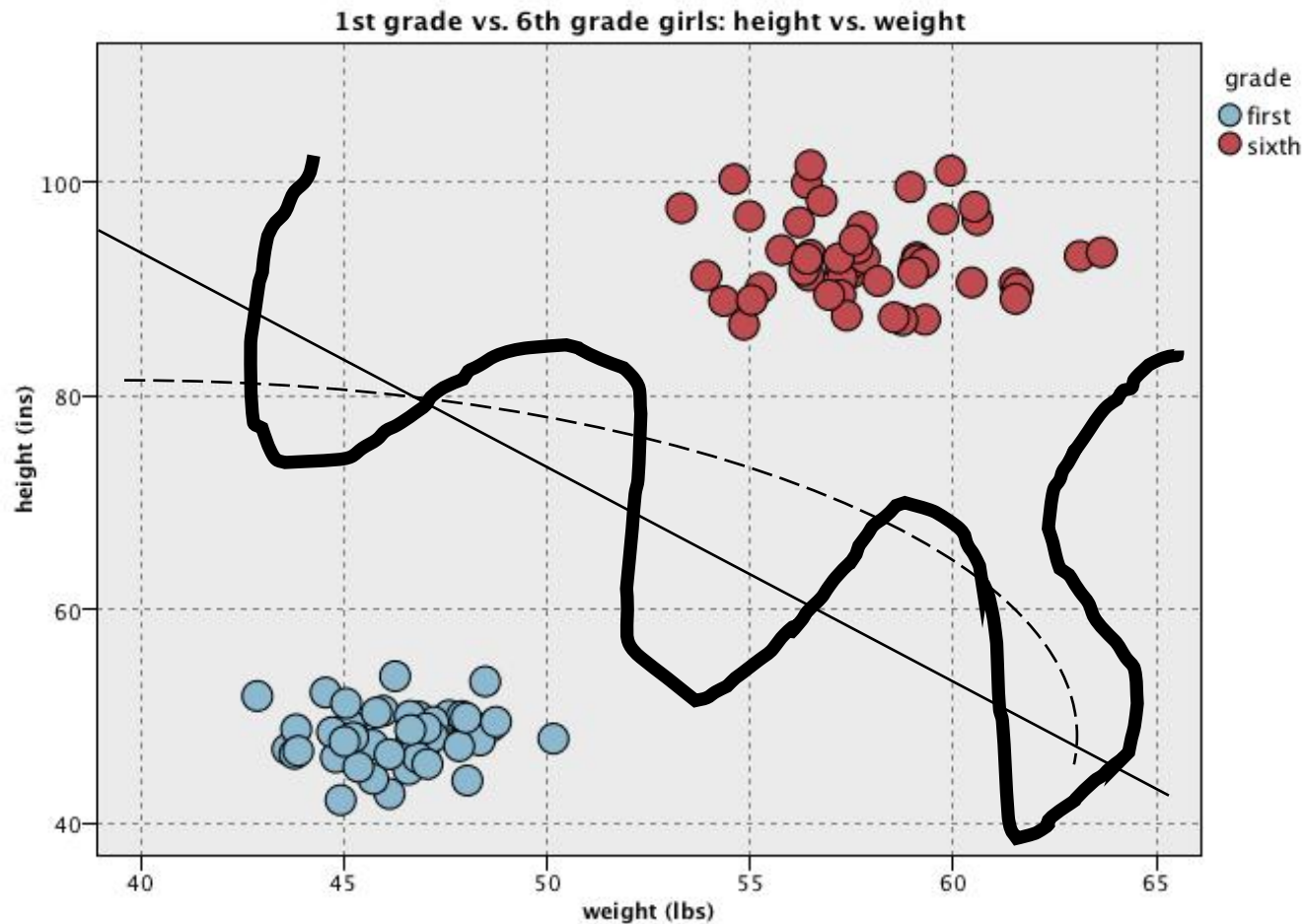
2D Classification example



2D Classification example

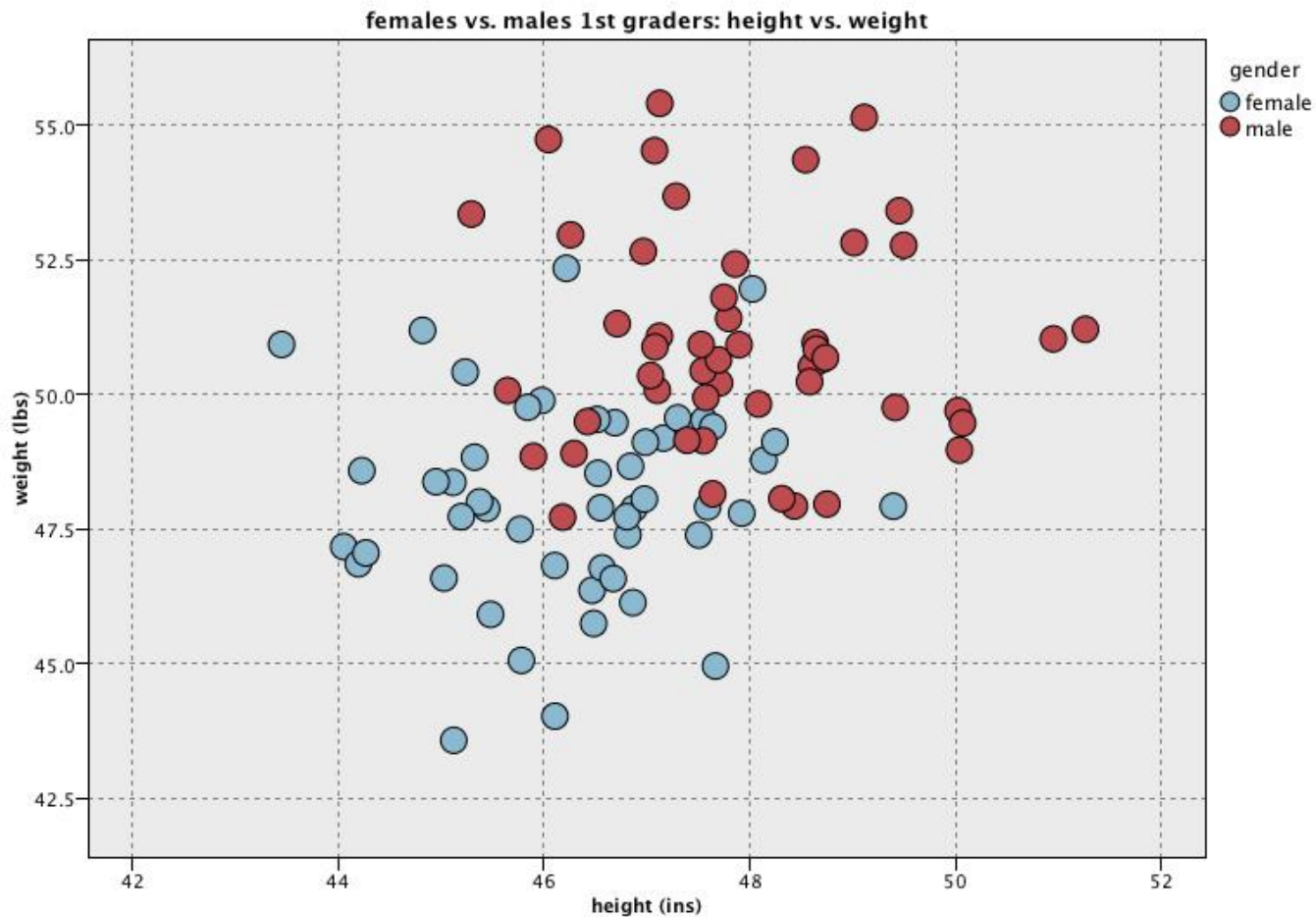


2D Classification example

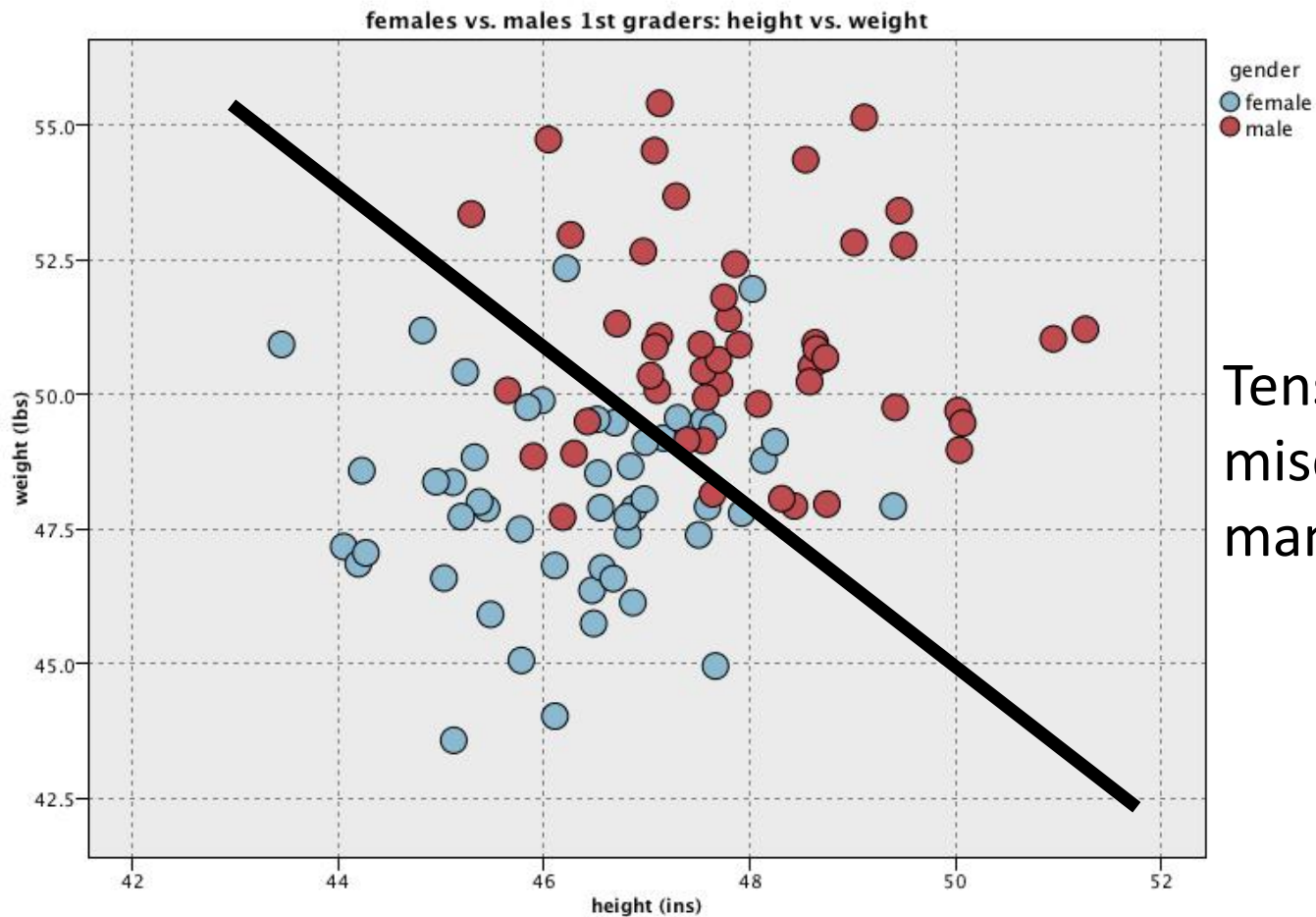


- But in real problems the separation is unlikely to be so neat
- Consider 1st grade boys vs. 1st grade girls

2D Classification example

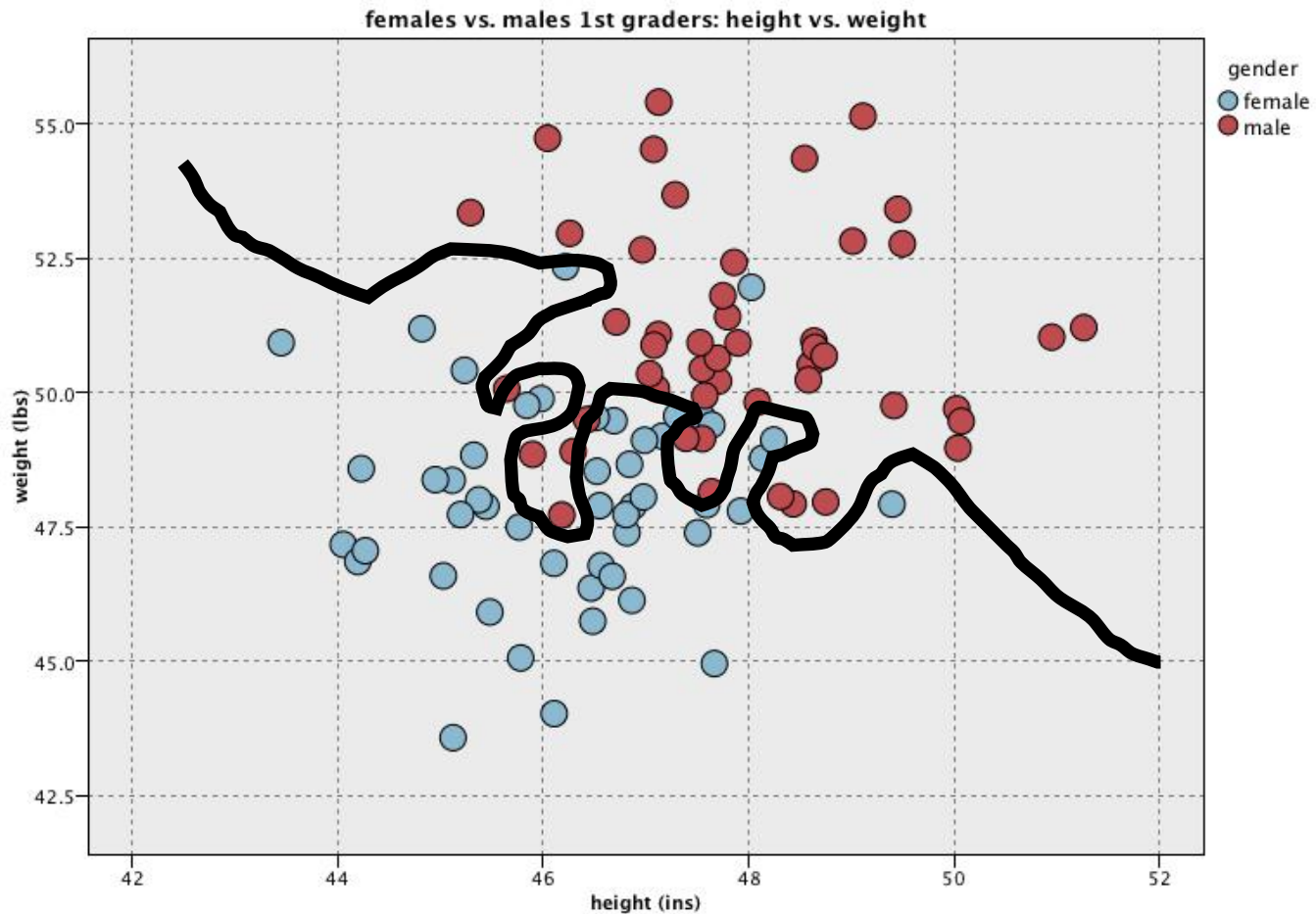


2D Classification example

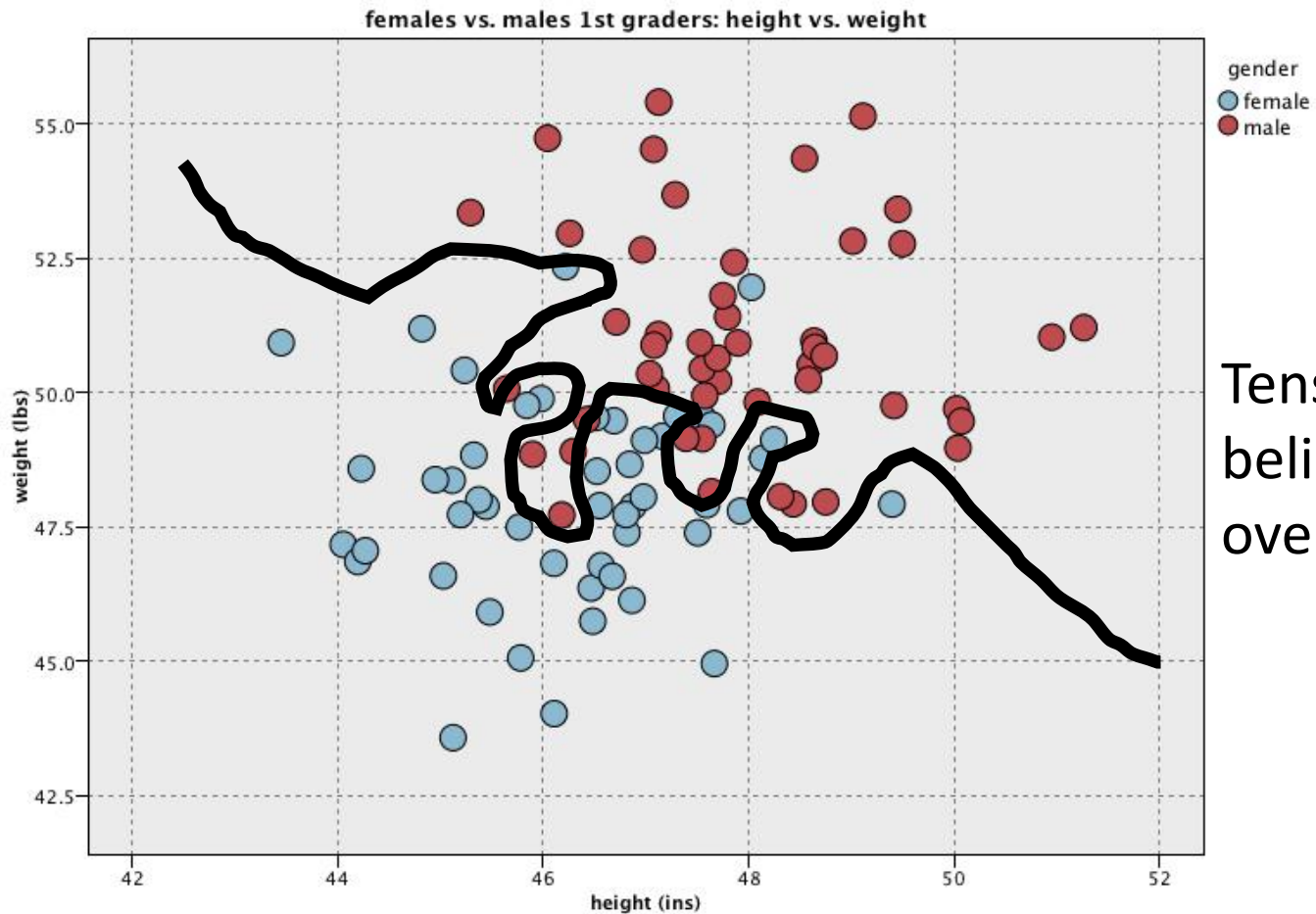


Tension:
misclassifying
many points

2D Classification example



2D Classification example



Tension: don't
believe real -
overfitting

The trade-off

- Want to find true predictive patterns in the data
- But, want to avoid overfitting spurious detail: i.e. don't want to make the model capture apparent patterns due to noise - we want results that are likely to be *generalizable* to future observations
- Solution – independent testing – reserve some data that has not been used in model fitting for the purpose of model evaluation and comparison

Definitions

- True Positive (TP) – observation is positive and was predicted as positive
- True Negative (TN) – observation is negative and was predicted as negative
- False Positive (FP) – observation is negative and was predicted as positive
- False Negative (FN) – observation is positive and was predicted as negative
- Classification accuracy – proportion of observations classified correctly = $(\#TP + \#TN)/N$

Evaluation

- Possible evaluation measures:
 - *Classification Accuracy* – or conversely, the *classification error rate* = $1 - \text{classification accuracy}$
 - *Differential penalties* – different errors may have different costs
 - Area Under Receiver-Operating Characteristic (ROC) Curve (AUC)
- How reliable are the predicted results ?

Classifier error rate

- Natural performance measure for classification problems: *error rate (or success rate)*
 - *Success*: instance's class is predicted correctly
 - *Error*: instance's class is predicted incorrectly
 - *Error rate*: proportion of errors made over the whole set of instances
 - *Success rate*: proportion of errors made over the whole set of instances = $1 - \text{Error rate}$

Cost-Benefit

- Cost-benefit is similar to classification error, except that we might want to count some errors to be worse than others
- Consider a disease where treatment involves taking a simple cheap and benign medicine to cure it (e.g. taking vitamin C), but if the disease is unchecked, the consequences are severe.
- In that case, I would want to put much more weight on missing positives than missing negatives; i.e. consequences of false negatives are much worse than false positives.
- For example, we might make the penalty (cost) for a false negative be 10 or 100 times that of a false positive

Sensitivity and Specificity

Test\Truth	Disease Free	Diseased	Total
Negative	TN	FN	FN+TN
Positive	FP	TP	TP+FP
Total	FP+TN	TP+FN	N

Sensitivity and Specificity

- Sensitivity = $\frac{\#TP}{\#TP + \#FN} =$

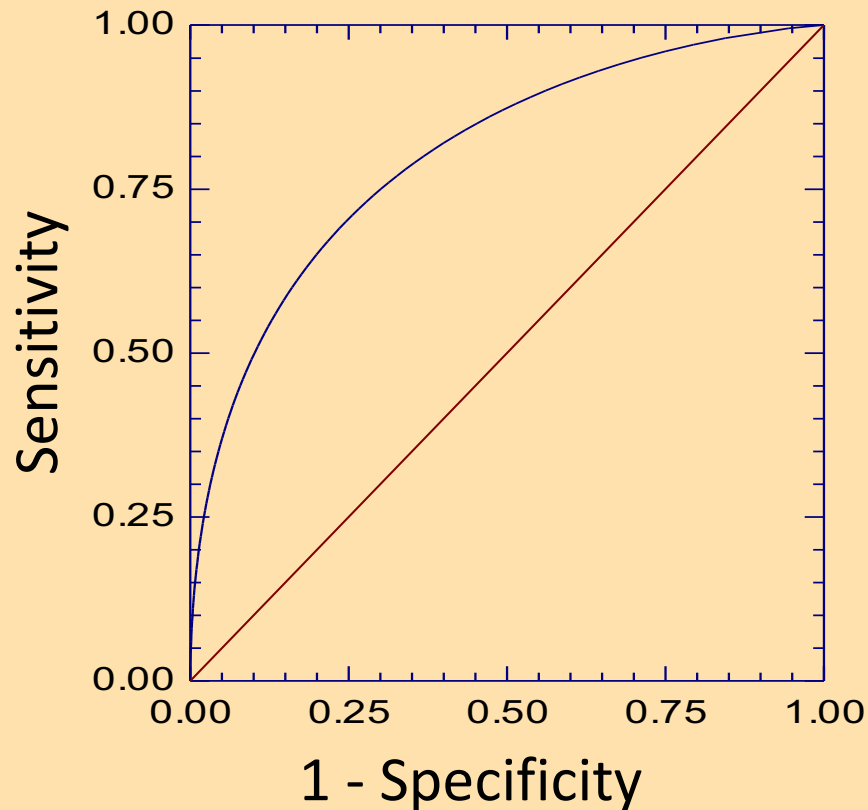
Proportion of positives correctly identified as positive

- Specificity = $\frac{\#TN}{\#TN + \#FP} =$

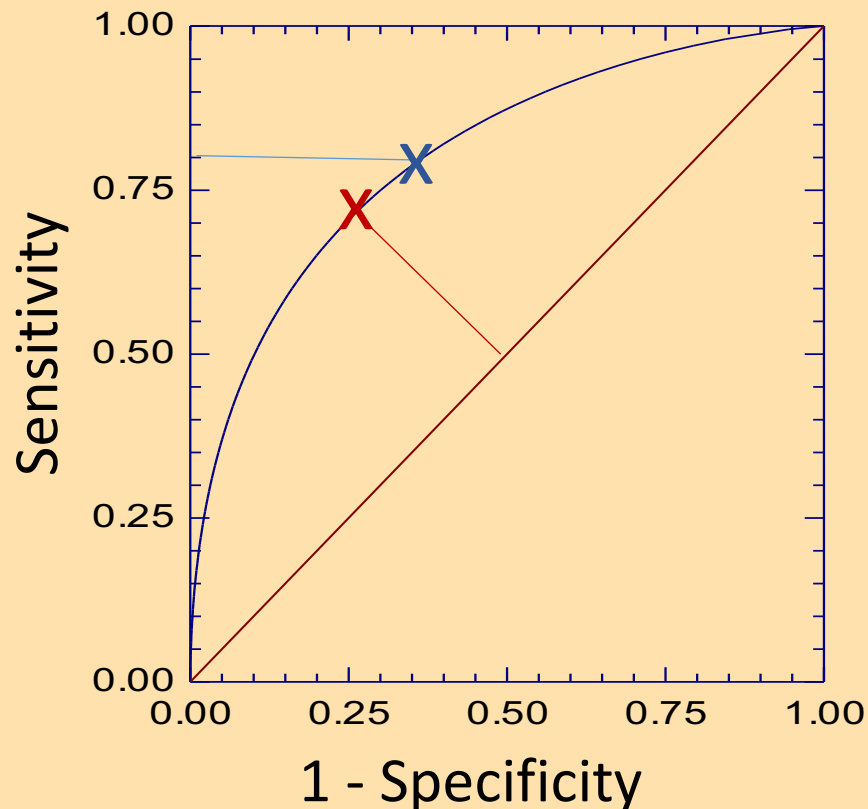
Proportion of negatives correctly identified as negative

- There is another trade-off here between sensitivity and specificity
 - Imagine a classification procedure that gives you a probability of being positive for a disease (such classifiers are common)
 - To classify individuals we need to choose a probability threshold to identify them as positive vs. negative
 - Increasing the threshold increases specificity but reduces sensitivity
 - Decreasing the threshold increases sensitivity but reduces specificity

Receiver operating characteristic (ROC) curve

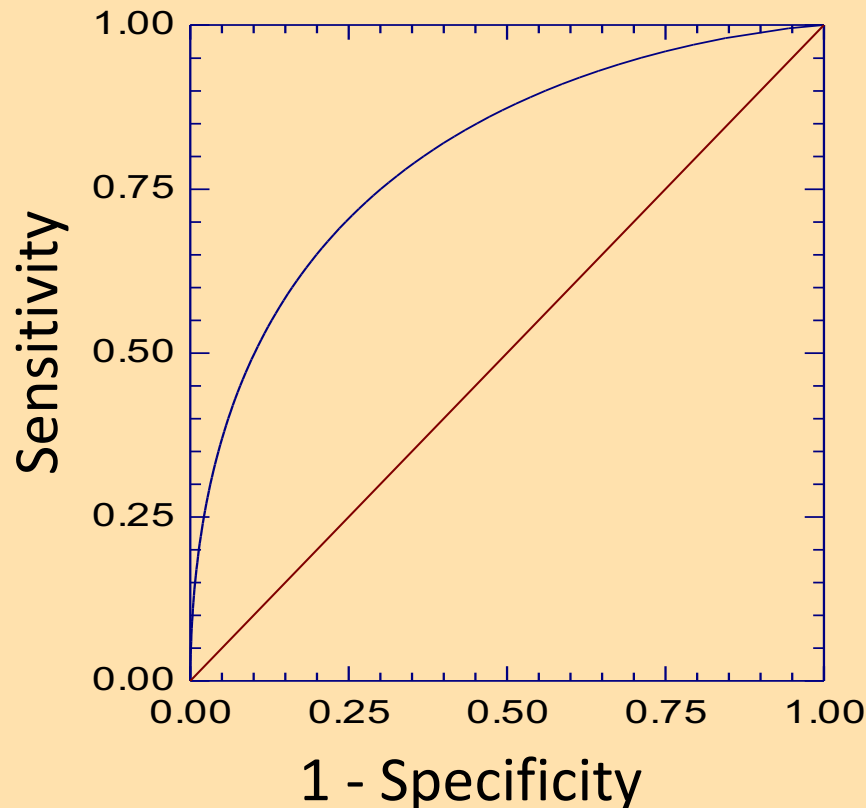


Choosing threshold based on ROC



- Many possible thresholds, each corresponding to one point on curve
- Choosing a single one depends on context
- Some studies say (for example) give me best specificity for a sensitivity of at least 0.8 (blue x)
- General alternative – maximal perpendicular from diagonal (red x)
- We will not be concerned with choosing thresholds, rather, we will use ROC to generate a metric

Area under the (ROC) curve (AUC)



- AUC gives a measure of how well the predictor does across all possible thresholds
- Ideal AUC is 1
- AUC for random predictor = 0.5
- Objective is to find classifier that maximizes AUC

Error rate vs. AUC

- When should we choose error rate and when AUC?
- Error rate (and cost-benefit) work well when your dataset is representative of the larger population (metric incorporates prevalence – e.g. proportion of people in population that have disease)
- AUC works better when your dataset is not representative of larger population, e.g. in “case-control” studies (metric is independent of prevalence)

Training set error rate: is generally
too optimistic!

**You can find patterns even in
random data**

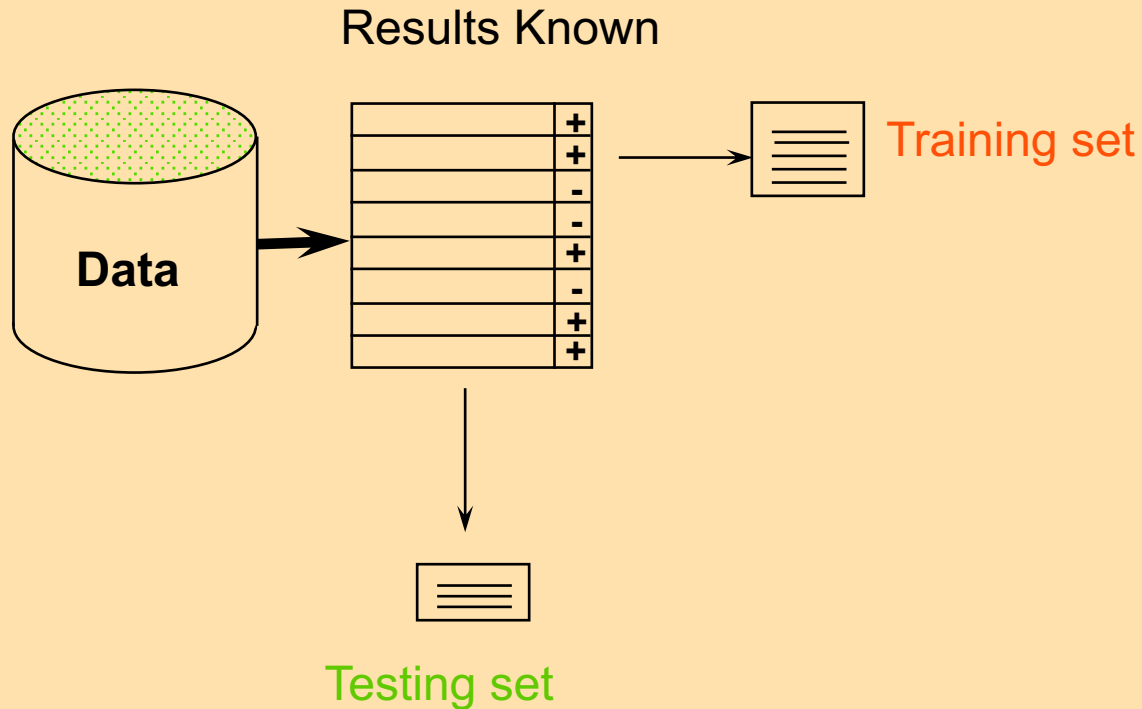
**So we need to evaluate on separate
independent (*Test*) set**

When you have lots of “instances”

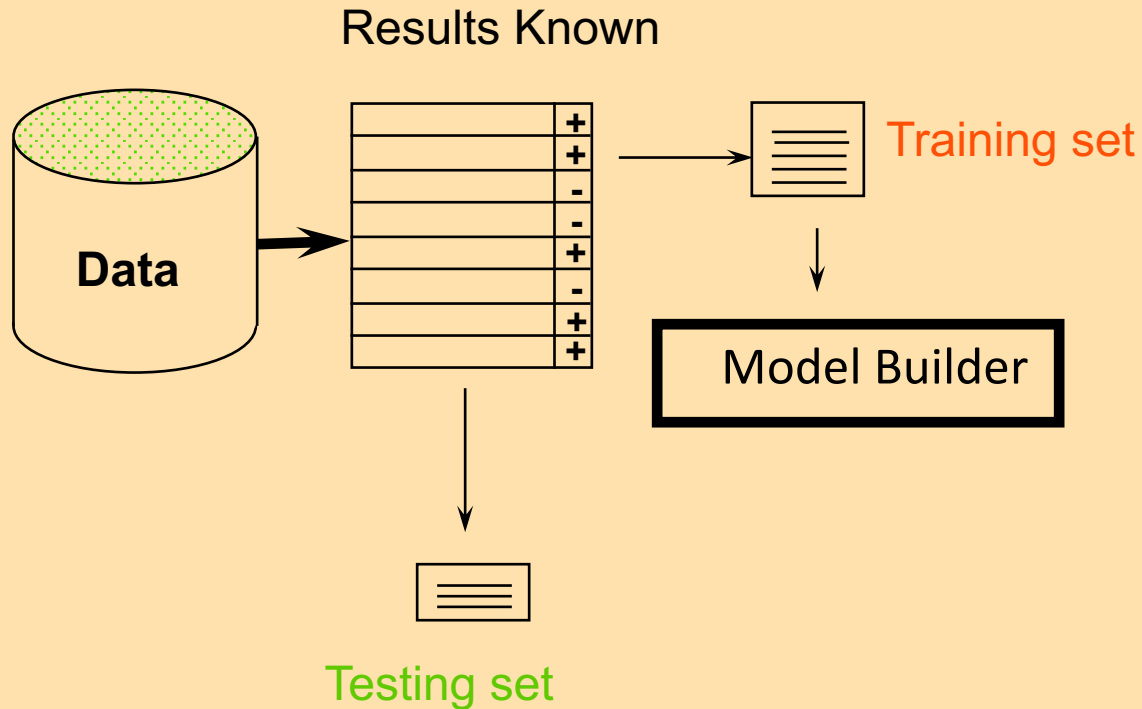
If many (>1000) instances are available, including >100 from each class

- A simple evaluation training/test evaluation will work
 - Randomly split data into training and test sets (often $\sim 2/3$ for train, $1/3$ for test) – may want to *stratify* on outcome (have matching proportions of each class in each set)
- Build a classifier using the *training* set and evaluate it using the *test* set
- We will look at cross-validation later for when you do not have so many observations

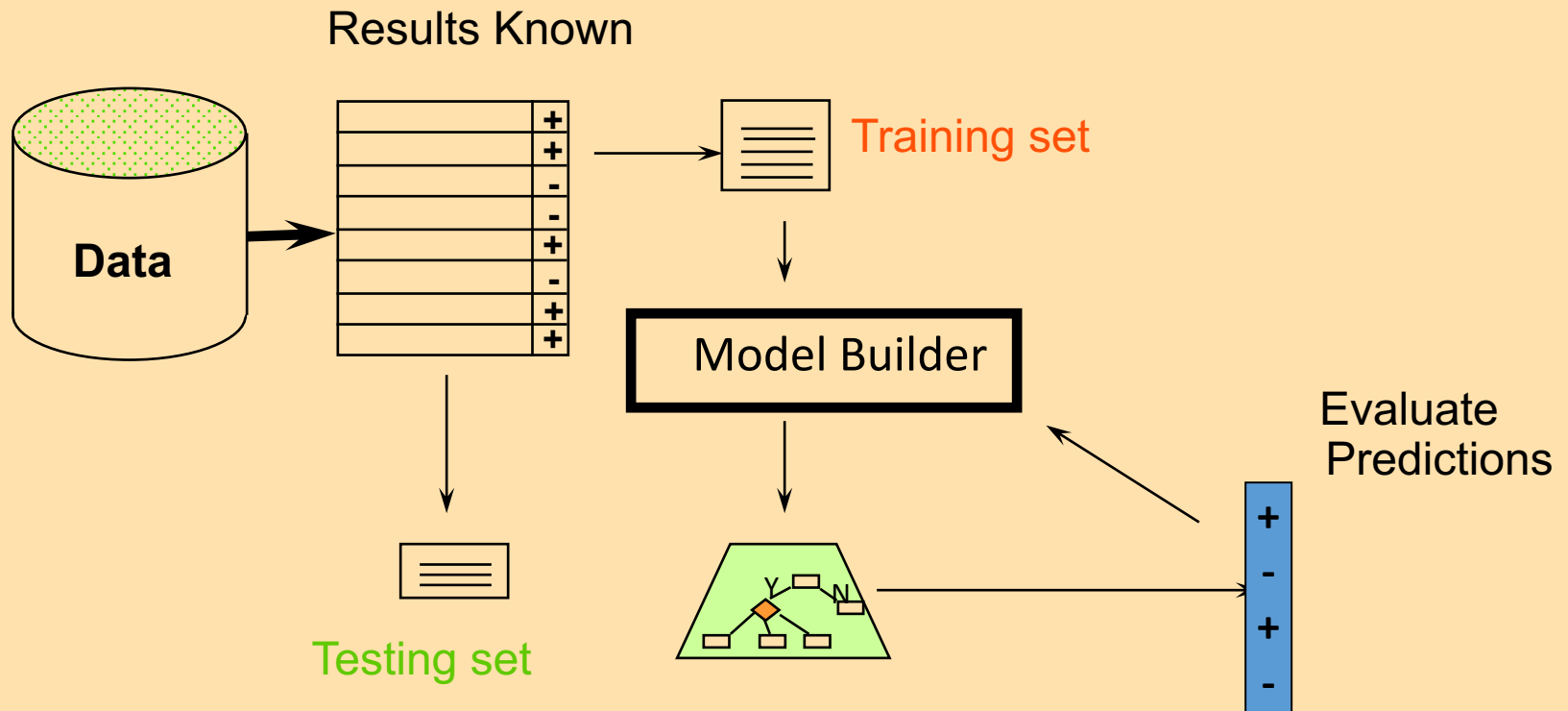
When you have lots of “instances”



When you have lots of “instances”

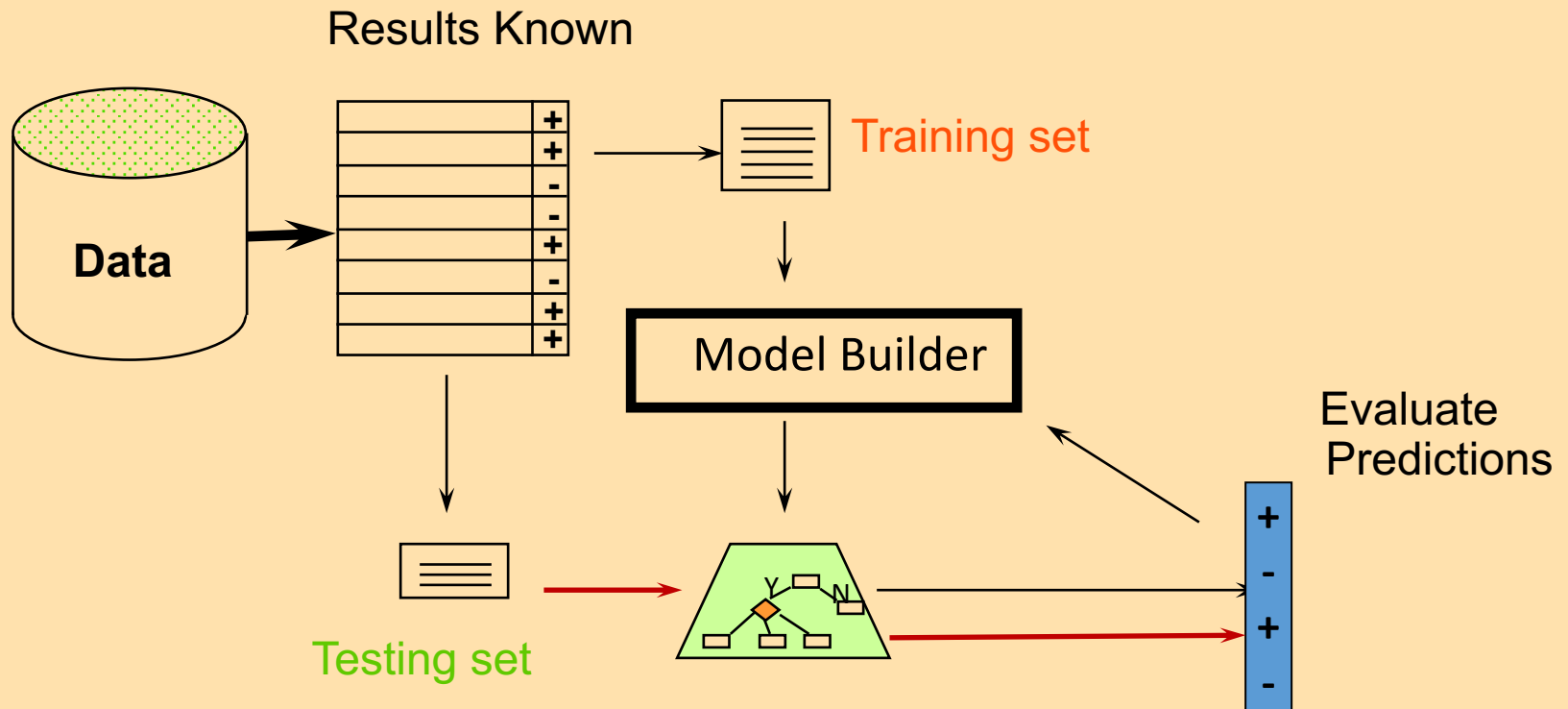


When you have lots of “instances”



At least greater than a few hundred instances and better >1000

When you have lots of “instances”



At least greater than a few hundred instances and better >1000

Classification methods

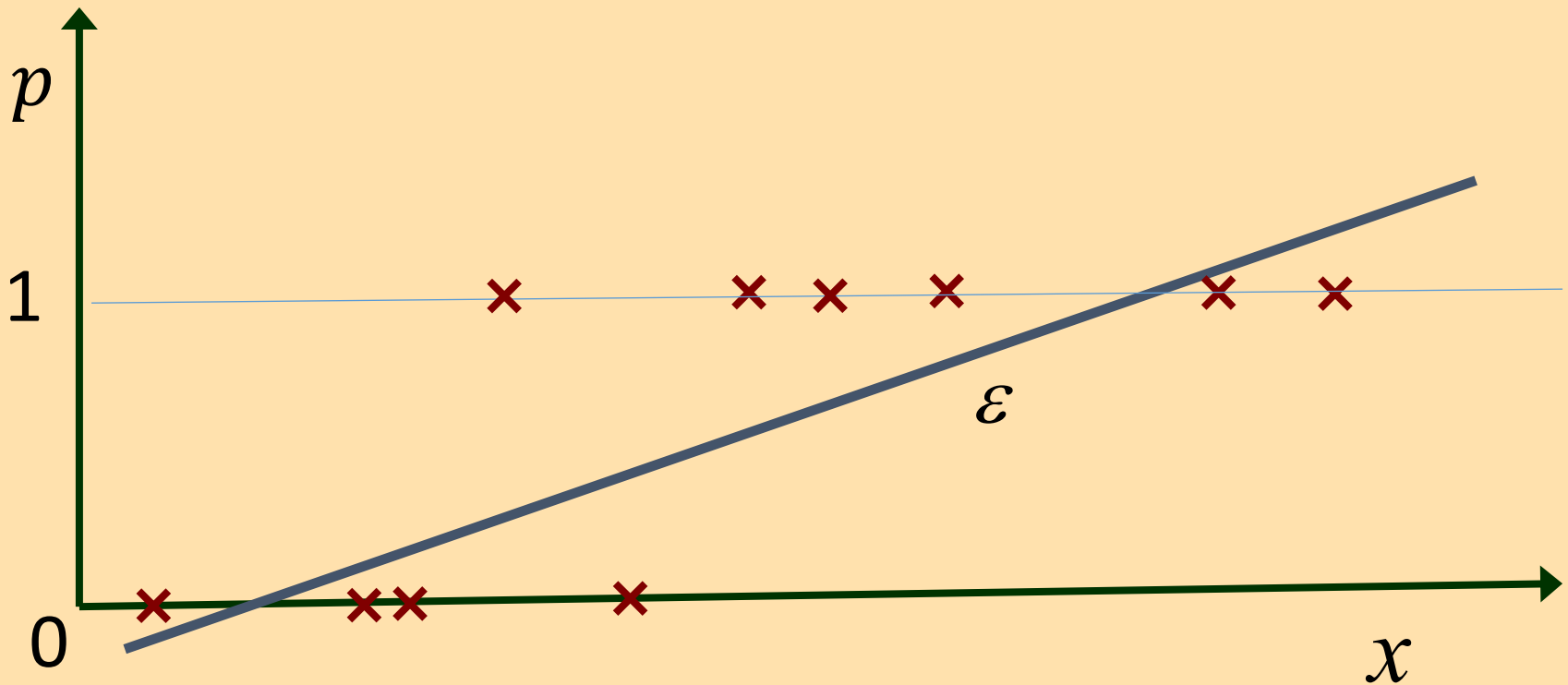
- Logistic regression
- K-nearest neighbors
- Classification trees
- Support vector machines (SVMs)
- Linear Discriminant Analysis (LDA)
- Neural Networks

Logistic Regression

Binary/flag outcome regression modeling

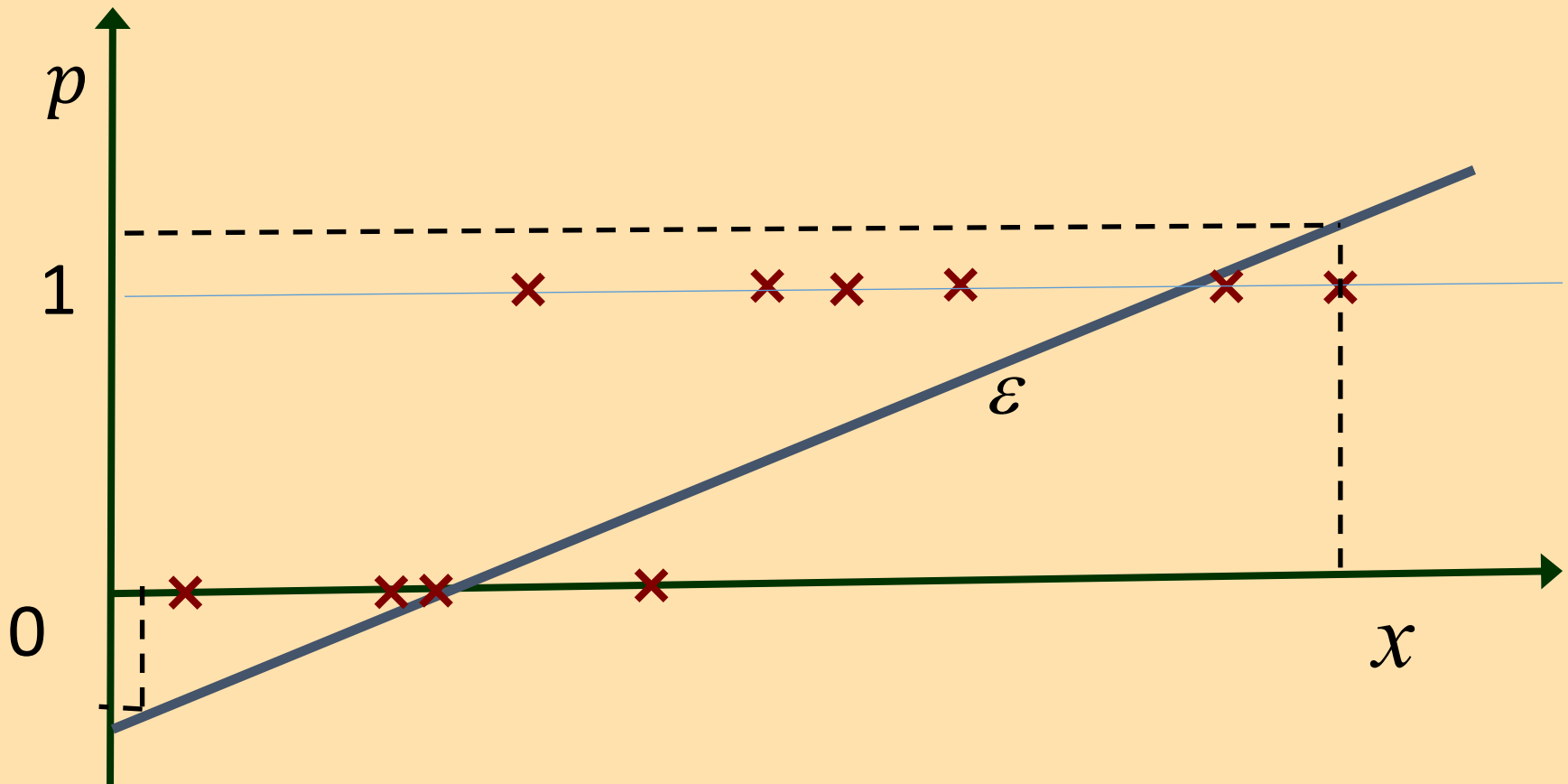
- We want a model where the probability of being in a class is based on the values of predictor(s)
- What about using linear regression?
- $p = ax + c$, where p is the probability of being in class 1 vs. 0, e.g. p = probability boy (=1) vs. girl (=0)
- What might be the concern here?

Linear regression?



Linear regression

Problem predictions – outside range 0 to 1



Binary/flag outcome regression modeling

- We want a model where the probability of being in a class depends on predictor(s)
- What about using linear regression?
- $p = ax + c$, where p is the probability of being in class 1 vs. 0, e.g. p = probability boy (=1) vs. girl (=0)
- What might be the concern here?
- Possible values for p are not restricted to be between 0 and 1 (as required for probabilities) – can be >1 or <0

Logistic regression

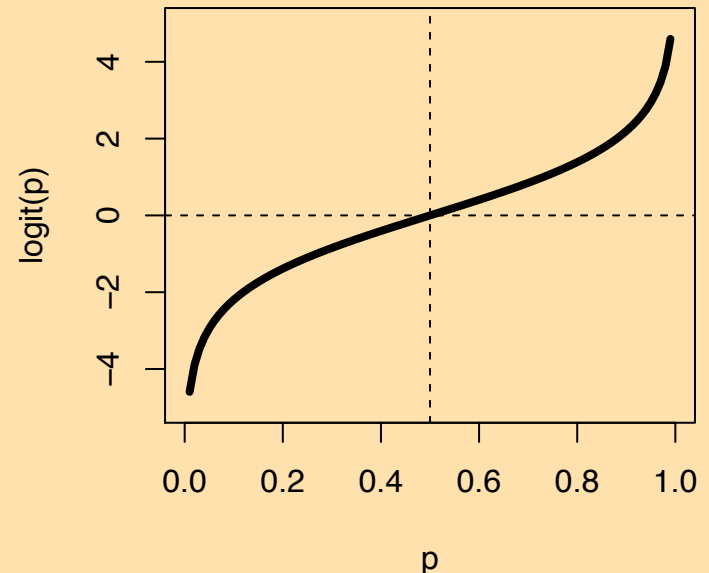
p must be between 0 and 1 (probability)

We can instead take the *odds* which is between 0 and infinity: $\frac{p}{1-p} > 0$ but still not quite what we need...

to get values in the range 0 to 1, we take the log of the odds (*logit function*) and get the logistic regression equation:

$$\text{logit}(p) = \log\left(\frac{p}{1-p}\right) = ax + c$$

We can extend logistic regression to multiple predictors just as we did for linear regression.



Logistic regression for classification

- When fitting logistic regression we get a model that relates predictors to a class probability
- To convert the probability to a class we need to threshold the probability
- E.g. if probability $p > 0.5$ then class as boy, otherwise if $p \leq 0.5$ class as girl

Logistic regression

- A long history (relatively) – well known
- Much statistical theory
- Works well for many problems
- Can be extended to multiple categories
- Can use step-wise/subset selection techniques
- Can provide interpretable models

Running example: UCSF Memory and Aging Clinic (MAC) Dataset

- Structural (volumetric) MRI – multiple dementia studies – but in same scanner and same protocol
- Single time point
- Gold standard Dx – autopsy (if dead) UCSF clinical expert joint decision (otherwise)

CN	SV	BV	AD	MCI	DLB	PSP	nfPPA
291	44	68	180	68	0	44	38

- Objective is to classify patients as having or not having dementia (binary) and if yes, what type of dementia (multi-class)?

ROI predictors

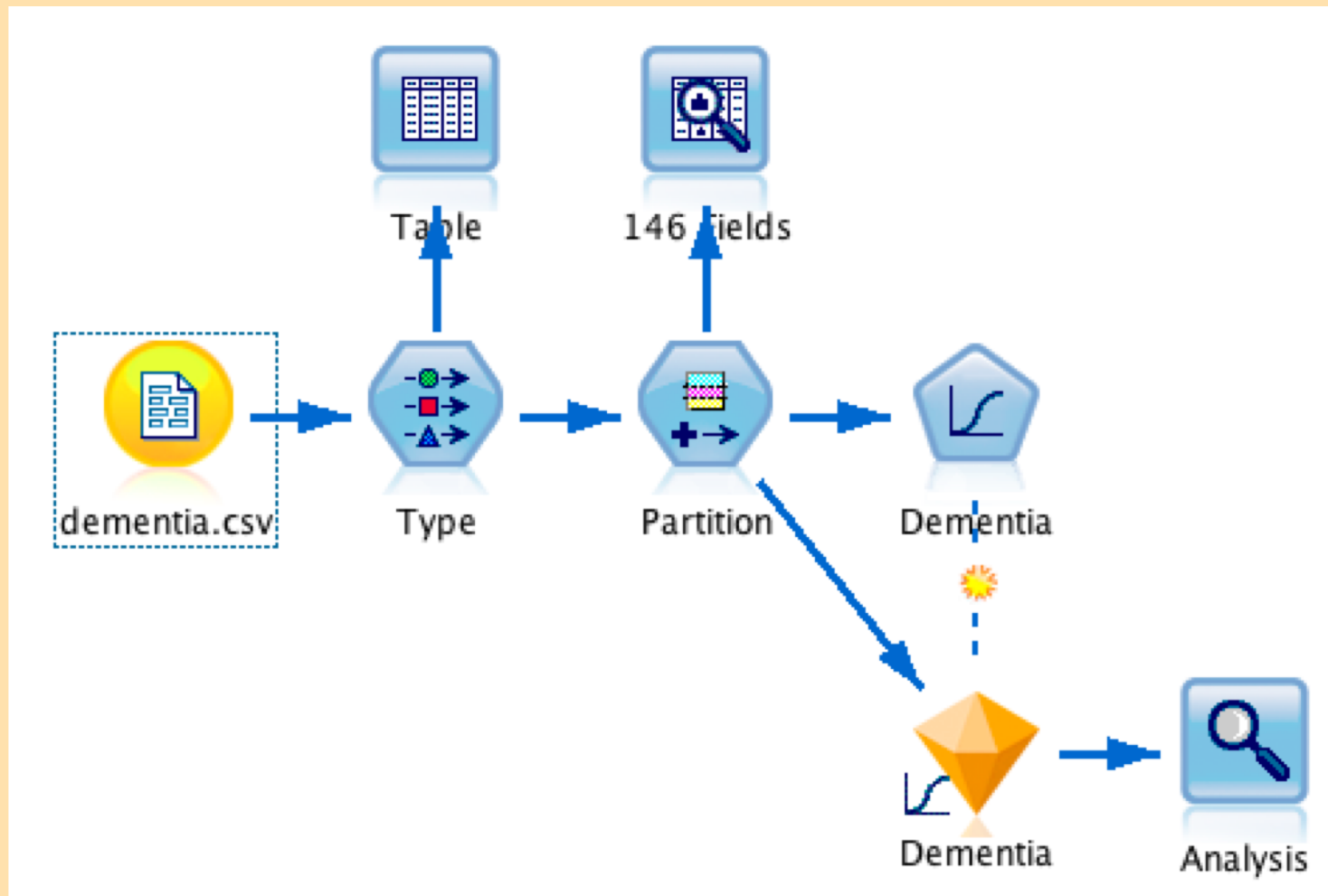
- ROI volumes are the main predictors:
Extract 136 ROIs as predictors for each subject – big data?
- ROIs are defined in terms of anatomical regions and landmarks in the human brain that are common to all individuals – often have specific functional roles



IBM Modeler analysis

- Classification analysis – predicting dementia existence and type based on voxel-based-morphometry gray matter maps
- Using region of interest (ROI) estimates as predictors
- So let's look at logistic regression predicting yes/no for dementia

IBM Modeler stream



Var. File node



dementia.csv

Preview Refresh

/Users/kornak/Documents/Teaching/Biostat202/2017/LecturesLabsAndHW/MyLectures/DataSets/Quest...

File Data Filter Types Annotations

File: /Users/kornak/Documents/Teaching/Biostat202/2017/LecturesLabsAndHW/MyLectures/DataSets/ ...

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☒ Read field names from file ☐ Specify number of fields

Skip header characters: EOL comment characters:

Strip lead and trail spaces: ☒ None ☐ Left ☐ Right ☐ Both

Invalid characters: ☒ Discard ☐ Replace with

Encoding: Decimal symbol:

☐ Line delimiter is newline character Lines to scan for column and type:

Field delimiters

☐ Space ☒ Comma ☐ Tab

☒ Newline ☐ Other

☐ Non-printing characters

☐ Allow multiple blank delimiters

☒ Automatically recognize dates and times

☐ Treat square brackets as lists

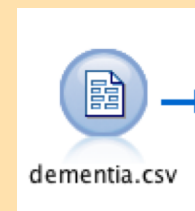
Quotes

Single quotes:

Double quotes:

OK Cancel Apply Reset

Var. File node – Preview



Preview from dementia.csv Node (163 fields, 10 records)

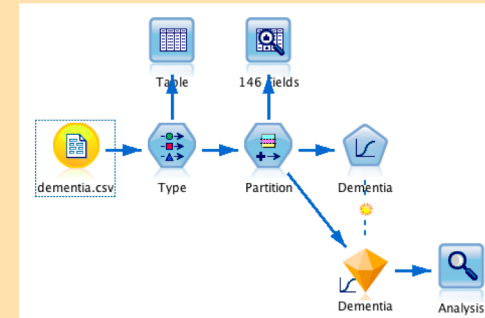
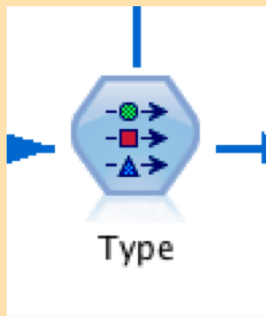
File Edit Generate

Table Annotations

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2	800	3576	2009-08-11	NIC060-1	1	4562	559.454	549.746	292.001	1401.2...	3	72	NIC 3T MRI	T1-long	1493	1486...	NIC 3T MRI	A
3	915	4042	2010-02-08	NIC096-1	1	4247	687.109	551.160	298.904	1537.1...	3	73	NIC 3T MRI	T1-long	1696	1618...	NIC 3T MRI	A
4	1063	4992	2011-05-26	NIC225-1	1	4549	644.104	586.846	515.496	1746.4...	3	78	NIC 3T MRI	T1-long	1972	2078...	NIC 3T MRI	A
5	1154	5480	2009-02-05	GHB087-1	1	1781	550.418	422.150	285.142	1257.7...	3	80	NIC 3T MRI	T1-long	1153	1328...	NIC 3T MRI	C
6	1201	5730	2012-02-14	NIC253-1	1	4020	445.386	451.453	356.003	1252.8...	3	78	NIC 3T MRI	T1-long	2105	2306...	NIC 3T MRI	A
7	1233	5896	2009-10-14	NIC072-1	1	3684	567.450	547.406	311.409	1426.2...	3	71	NIC 3T MRI	T1-long	2165	1552...	NIC 3T MRI	A
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9	1321	6438	2010-01-05	GHB212-1	1	2583	589.887	468.907	264.074	1322.8...	3	65	NIC 3T MRI	T1-long	1320	1578...	NIC 3T MRI	C
10	1327	6565	2008-04-18	GHB005-1	1	835	558.285	435.448	215.101	1208.8...	3	66	NIC 3T MRI	T1-long	1326	1264...	NIC 3T MRI	C

OK

Type node – initial



Types Format Annotations

Read Values Clear Values Clear All Values

Field	Measurement	Values	Missing	Check	Role
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PIDN	Continuous	<Read>		None	Input
DCDate	Continuous	<Read>		None	Input
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wm	Continuous	<Read>		None	Input
csf	Continuous	<Read>		None	Input
tiv	Continuous	<Read>		None	Input
MagnetStreng...	Continuous	<Read>		None	Input
ageAtScan	Continuous	<Read>		None	Input
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ScanType	Categorical	<Read>		None	Input
ROWNUM	Continuous	<Read>		None	Input
InstrID	Continuous	<Read>		None	Input
ScannerID_2	Categorical	<Read>		None	Input
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PIBPos	Categorical	<Read>		None	Input
Sex	Categorical	<Read>		None	Input
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Left_Accumbe...	Continuous	<Read>		None	Input
Right_Amygd...	Continuous	<Read>		None	Input
Left_Amygdala	Continuous	<Read>		None	Input
Brain_Stem	Continuous	<Read>		None	Input
Right_Caudate	Continuous	<Read>		None	Input
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Left_Cerebell...	Continuous	<Read>		None	Input
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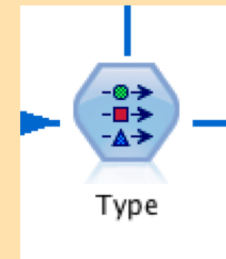
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Right_Plms_po...	Continuous	<Read>	None	Input
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Left_PO_parie...	Continuous	<Read>	None	Input
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Left_PoG_post...	Continuous	<Read>	None	Input
Right_PoRG_p...	Continuous	<Read>	None	Input
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Left_PP_planu...	Continuous	<Read>	None	Input
Right_PrG_pre...	Continuous	<Read>	None	Input
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Right_STG_su...	Continuous	<Read>	None	Input
Left_STG_sup...	Continuous	<Read>	None	Input
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Left_TMP_tem...	Continuous	<Read>	None	Input
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Left_TriFG_tri...	Continuous	<Read>	None	Input
Right_TTG_tra...	Continuous	<Read>	None	Input
Left_TTG_tran...	Continuous	<Read>	None	Input
drop	Categorical	<Read>	None	Input
Dementia	Categorical	<Read>	None	Input

View current fields View unused field settings

OK Cancel

Apply Reset

Type node – after correcting



Type						
Preview						
Types Format Annotations						
Read Values Clear Values Clear All Values						
Field	Measurement	Values	Missing	Check	Role	
field1	Continuous	[1,3095]	None	☐ None	☐ None	
PIDN	Continuous	[65,19260]	None	☒ Record ID	☒ Record ID	
DCDate	Continuous	[2007-11-16,2015...	None	☐ None	☐ None	
SourceID	Typeless		None	☐ None	☐ None	
ScanNo	Ordinal	1	None	☐ None	☐ None	
vbmID	Continuous	[5,4963]	None	☐ None	☐ None	
qm	Continuous	[362.558,826.936]	None	☐ Input	☐ Input	
wm	Continuous	[354.125,738.869]	None	☐ Input	☐ Input	
csf	Continuous	[189.1,515.496]	None	☐ Input	☐ Input	
tiv	Continuous	[1007.5,1843.11]	None	☐ Input	☐ Input	
MagnetStrength	Nominal	3	None	☐ None	☐ None	
ageAtScan	Continuous	[33.99]	None	☐ Input	☐ Input	
ScannerID	Flag	"NIC 3T MRI"/"NIC 3...	None	☐ Input	☐ Input	
ScanType	Nominal	MP-LAS-ABN,T1-AD...	None	☐ None	☐ None	
ROWNUM	Continuous	[1,3095]	None	☐ None	☐ None	
InstrID	Continuous	[126430,343119]	None	☐ None	☐ None	
ScannerID_2	Flag	"NIC 3T MRI"/"NIC 3...	None	☐ None	☐ None	
MacCohort_kr	Nominal	AD,CONTROL,PSP,bv...	None	☐ None	☐ None	
BPpos	Nominal	"0","1","NA	None	☐ None	☐ None	
Sex	Flag	male/female	None	☐ Input	☐ Input	
Educ	Continuous	[4,32]	None	☐ Input	☐ Input	
Race	Nominal	"Asian Indian","Black...	None	☐ Input	☐ Input	
DateofDeath	Continuous	[2010-06-11,2015...	None	☐ None	☐ None	
autopsy.	Nominal	"*,AUTOPSY PERFO...	None	☐ None	☐ None	
PiBDone.	Flag	Yes/No	None	☐ None	☐ None	
X3rd_Ventricle	Continuous	[58.75655516,184...	None	☐ Input	☐ Input	
X4th_Ventricle	Continuous	[91.34785011,289...	None	☐ Input	☐ Input	
Right_Accumbens_Area	Continuous	[31.5960242,1477...	None	☐ Input	☐ Input	
Left_Accumbens_Area	Continuous	[21.71148099,161...	None	☐ Input	☐ Input	
Right_Amygdala	Continuous	[84.12848975,366...	None	☐ Input	☐ Input	
Left_Amygdala	Continuous	[68.73411328,383...	None	☐ Input	☐ Input	
Brain_Stem	Continuous	[506.5979247,1693...	None	☐ Input	☐ Input	
Right_Caudate	Continuous	[126.6476948,1154...	None	☐ Input	☐ Input	
Left_Caudate	Continuous	[117.6457182,1368...	None	☐ Input	☐ Input	
Right_Cerebellum_Ext...	Continuous	[5573.597537,1788...	None	☐ Input	☐ Input	
Left_Cerebellum_Ext...	Continuous	[4978.182021,1657...	None	☐ Input	☐ Input	
Right_Cerebellum_Whi...	Continuous	[2135.978191,6286...	None	☐ Input	☐ Input	
Left_Cerebellum_Whi...	Continuous	[2369.712793,6217...	None	☐ Input	☐ Input	
Right_Cerebral_White...	Continuous	[41860.09373,6672...	None	☐ Input	☐ Input	
Left_Cerebral_White...	Continuous	[41414.18309,6593...	None	☐ Input	☐ Input	
Cerebrospinal_Fluid	Continuous	[77.18923729,252...	None	☐ Input	☐ Input	
Right_Hippocampus	Continuous	[372.874375,1204...	None	☐ Input	☐ Input	
Left_Hippocampus	Continuous	[418.7640745,1047...	None	☐ Input	☐ Input	
Right_Inf_Lat_Vent	Continuous	[8.895621569,67.5...	None	☐ Input	☐ Input	
Left_Inf_Lat_Vent	Continuous	[5.335835814,24.3...	None	☐ Input	☐ Input	
Right_Lateral_Ventricle	Continuous	[310.2823222,1008...	None	☐ Input	☐ Input	
Left_Lateral_Ventricle	Continuous	[313.5167702,1294...	None	☐ Input	☐ Input	
Right_Pallidum	Continuous	[14.9530859,131.0...	None	☐ Input	☐ Input	
Left_Pallidum	Continuous	[13.81248181,164...	None	☐ Input	☐ Input	
Right_Putamen	Continuous	[94.64779961,1490...	None	☐ Input	☐ Input	
Left_Putamen	Continuous	[115.9943711,1647...	None	☐ Input	☐ Input	
Right_Thalamus_Proper	Continuous	[401.5123147,1719...	None	☐ Input	☐ Input	
Left_Thalamus_Proper	Continuous	[456.6295583,1658...	None	☐ Input	☐ Input	
Right_Ventral_DC	Continuous	[230.2842237,461...	None	☐ Input	☐ Input	
Left_Ventral_DC	Continuous	[240.8136756,526...	None	☐ Input	☐ Input	
Right_vessel	Continuous	[0.111729383,0.77...	None	☐ Input	☐ Input	
Left_vessel	Continuous	[0.64625213,3.55...	None	☐ Input	☐ Input	
Optic_Chiasm	Continuous	[1.350985626,9.89...	None	☐ Input	☐ Input	
Cerebellar_Vermal_Lo...	Continuous	[697.7441838,1596...	None	☐ Input	☐ Input	
Cerebellar_Vermal_Lo...	Continuous	[265.644736,712.7...	None	☐ Input	☐ Input	
Cerebellar_Vermal_Lo...	Continuous	[254.1379361,975...	None	☐ Input	☐ Input	

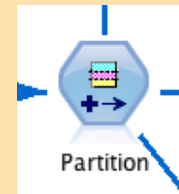
Right_MPoG_postcentr...	Continuous	[67.67728131,202...	None	☐ Input
Left_MPoG_postcentr...	Continuous	[74.01055394,262...	None	☐ Input
Right_MPrG_precentra...	Continuous	[310.6314755,777...	None	☐ Input
Left_MPrG_precentra...	Continuous	[251.8652834,780...	None	☐ Input
Right_MSFG_superior...	Continuous	[375.897864,2118...	None	☐ Input
Left_MSFG_superior...	Continuous	[346.6053448,1911...	None	☐ Input
Right_MTG_middle_te...	Continuous	[547.5187223,4615...	None	☐ Input
Left_MTG_middle_te...	Continuous	[949.3164435,4346...	None	☐ Input
Right_OCP_occipital_p...	Continuous	[184.6869897,719...	None	☐ Input
Left_OCP_occipital_p...	Continuous	[182.2891504,835...	None	☐ Input
Right_OFuG_occipital...	Continuous	[421.209736,1131...	None	☐ Input
Left_OFuG_occipital_f...	Continuous	[331.3296358,1220...	None	☐ Input
Right_OplFG_opercula...	Continuous	[184.5597767,983...	None	☐ Input
Left_OplFG_opercula...	Continuous	[170.6109803,927...	None	☐ Input
Right_OrIFG_orbital_p...	Continuous	[72.63498808,412...	None	☐ Input
Left_OrIFG_orbital_p...	Continuous	[43.62708166,338...	None	☐ Input
Right_PCGG_posterior...	Continuous	[544.2258615,1247...	None	☐ Input
Left_PCGG_posterior...	Continuous	[581.4855684,1368...	None	☐ Input
Right_PCu_precuneus	Continuous	[1531.975308,3645...	None	☐ Input
Left_PCu_precuneus	Continuous	[1316.489579,3537...	None	☐ Input
Right_PHG parahippo...	Continuous	[337.6894213,694...	None	☐ Input
Left_PHG parahippo...	Continuous	[371.2698957,914...	None	☐ Input
Right_Plns_posterior...	Continuous	[152.5767199,924...	None	☐ Input
Left_Plns_posterior...	Continuous	[215.9756448,814...	None	☐ Input
Right_PO_parietal_ope...	Continuous	[162.4111996,804...	None	☐ Input
Left_PO_parietal_ope...	Continuous	[280.152219,855.5...	None	☐ Input
Right_PoG_postcentral...	Continuous	[733.9963874,2558...	None	☐ Input
Left_PoG_postcentral...	Continuous	[927.4357129,2888...	None	☐ Input
Right_POrG_posterior...	Continuous	[180.6825849,742...	None	☐ Input
Left_POrG_posterior...	Continuous	[82.04551118,782...	None	☐ Input
Right_PP_planum_tem...	Continuous	[104.90551,489.50...	None	☐ Input
Left_PP_planum_pola...	Continuous	[145.6896541,555...	None	☐ Input
Right_PrG_precentral...	Continuous	[881.9382684,3119...	None	☐ Input
Left_PrG_precentral...	Continuous	[1013.286891,3145...	None	☐ Input
Right_PT_planum_tem...	Continuous	[105.5180343,622...	None	☐ Input
Left_PT_planum_tem...	Continuous	[181.9479349,700...	None	☐ Input
Right_SCA_subcallosal...	Continuous	[64.32918989,322...	None	☐ Input
Left_SCA_subcallosal...	Continuous	[65.64066,358.841...	None	☐ Input
Right_SFG_superior...	Continuous	[1022.292171,3654...	None	☐ Input
Left_SFG_superior...	Continuous	[813.8198456,3774...	None	☐ Input
Right_SMC_suppleme...	Continuous	[353.486501,1601...	None	☐ Input
Left_SMC_suppleme...	Continuous	[302.2308103,1612...	None	☐ Input
Right_SMG_supramarg...	Continuous	[565.5655709,2528...	None	☐ Input
Left_SMG_supramarg...	Continuous	[854.6513809,2499...	None	☐ Input
Right_SOG_superior...	Continuous	[228.0805283,1093...	None	☐ Input
Left_SOG_superior...	Continuous	[170.8020032,883...	None	☐ Input
Right_SPL_superior...	Continuous	[934.2002907,3381...	None	☐ Input
Left_SPL_superior...	Continuous	[765.3556043,3185...	None	☐ Input
Right_STG_superior...	Continuous	[314.631001,1953...	None	☐ Input
Left_STG_superior...	Continuous	[542.5562204,1828...	None	☐ Input
Right_TMP_temporal...	Continuous	[163.1710183,2649...	None	☐ Input
Left_TMP_temporal...	Continuous	[65.94066814,2461...	None	☐ Input
Right_TriFG_triangular...	Continuous	[179.0097257,872...	None	☐ Input
Left_TriFG_triangular...	Continuous	[97.04780146,813...	None	☐ Input
Right_TTG_transverse...	Continuous	[74.64149524,525...	None	☐ Input
Left_TTG_transverse...	Continuous	[161.4371758,533...	None	☐ Input
drop	Flag	FALSE/FALSE	None	☐ None
Dementia	Flag	TRUE/FALSE	None	☒ Target

☒ View current fields ☐ View unused field settings

OK Cancel

Apply Reset

Partition node



Partition

Generate Preview

Settings Annotations

Partition field:

Partitions: ☒ Train and test ☐ Train, test and validation

Training partition size: Label: Value =

Testing partition size: Label: Value =

Validation partition size: Label: Value =

Total size: 100%

Values: ☐ Use system-defined values ("1", "2" and "3")
☒ Append labels to system-defined values
☐ Use labels as values

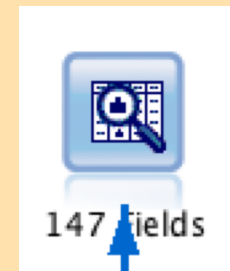
☒ Repeatable partition assignment

Seed:

☐ Use unique field to assign partitions:

OK Cancel Apply Reset

Audit node



146 Fields

 ? -

Settings Quality Output Annotations

☒ Default ☐ Use custom fields

Fields:  

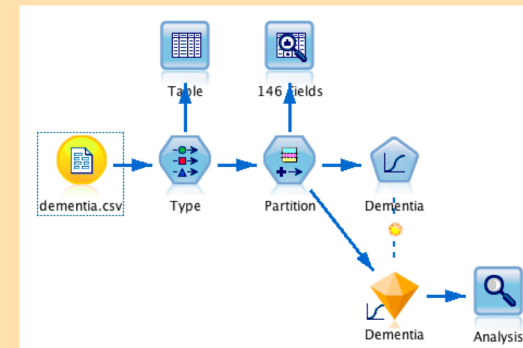
Overlay: 

Display

☒ Graphs ☒ Basic statistics ☐ Advanced statistics

☐ Calculate median and mode (may slow performance on large datasets)

OK  Run Cancel Apply Reset



Audit node



147 fields

Data Audit of [146 fields] #1

File Edit Generate

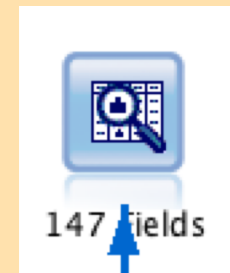
Audit Quality Annotations

Field	Graph	Measurement	Min	Max	Mean	Std. Dev	Skewness	Unique	Valid
PIDN		Continuous	65	19260	12372.7...	3514.176	-0.021	--	660
gm		Continuous	362.558	826.936	568.708	65.967	0.031	--	660
wm		Continuous	354.125	738.869	492.911	61.072	0.478	--	660
csf		Continuous	189.100	515.496	300.274	55.397	0.496	--	660
tiv		Continuous	1007.500	1843.110	1361.893	132.946	0.437	--	660
ageAtScan		Continuous	33	99	66.698	8.945	0.082	--	660
Sex		Flag	--	--	--	--	--	2	660
Educ		Continuous	4	32	16.693	3.023	0.108	--	639
X3rd_Ventricle		Continuous	58.757	184.767	119.459	20.945	0.051	--	660
X4th_Ventricle		Continuous	91.348	289.200	163.998	22.729	0.554	--	660

¹ Indicates a multimode result ² Indicates a sampled result

OK

Audit node



Data Audit of [146 fields] #2

File Edit Generate

Audit Quality Annotations

Field	Graph	Measurement	Min	Max	Mean	Std. Dev	Skewness	Unique	Valid
Right_TMP_temporal_pole		Continuous	163.171	2649.916	1797.301	381.095	-1.262	--	660
Left_TMP_temporal_pole		Continuous	65.941	2461.309	1655.974	386.556	-1.317	--	660
Right_TriFG_triangular_part_of_the_inferior_frontal_gyrus		Continuous	179.010	872.055	602.290	103.471	-0.795	--	660
Left_TriFG_triangular_part_of_the_inferior_frontal_gyrus		Continuous	97.048	813.283	529.719	102.303	-0.758	--	660
Right_TTG_transverse_temporal_gyrus		Continuous	74.641	525.473	302.991	58.504	-0.026	--	660
Left_TTG_transverse_temporal_gyrus		Continuous	161.437	533.214	342.375	66.575	0.047	--	660
Dementia		Flag	--	--	--	--	--	2	660
Partition		Nominal	--	--	--	--	--	2	660

¹ Indicates a multimode result ² Indicates a sampled result

OK

Audit node



147 fields

Data Audit of [146 fields] #1

File Edit Generate

Audit Quality Annotations

Field	Graph	Measurement	Min	Max	Mean	Std. Dev	Skewness	Unique	Valid
PIDN		Continuous	65	19260	12372.7...	3514.176	-0.021	--	660
gm		Continuous	362.558	826.936	568.708	65.967	0.031	--	660
wm		Continuous	354.125	738.869	492.911	61.072	0.478	--	660
csf		Continuous	189.100	515.496	300.274	55.397	0.496	--	660
tiv		Continuous	1007.500	1843.110	1361.893	132.946	0.437	--	660
ageAtScan		Continuous	33	99	66.698	8.945	0.082	--	660
Sex		Flag	--	--	--	--	--	2	660
Educ		Continuous	4	32	16.693	3.023	0.108	--	639
X3rd_Ventricle		Continuous	58.757	184.767	119.459	20.945	0.051	--	660
X4th_Ventricle		Continuous	91.348	289.200	163.998	22.729	0.554	--	660

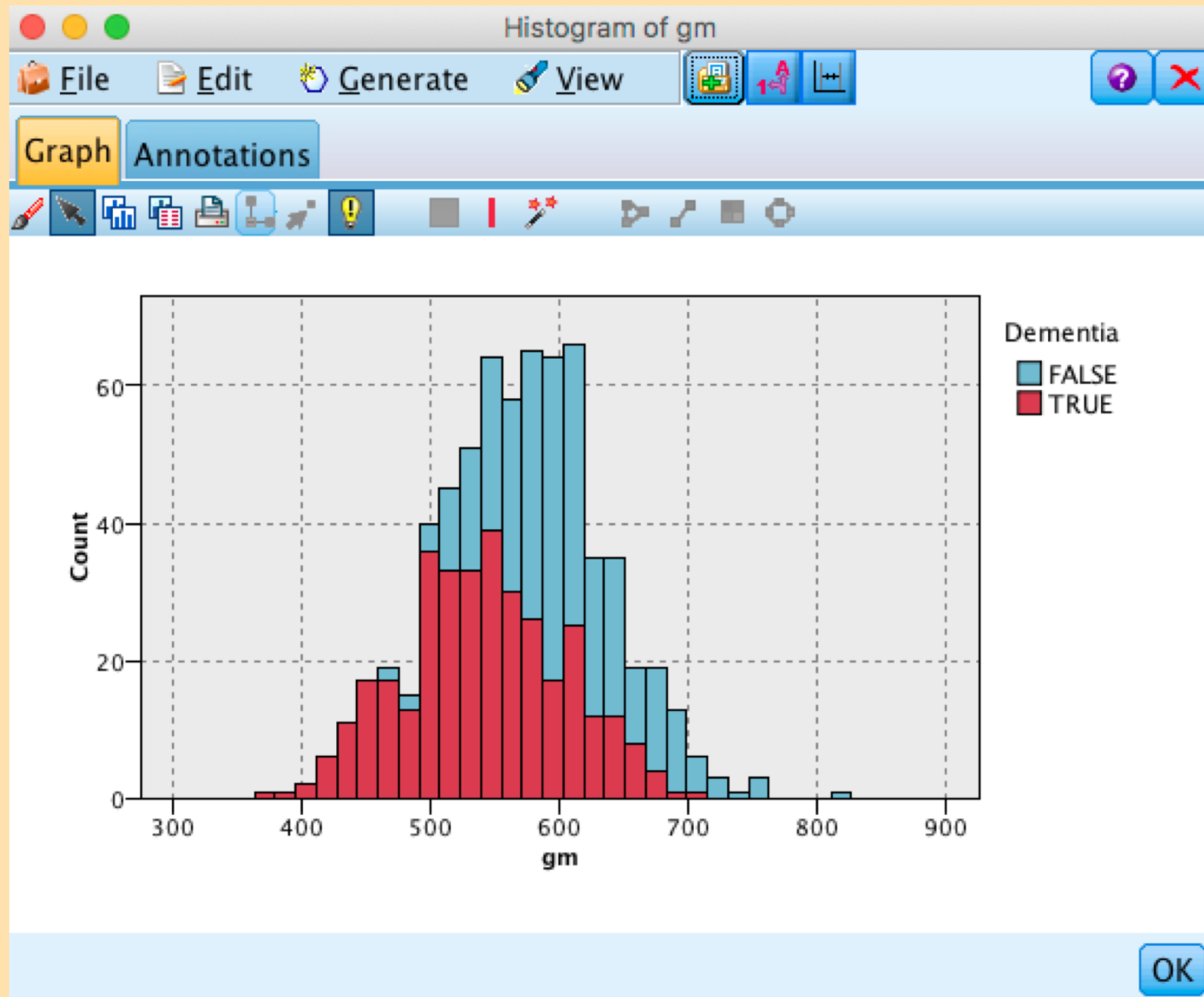
¹ Indicates a multimode result ² Indicates a sampled result

OK

Audit node



147 fields



Audit node



147 fields

Data Audit of [146 fields] #2

File Edit Generate

Audit **Quality** Annotations

Complete fields (%): 99.32% Complete records (%): 96.82%

Field	Measurement	Outliers	Extremes	Action	Impute Missi...	Method	% Complete	Valid Records	Null Value	Emp
PIDN	Continuous	1	0 None		Never	Fixed	100	660	0	
qm	Continuous	2	0 None		Never	Fixed	100	660	0	
wm	Continuous	5	0 None		Never	Fixed	100	660	0	
csf	Continuous	4	0 None		Never	Fixed	100	660	0	
tiv	Continuous	4	0 None		Never	Fixed	100	660	0	
ageAtScan	Continuous	2	0 None		Never	Fixed	100	660	0	
Sex	Flag	--	-- --		Never	Fixed	100	660	0	
Educ	Continuous	10	1 None		Never	Fixed	96.818	639	21	
X3rd Ven...	Continuous	1	0 None		Never	Fixed	100	660	0	
X4th Vent...	Continuous	5	1 None		Never	Fixed	100	660	0	
Right Acc...	Continuous	7	0 None		Never	Fixed	100	660	0	
Left Accu...	Continuous	1	0 None		Never	Fixed	100	660	0	
Right Am...	Continuous	10	0 None		Never	Fixed	100	660	0	
Left Amy...	Continuous	4	0 None		Never	Fixed	100	660	0	
Brain Stem	Continuous	7	4 None		Never	Fixed	100	660	0	
Right Cau...	Continuous	5	0 None		Never	Fixed	100	660	0	
Left Caud...	Continuous	5	0 None		Never	Fixed	100	660	0	
Right Cer...	Continuous	7	1 None		Never	Fixed	100	660	0	
Left Cere...	Continuous	6	1 None		Never	Fixed	100	660	0	
Right Cer...	Continuous	4	1 None		Never	Fixed	100	660	0	
Left Cere...	Continuous	6	1 None		Never	Fixed	100	660	0	
Right Cer...	Continuous	1	0 None		Never	Fixed	100	660	0	
Right SO...	Continuous	10	0 None		Never	Fixed	100	660	0	
Left SOG ...	Continuous	8	0 None		Never	Fixed	100	660	0	
Right SPL...	Continuous	11	0 None		Never	Fixed	100	660	0	
Left SPL s...	Continuous	9	0 None		Never	Fixed	100	660	0	
Right STG...	Continuous	6	0 None		Never	Fixed	100	660	0	
Left STG ...	Continuous	5	0 None		Never	Fixed	100	660	0	
Right TM...	Continuous	14	0 None		Never	Fixed	100	660	0	
Left TMP ...	Continuous	15	0 None		Never	Fixed	100	660	0	
Right TrIF...	Continuous	7	0 None		Never	Fixed	100	660	0	
Left TrIFG...	Continuous	8	0 None		Never	Fixed	100	660	0	
Right TT...	Continuous	4	0 None		Never	Fixed	100	660	0	
Left TTG ...	Continuous	0	0 None		Never	Fixed	100	660	0	
Dementia	Flag	--	-- --		Never	Fixed	100	660	0	
Partition	Nominal	--	-- --		Never	Fixed	100	660	0	

OK

Dementia

Logistic node



Dementia

Fields Model Expert Analyze Annotations

Model name: ☒ Auto ☐ Custom

☒ Use partitioned data

☐ Build model for each split

Procedure: ☐ Multinomial ☒ Binomial

Binomial Procedure

Method: **Forwards Stepwise**

Categories: Enter Forwards Stepwise Backwards Stepwise

Field Name	Contrast	Base Category
------------	----------	---------------

☒ Include constant in equation

OK Run Cancel Apply Reset

Logistic node



Dementia

Fields Model Expert **Analyze** Annotations

Model Evaluation

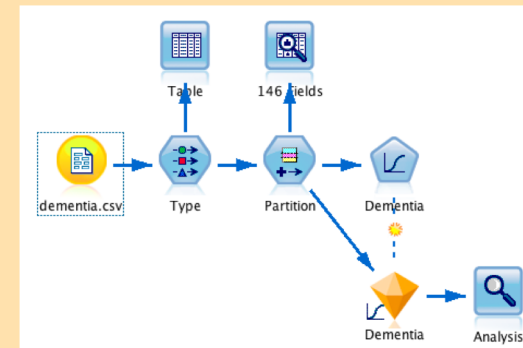
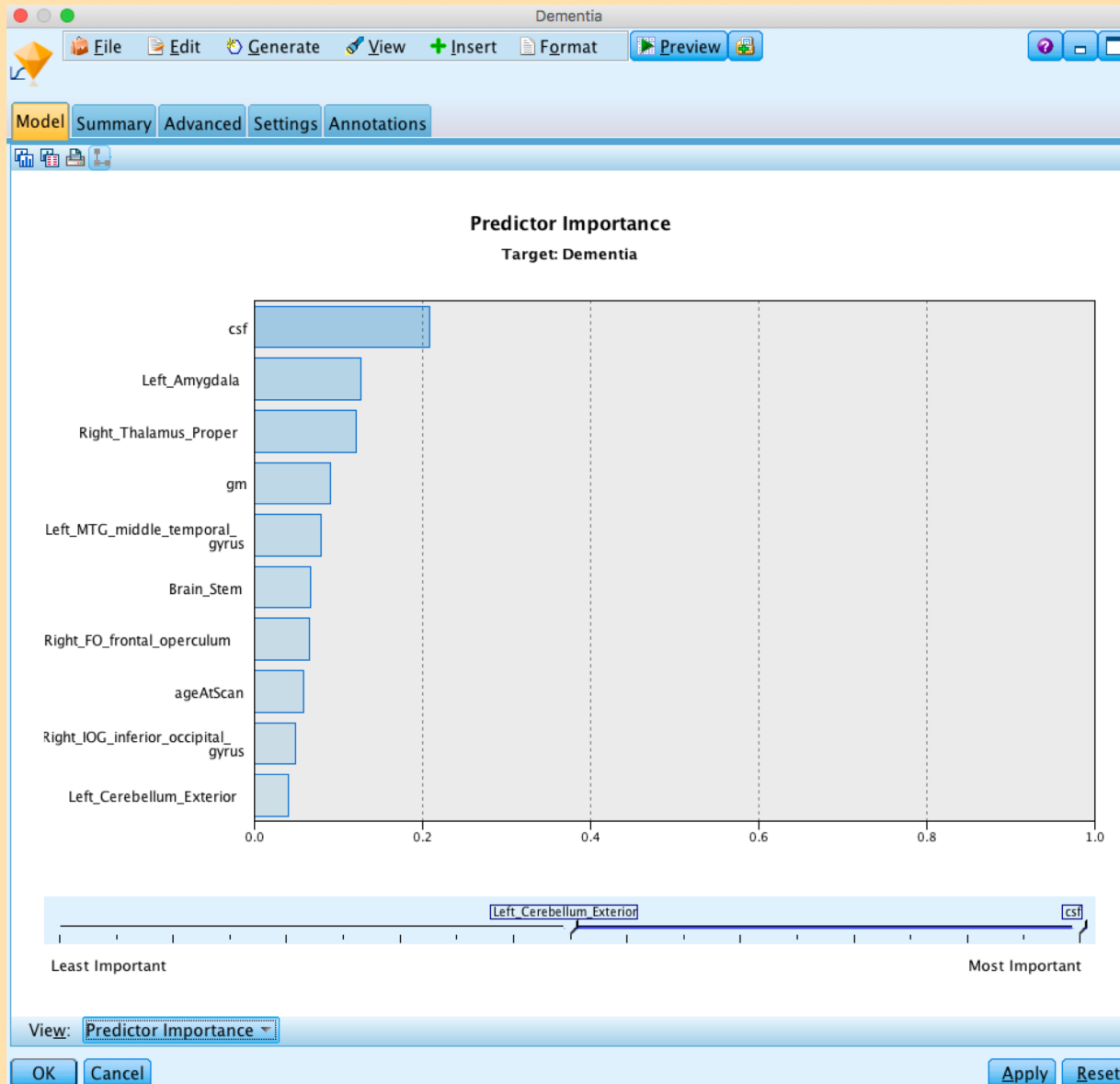
☒ Calculate predictor importance

Propensity Scores (valid only for flag targets)

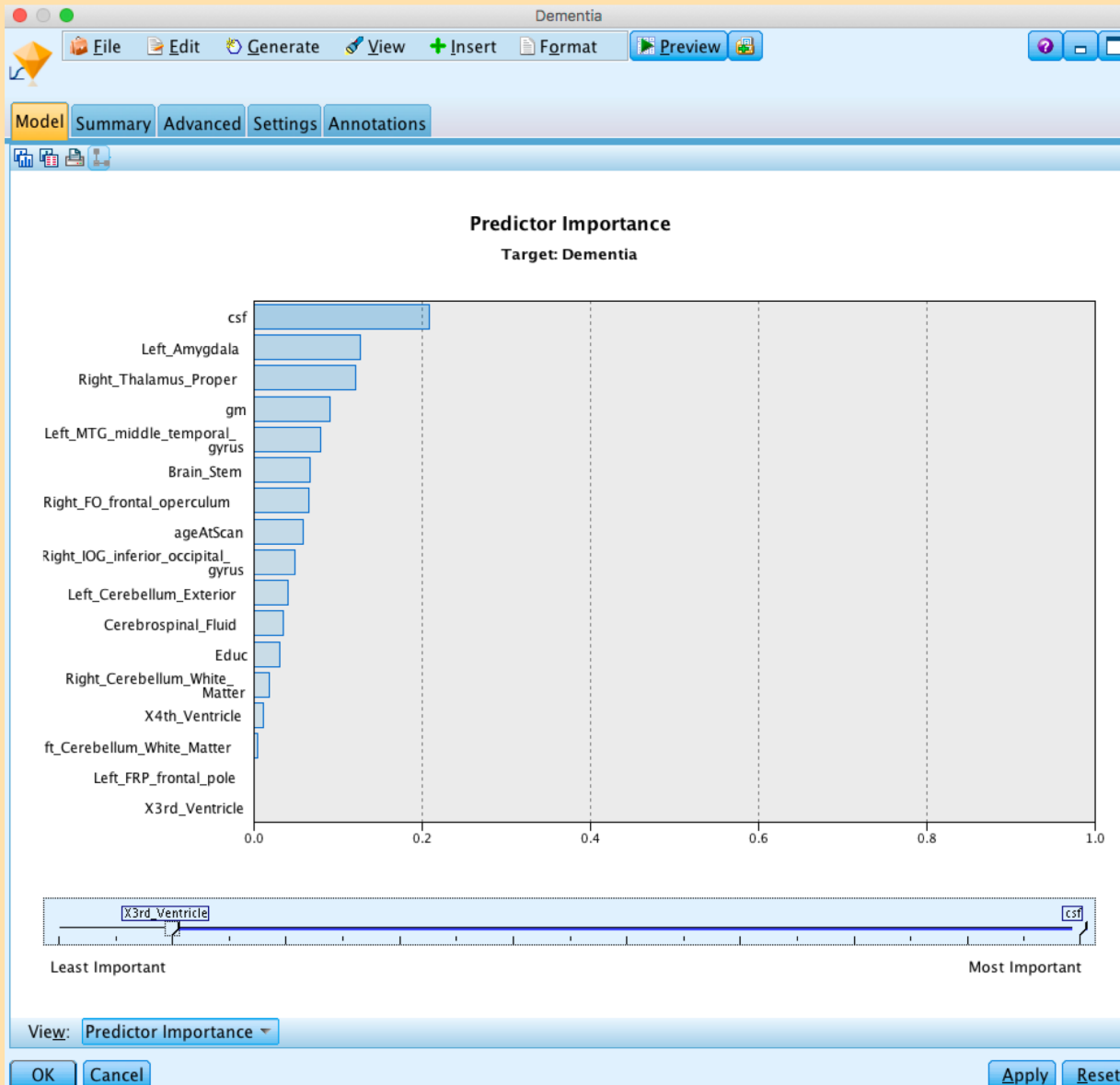
☐ Calculate raw propensity scores

OK  Run Cancel Apply Reset

Golden Nugget



Golden Nugget



Also, the Advanced tab has a lot of information about what happened in the forward step-wise procedure, which predictors were retained etc.

Analysis node



Analysis

Analyze \$L-Dementia

Analysis Output Annotations

☒ Coincidence matrices (for symbolic targets)

☐ Performance evaluation

☒ Evaluation metric (AUC & Gini, binary classifiers only)

☐ Confidence figures (if available)

Threshold for: 90 % correct

Improve accuracy: 2.0 fold

Find predicted/predictor fields using:

☒ Model output field metadata

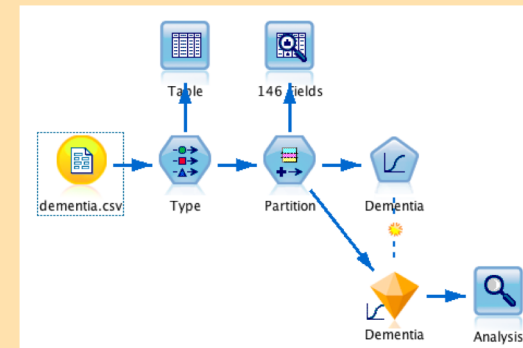
☐ Field name format (for example, '\$<x> - <target field>')

☒ Separate by partition

☐ User defined analysis [Define User Measure...](#)

Break down analysis by fields:

OK Run Cancel Apply Reset



Analysis node



Analysis of [Dementia] #2

File Edit

Analysis Annotations

Collapse All Expand All

Results for output field Dementia

- Individual Models
 - Comparing \$L-Dementia with Dementia

'Partition'	1_Training		2_Testing	
Correct	394	90.37%	196	87.5%
Wrong	42	9.63%	28	12.5%
Total	436		224	
 - Coincidence Matrix for \$L-Dementia (rows show actuals)

'Partition' = 1_Training	FALSE	TRUE	\$null\$
FALSE	191	11	4
TRUE	17	203	10

'Partition' = 2_Testing	FALSE	TRUE	\$null\$
FALSE	92	15	2
TRUE	6	104	5
- Evaluation Metrics

'Partition'	1_Training		2_Testing	
Model	AUC	Gini	AUC	Gini
\$L-Dementia	0.944	0.888	0.93	0.859

OK

Monday's lecture – Machine Learning 3

- K-nearest neighbors
- Cross-validation
- Classification Trees
- Neural Networks (Neural Nets)

Note: HW #4 is on CLE

– due 11.55pm on Thursday August 23