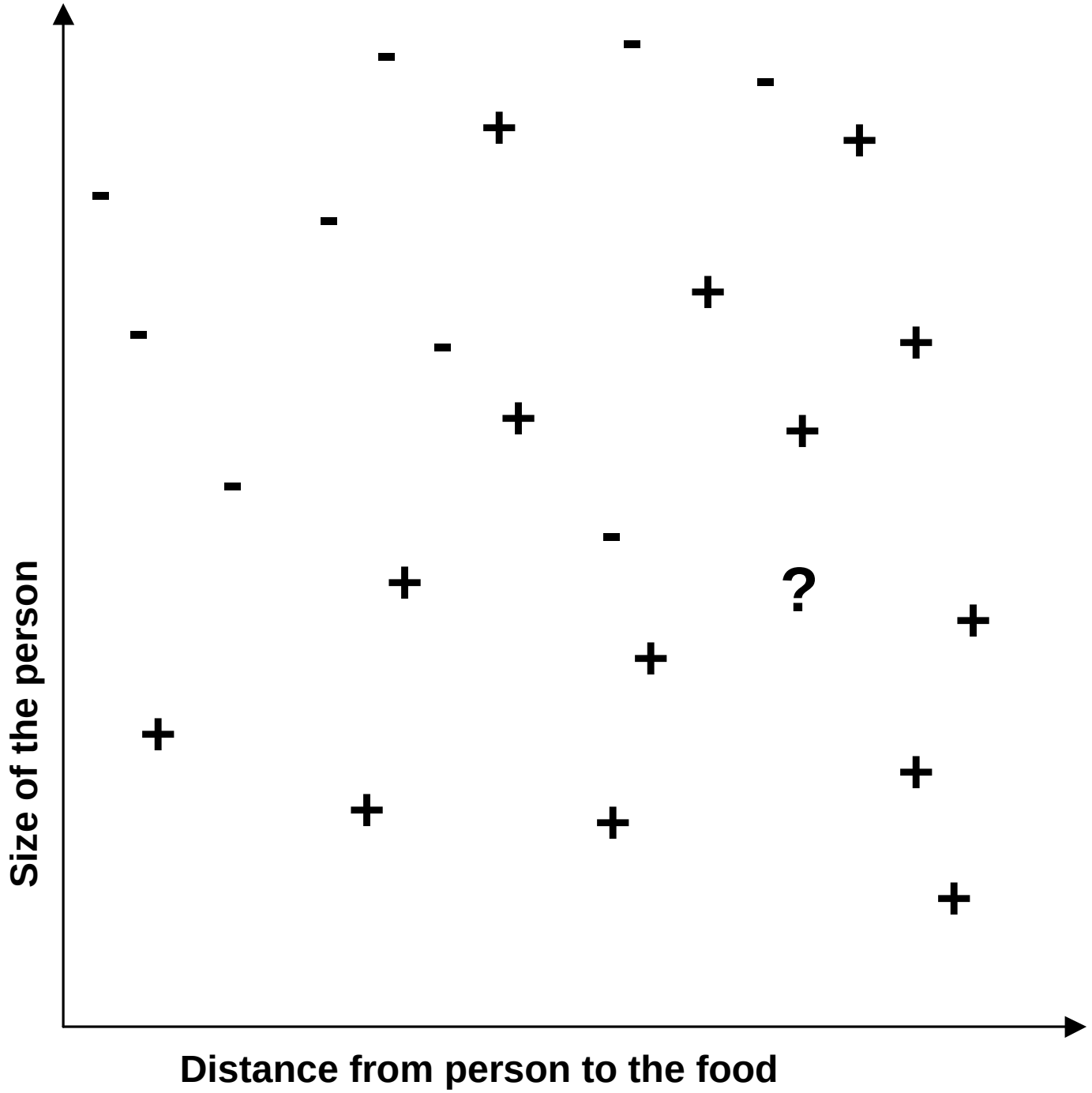
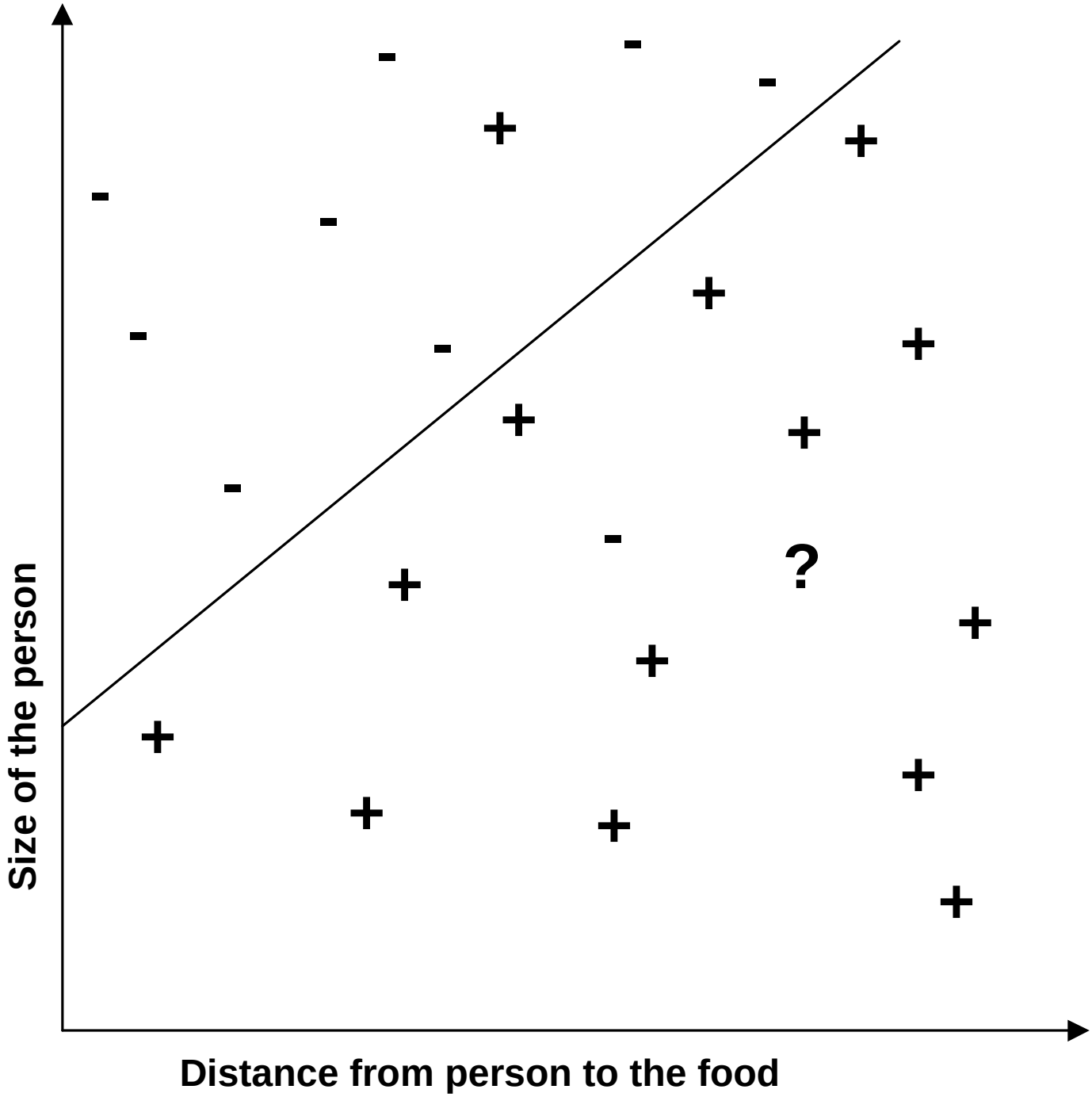
A Classification Algorithm is a procedure for selecting a hypothesis from a set of alternatives that best fits a set of observations.

Working Definition of Classification
(Supervised Learning)



\+ = Got the food

\- = Got caught



+ = Got the food

- = Got caught

Training Set -- Set of labeled examples
(Set of observations begin matched by the learning algorithm.)

Labeled Example -- Vector of feature values and associated label.
(A single observation)

Feature Value -- A numeric or ordinal value.
(The value of one particular aspect of an observation)

Label -- A numeric or ordinal value.
(The value to be predicted by the learning algorithm.)

Hypothesis -- A mapping from feature vectors to labels
(The output of the learning algorithm. One possible pattern observed in the data.)

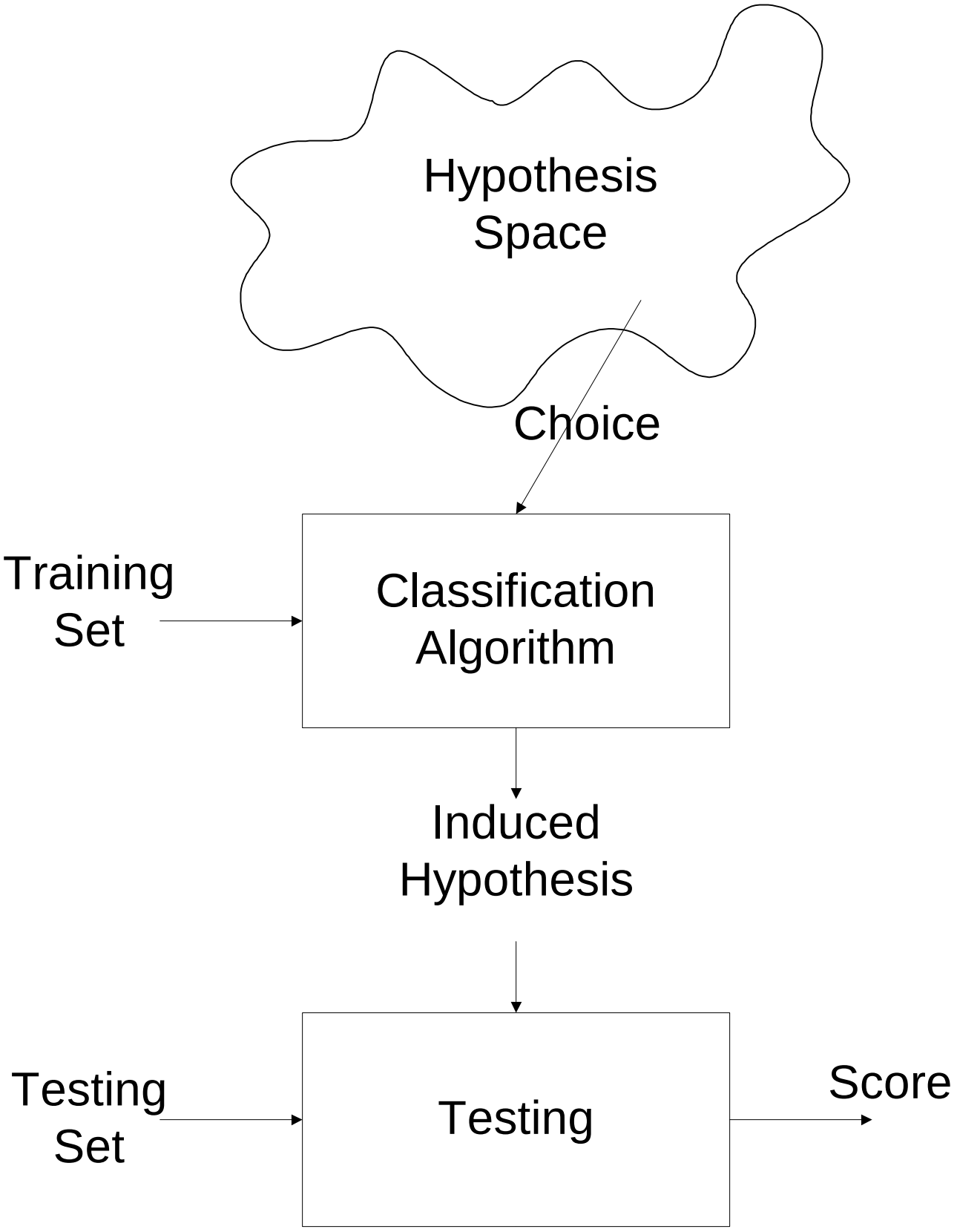
Hypothesis Space -- A set of hypotheses.
(The space of all possible hypotheses considered by a learning algorithm.)

Target Concept -- A mapping from feature vectors to labels.
(The "real world" mapping being sought. We assume the training set is generated from a distribution base upon this mapping. We do not assume the target concept is a member of the hypothesis space.)

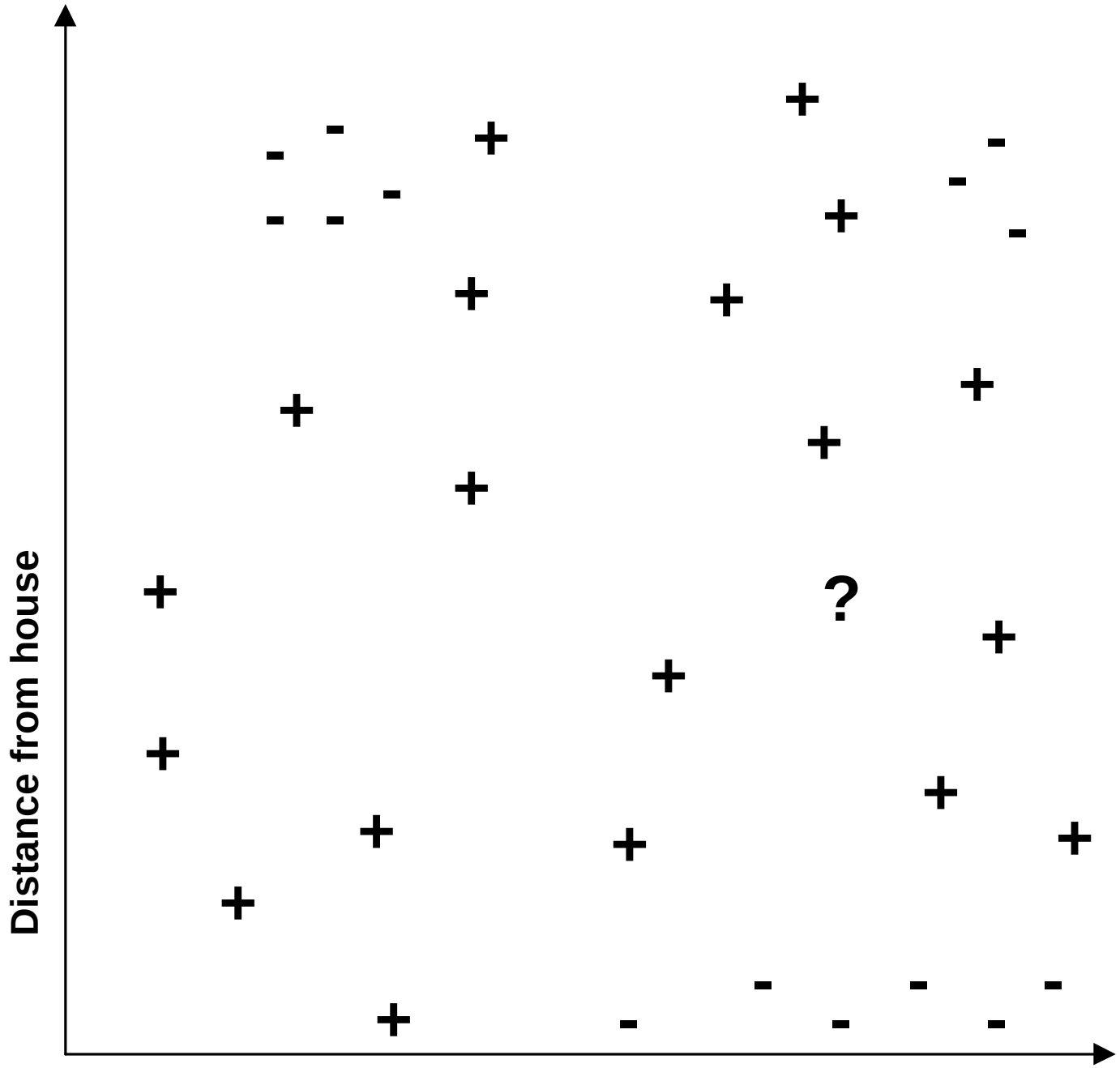
Objective Function -- A mapping that maps a training set and hypothesis to a real value.
(Measures the match between a set of observations and a hypothesis that seeks to predict those observations. Also called the loss function, cost function, or utility measure.)

Classification Algorithm -- A mapping from training sets to hypotheses that minimizes the objective function.
(Supervised learning algorithm. Most practical classification algorithms are approximate, they strive to but go not guarantee to return the hypothesis that minimized the objective function.)

Components of a Classification Learning System (input/output of Supervised Learning)



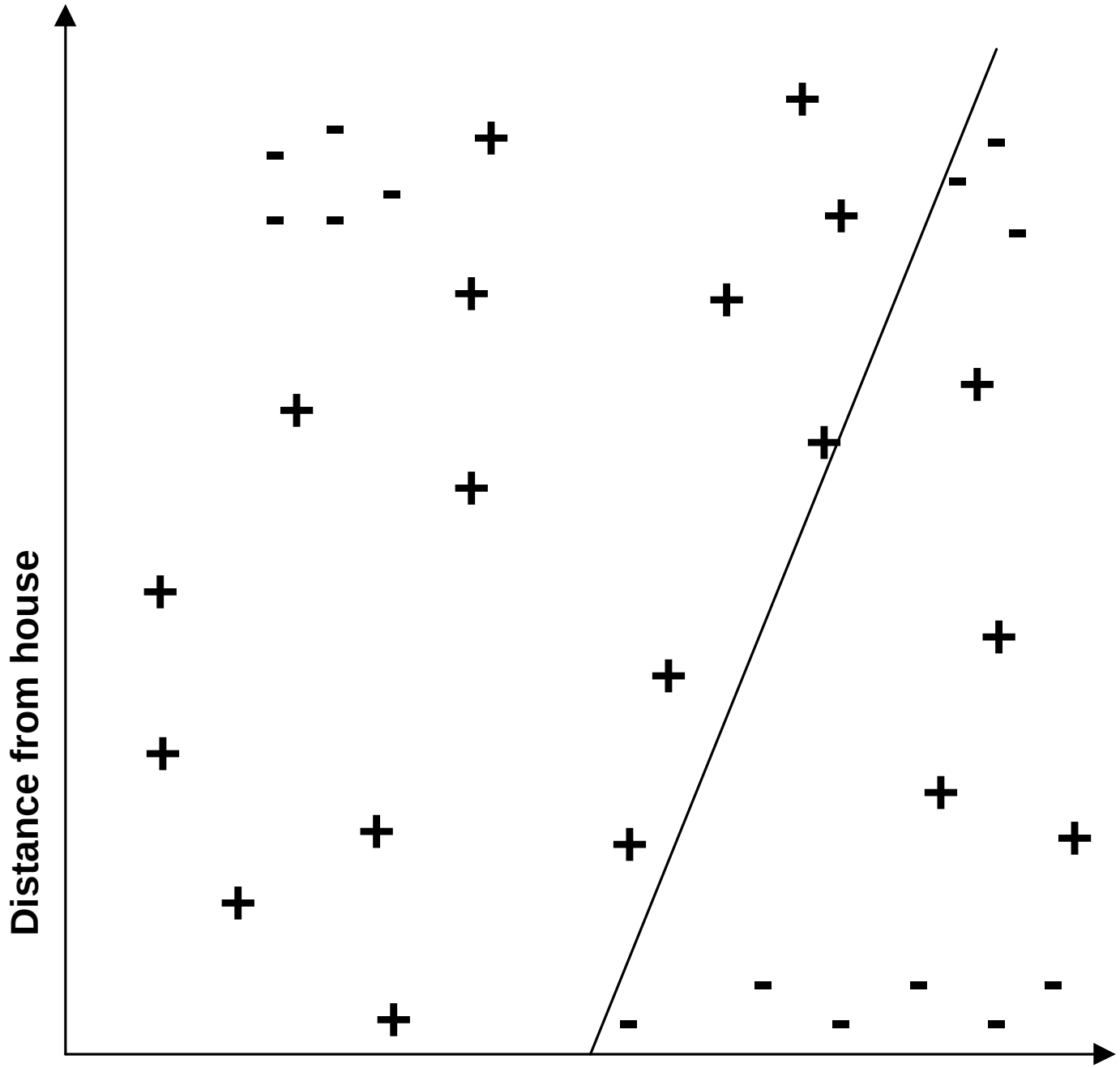
Block Diagram of a Classification Algorithm



\+ = Relief in safety

\- = Scolded by owner

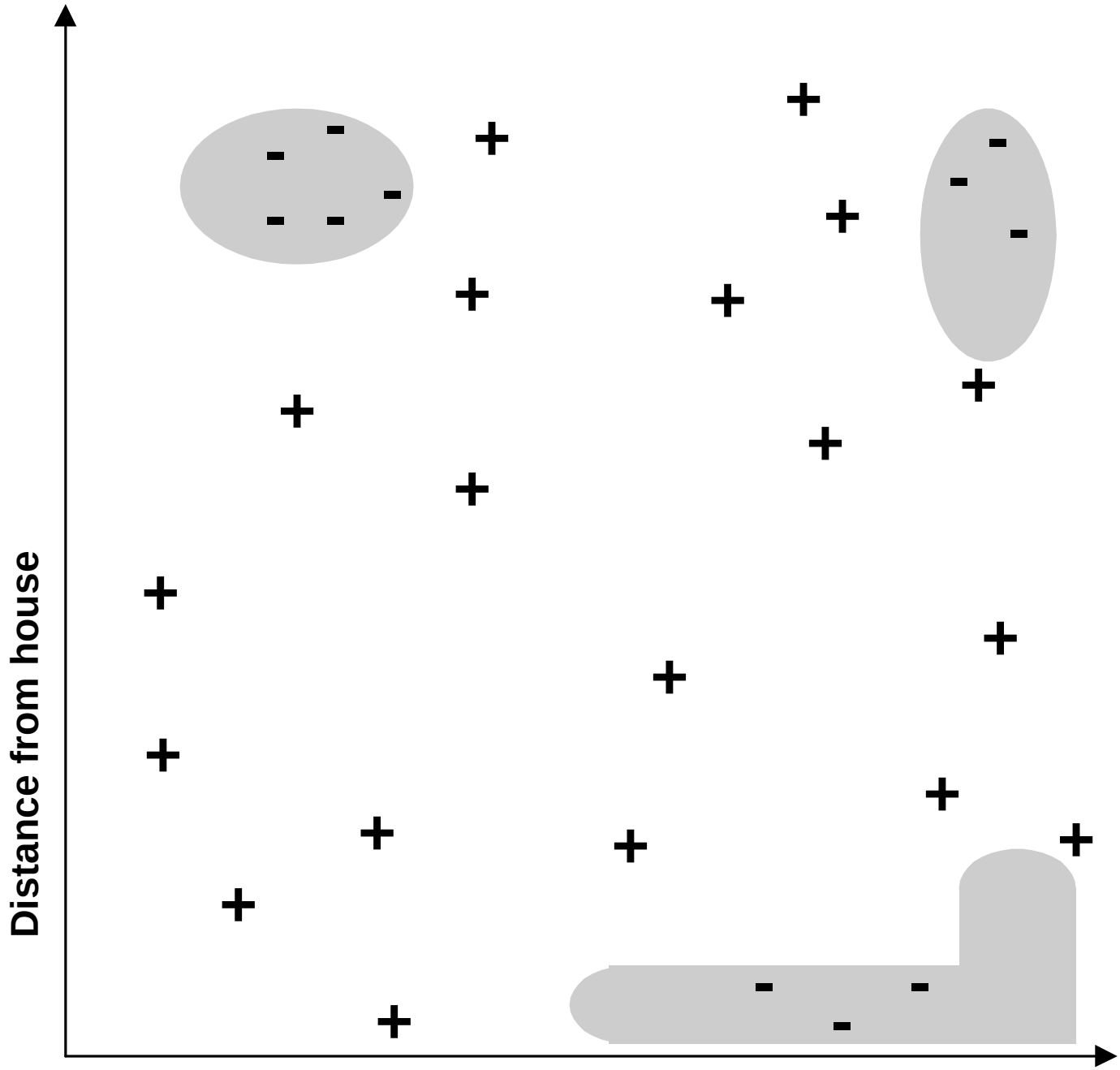
Relief in the front yard



\+ = Relief in safety

\- = Scolded by owner

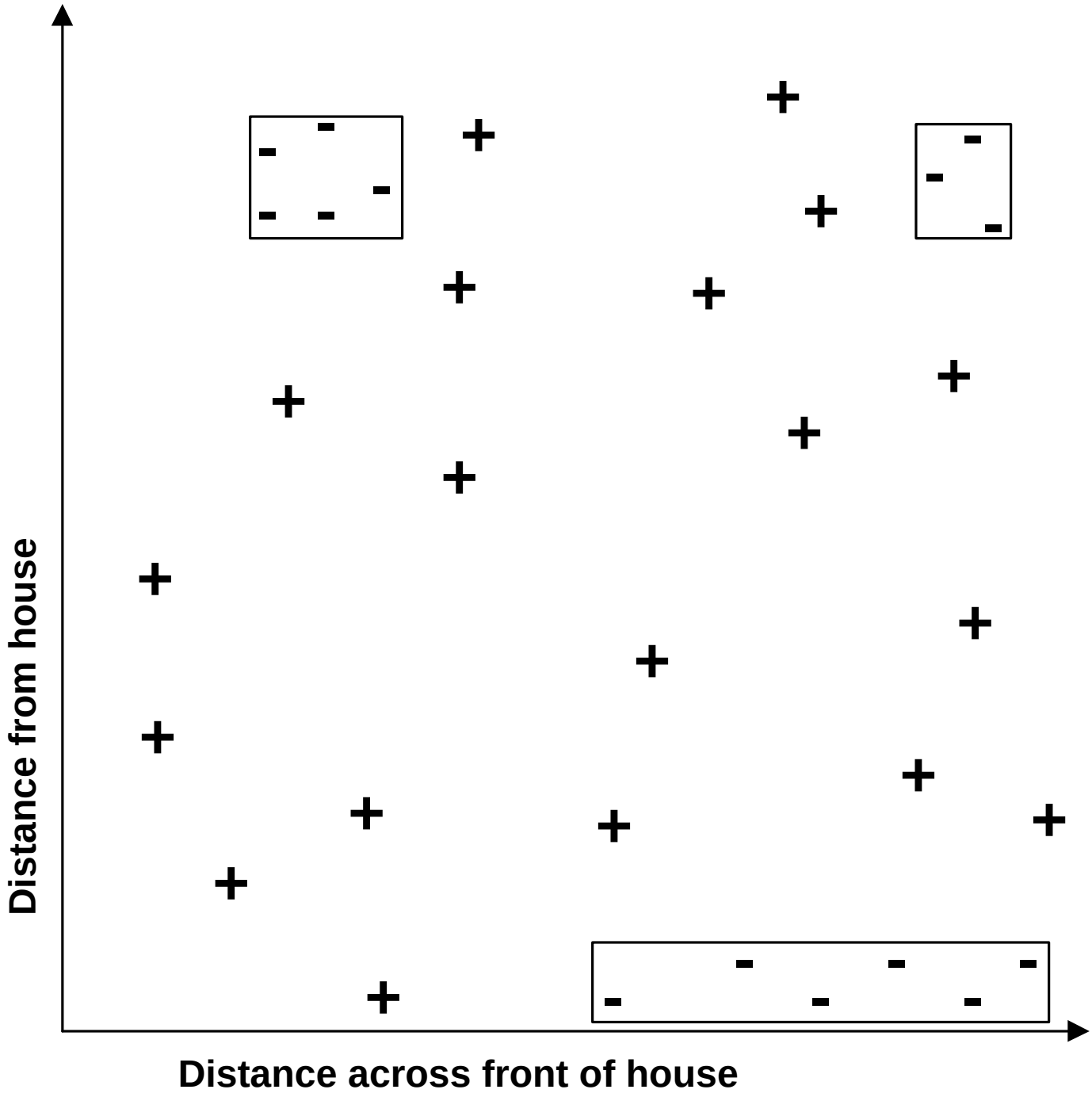
Relief in the front yard



+ = Relief in safety

- = Scolded by owner

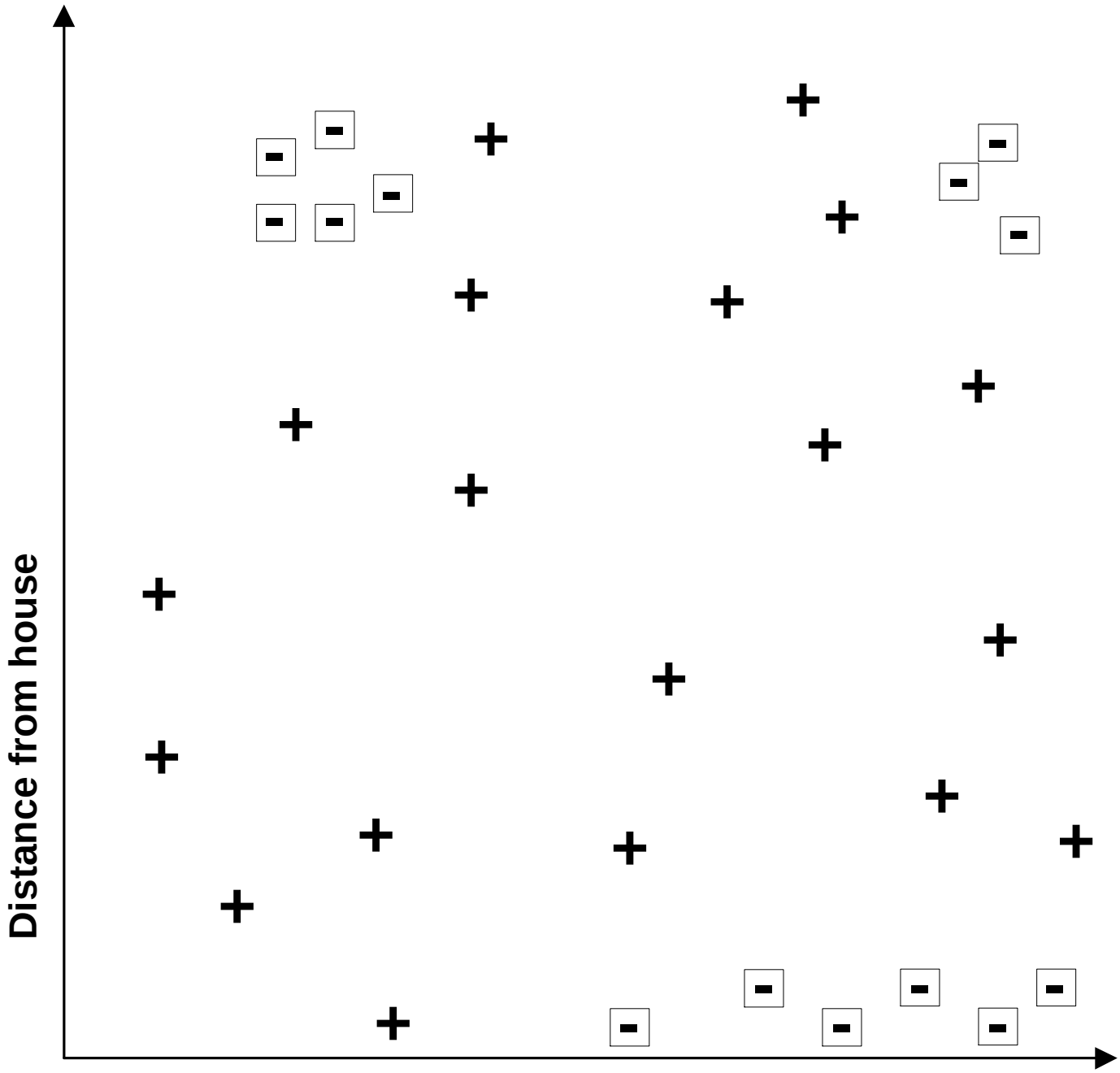
Relief in the front yard



\+ = Relief in safety

\- = Scolded by owner

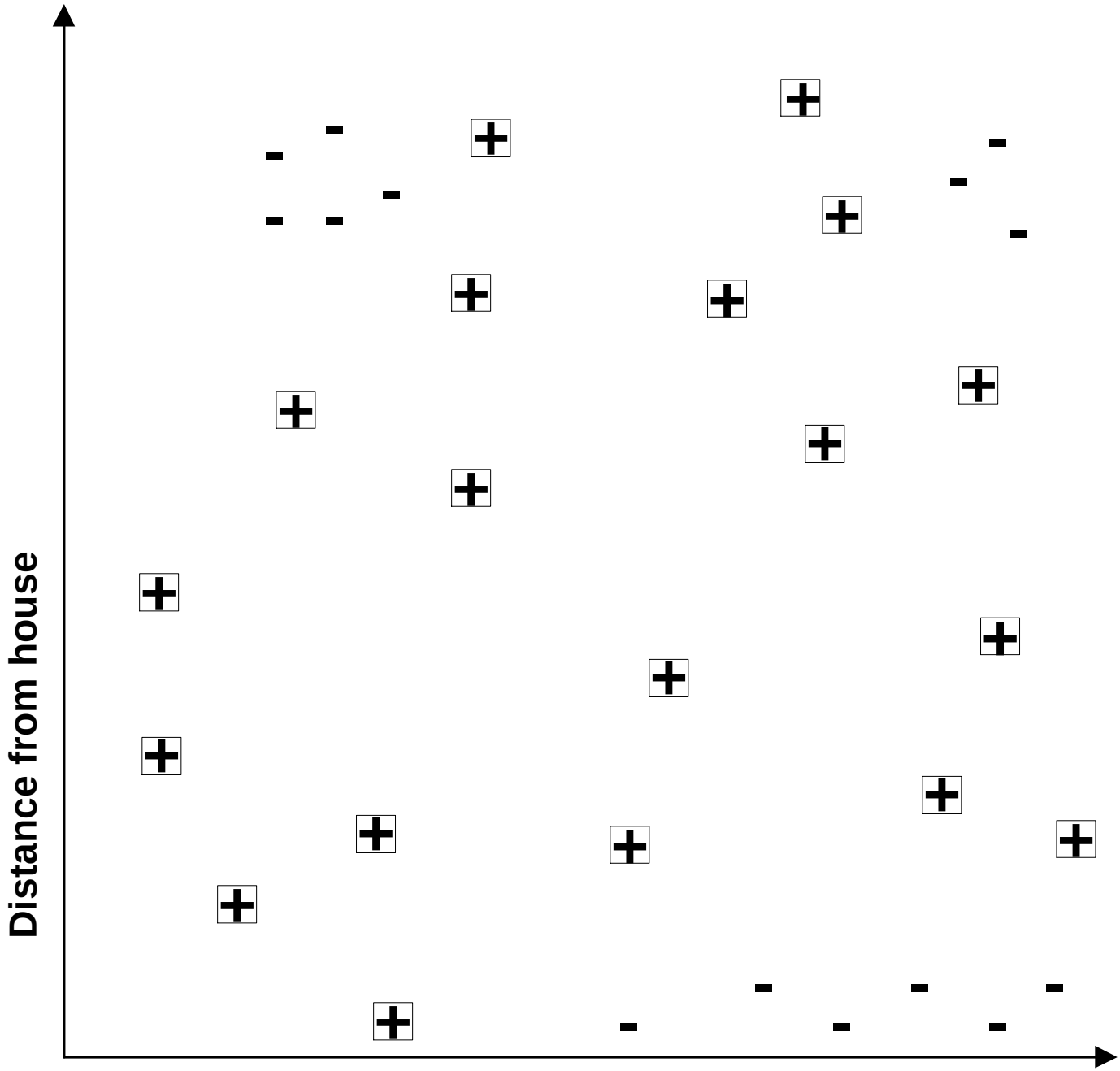
Relief in the front yard



\+ = Relief in safety

\- = Scolded by owner

Relief in the front yard



+ = Relief in safety

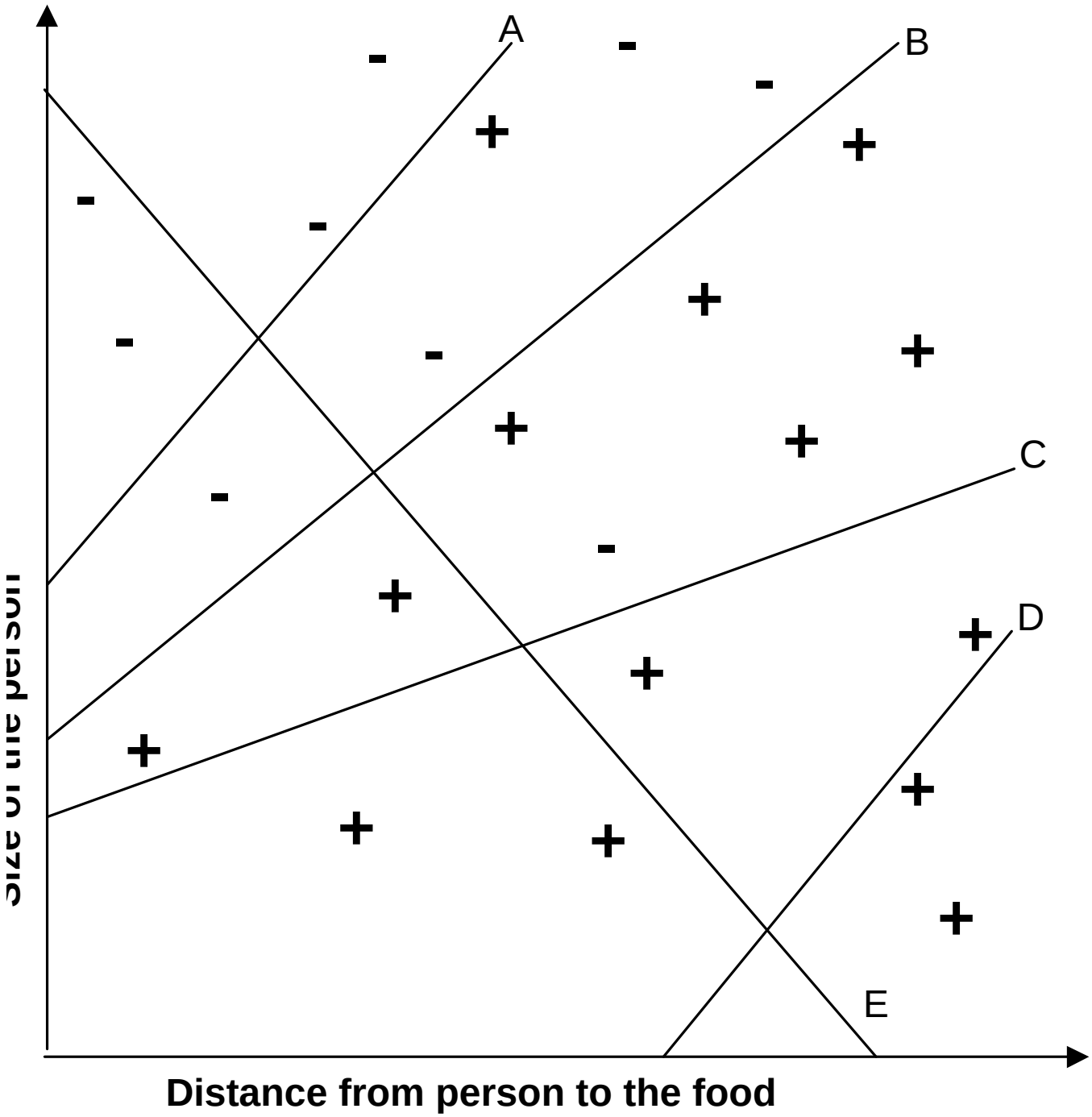
- = Scolded by owner

Relief in the front yard

Generalization -- Making predictions about unseen examples based on observations

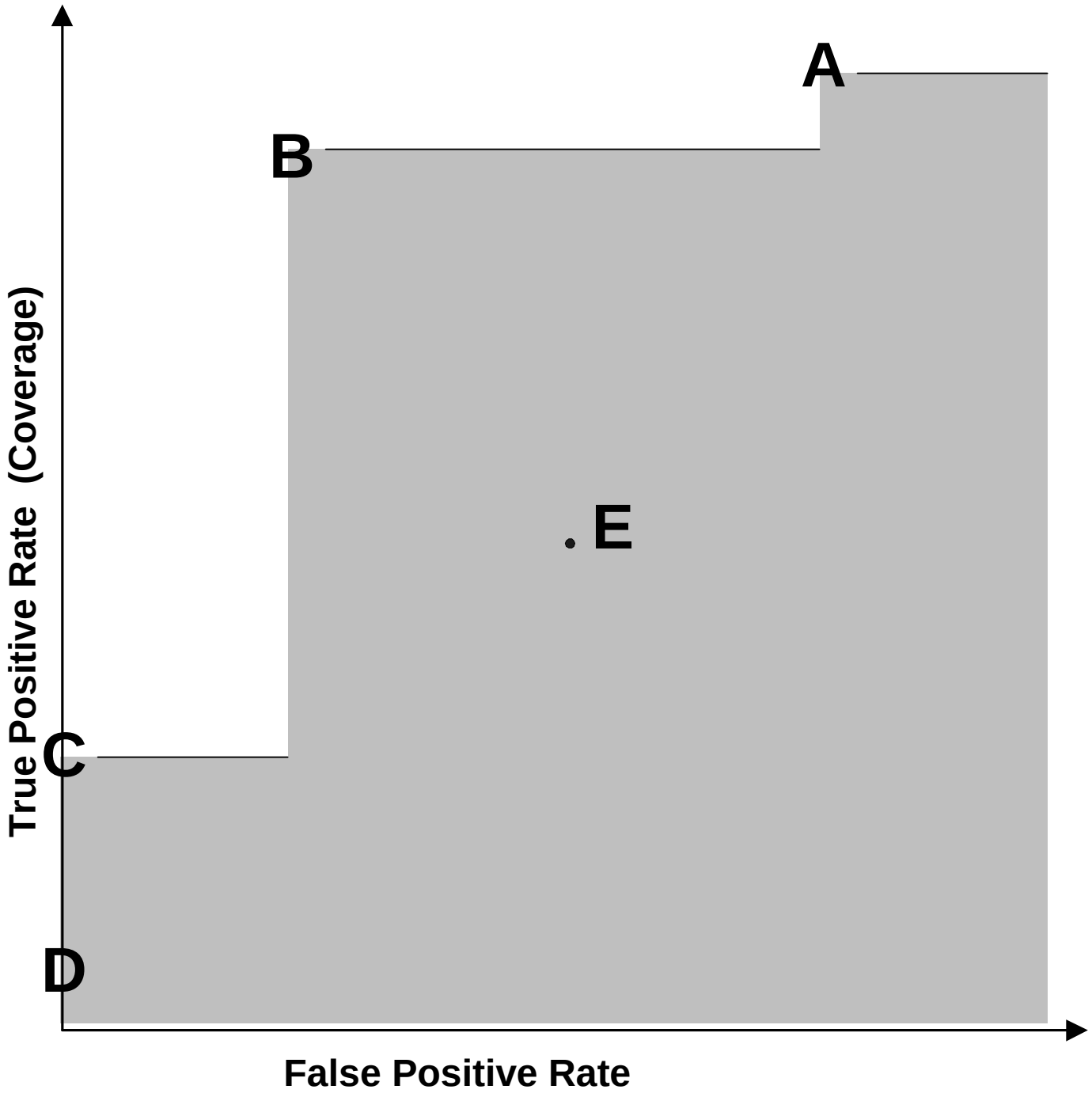
More Hypotheses = Less Generalization

Definition of Generalization



+ = Got the food

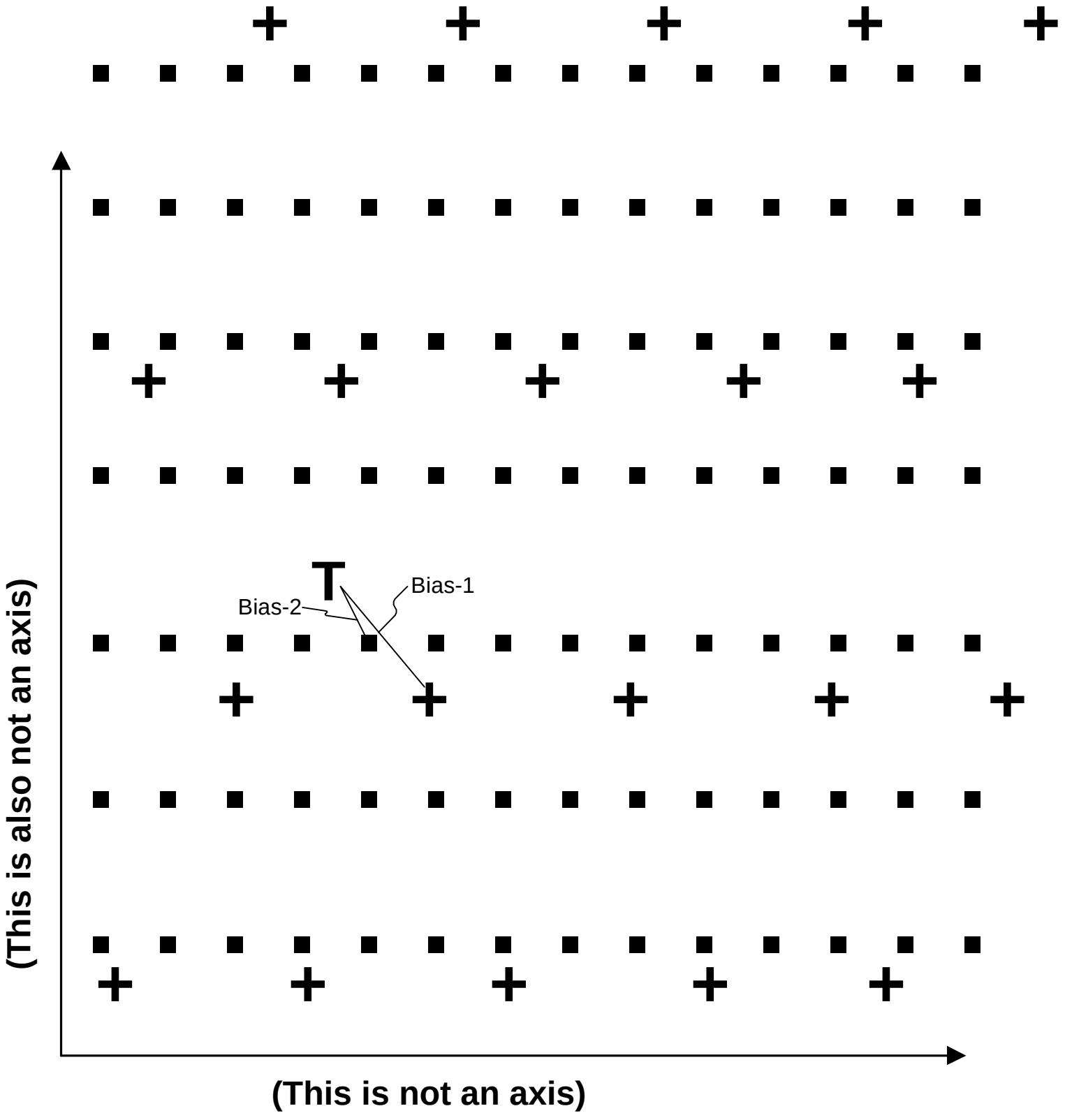
- = Got caught



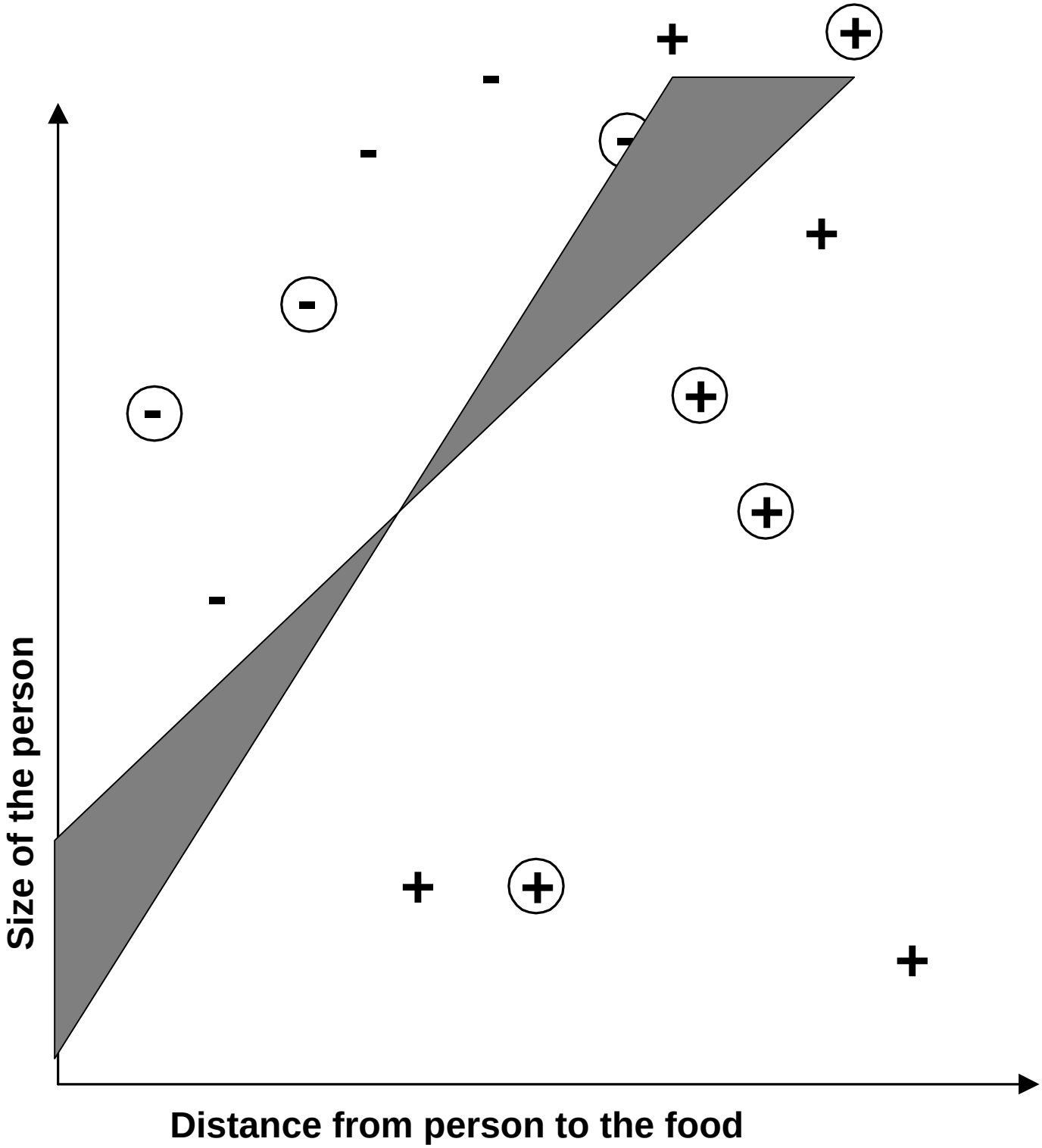
ROC -- Receiver Operator Characteristic

Bias -- Everything that affects the hypothesis selected by the Classification Algorithm except the training data itself.

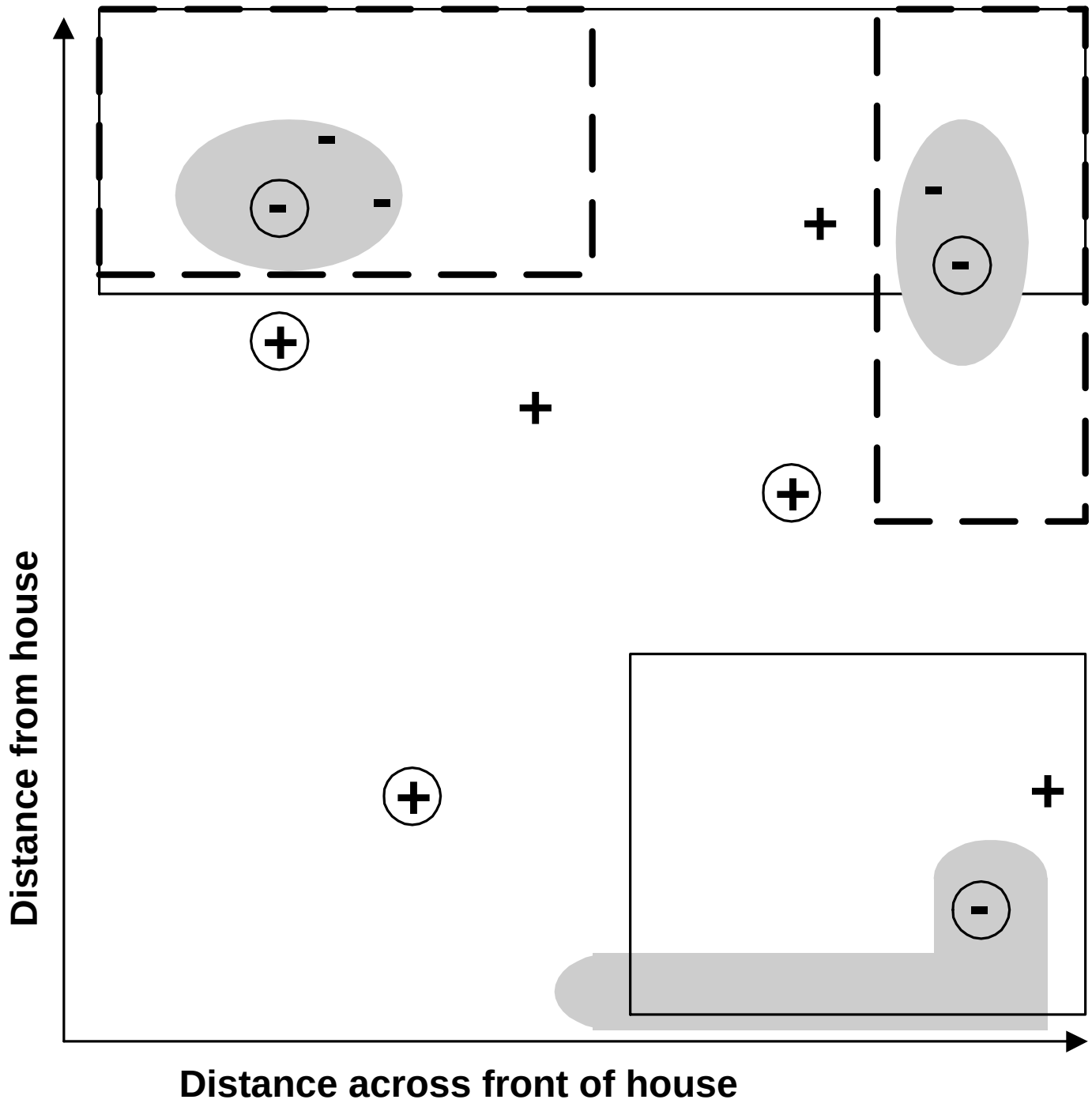
Bias -- A measure (in terms of the objective function) of the inherent error of the classification algorithm, given unbounded amounts of training data. (It is a measure of the "best the algorithm can do")

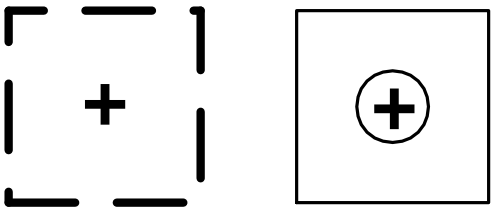


Two Hypothesis Spaces S1 and S2



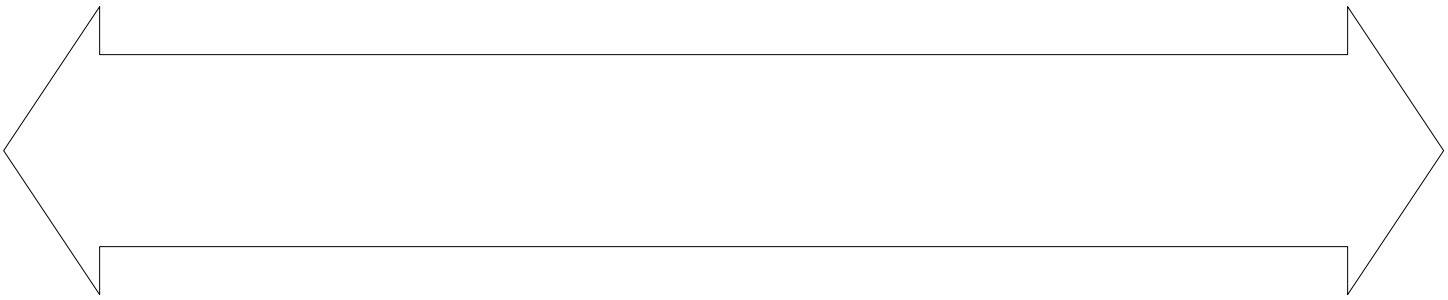
The variance between hypotheses





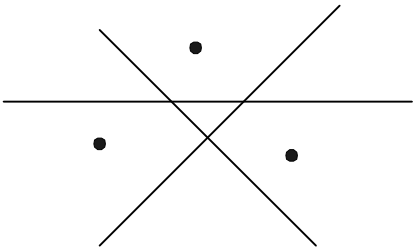
Variance in Relief

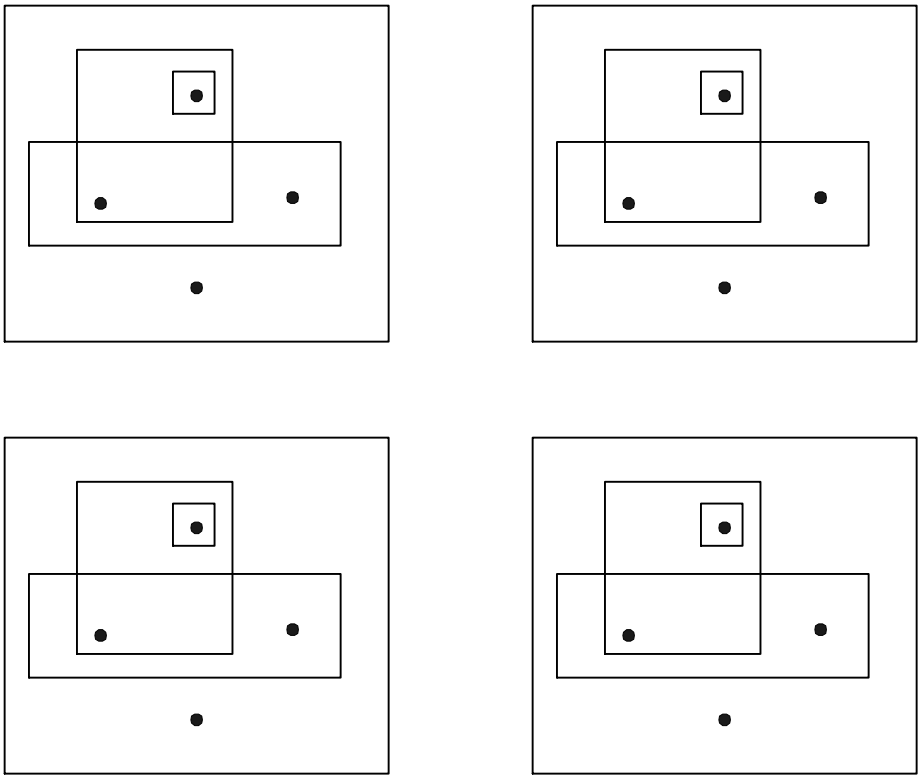
Weak Bias	Strong Bias
Large Hypothesis Space	Small Hypothesis Space
Large Training Set	Small Training Set
Overfit	Overgeneralization
Variance Error	Bias Error
Low Stability	High Stability
Noise Sensitive	Noise Tolerant



The *VC-Dim* of a set of hypotheses is the largest N such that there exists a set of N feature vectors shattered by the hypothesis space.

A set of feature vectors is *shattered* by a set of hypotheses iff there exists a hypothesis H for each possible binary labeling of those vectors



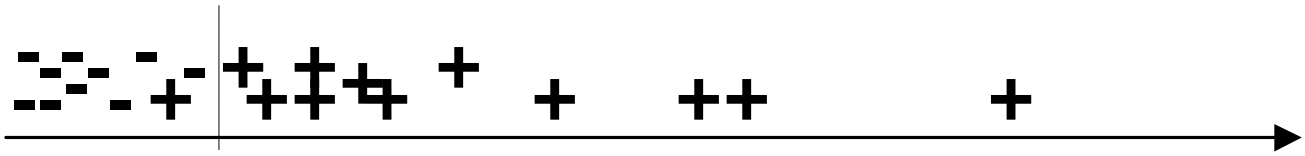


Vapnik-Chervonenkis Dimension (VC-Dimension)

x	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
+ Ex01	0	0	1	1	0	0	0	1	0	0	0	1	0	0	0	0	1	0	0
+ Ex02	0	0	1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0
+ Ex03	0	0	0	1	1	0	0	0	0	1	1	0	0	1	0	1	0	0	0
+ Ex04	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
- Ex05	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
- Ex06	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0	0	1	0
- Ex07	0	0	0	0	1	0	0	1	1	0	1	1	0	0	1	0	1	0	0
- Ex08	0	0	1	0	0	1	0	0	1	1	1	0	1	0	1	0	0	0	0

x=+ if a+d>1 or c+h-l>1 ...

The Curse of Dimensionality



Distance to nearest flower

\+ = Relief in safety

\- = Scolded by owner

Re-Representing the front yard problem

Problem 1: Fit the problem of recognizing alpha-numeric characters into the classification framework. Specify with two sentences or a paragraph what each of the framework's components are in the case of character recognition, and how they would be obtained.

Problem 2: Propose a variant with a stronger bias by specifying a different representation of the examples.

Problem 3: Again propose another variant that has a stronger bias, but in this case specify a different hypothesis space (leaving the representation fixed.)

Homework 1B