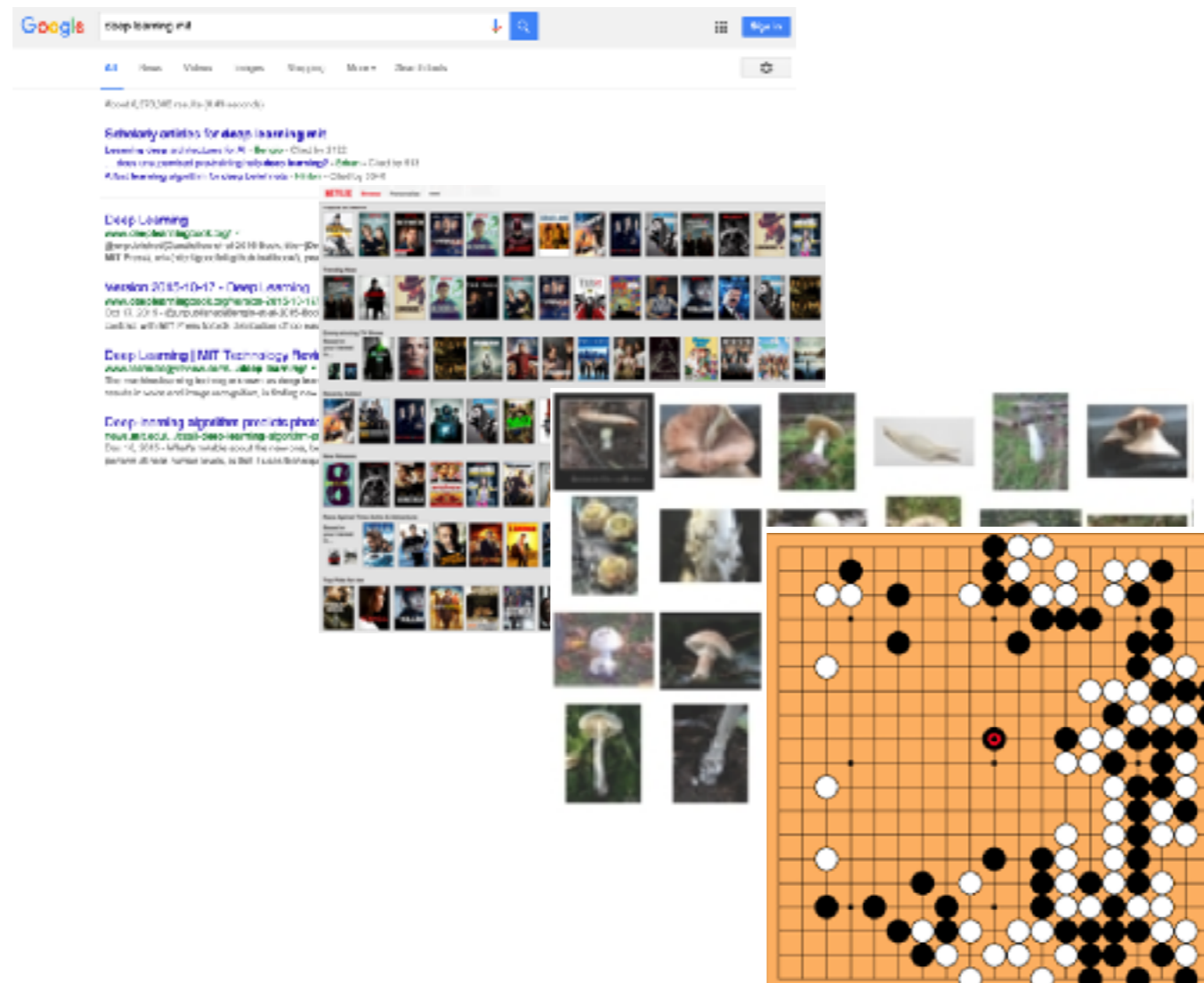# Machine Learning
Lecture 1

Machine learning is everywhere

‣ Search, content recommendation, image/scene analysis, machine translation, dialogue systems, automated assistants, game playing, sciences (biology, chemistry, etc), …

Machine learning: what is it?

‣ A brief definition

Machine learning as a discipline aims to design, understand and apply computer programs that learn from experience (i.e., data) for the purpose of modeling, prediction, or control

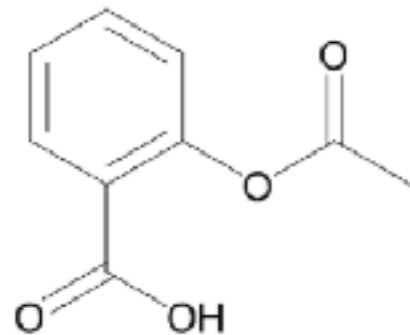# Prediction problems

‣ About future events

Market value

Time

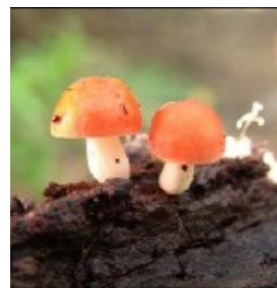‣ Also collision avoidance, monitoring, medical risk, etc.

Prediction problems

‣ About properties we don't yet know

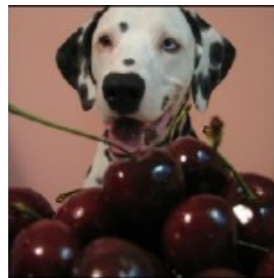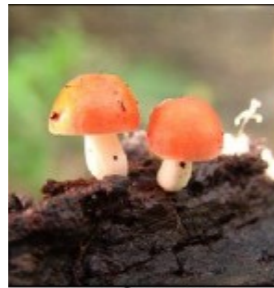would I like this movie?

soluble in water?

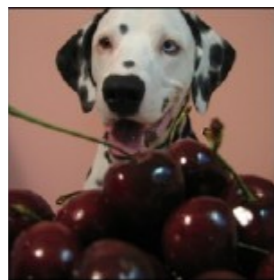what is the image about?

"ML is very cool"   what is it in Spanish?

Example: supervised learning

‣ It is easier to express tasks in terms of examples of what you want (rather than how to solve them)

‣ E.g., image classification (1K categories)

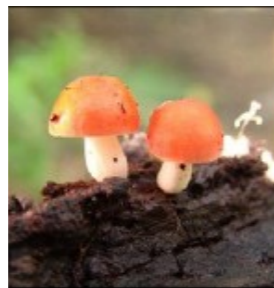| **Image**	**Category**
	mushroom
	cherry
…	…

Example: supervised learning

‣ It is easier to express tasks in terms of examples of what you want (rather than how to solve them)

‣ E.g., image classification (1K categories)

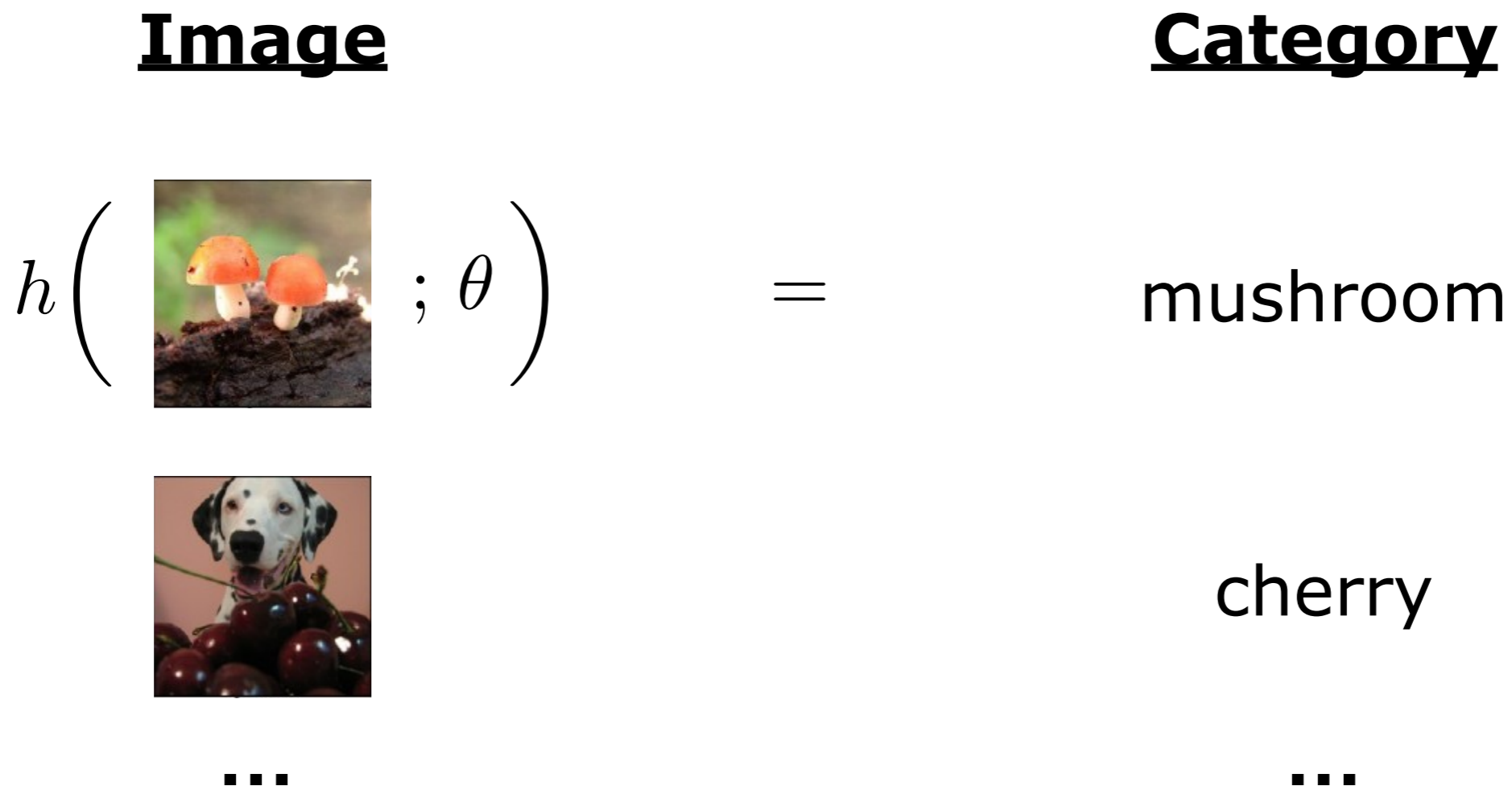| **Image**	**Category**
	mushroom
	cherry
...	...

‣ Rather than specify the solution directly (hard), we automate the process of finding one based on examples

Example: supervised learning

‣ It is easier to express tasks in terms of examples of what you want (rather than how to solve them)

‣ E.g., image classification (1K categories)

Image   **Category**

$$h\left(\text{[image]} \; ; \theta \right) =$$ mushroom

[image]   cherry

...   ...

‣ Rather than specify the solution directly (hard), we automate the process of finding one based on examples

Example: supervised learning

‣ It is easier to express tasks in terms of examples of what you want (rather than how to solve them)

‣ No limit to what you can learn to predict…

English		**Spanish**
$h\big(\text{ Is it real? }; \theta\big)$	$=$	¿Es real?
Will it continue?		¿Continuará?
For how long?		¿Por cuanto tiempo?
...		**...**

‣ Already in production for some language pairs (Google)

A concrete example

‣ Learning to predict preferences from just a little data…

A concrete example

‣ Learning to predict preferences from just a little data…
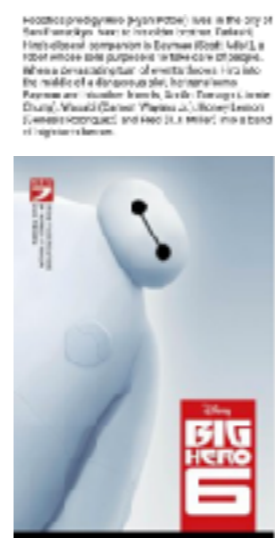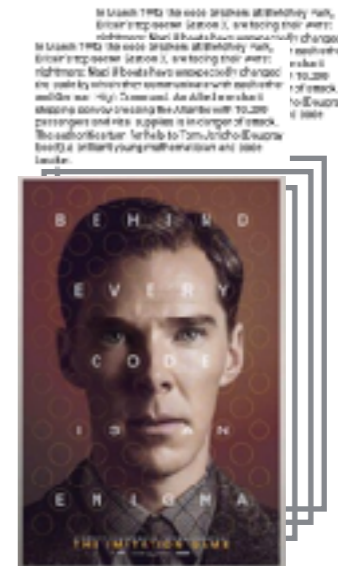

-1   -1   +1   +1   ?,   ?, ….

A concrete example

‣ Learning to predict preferences from just a little data...
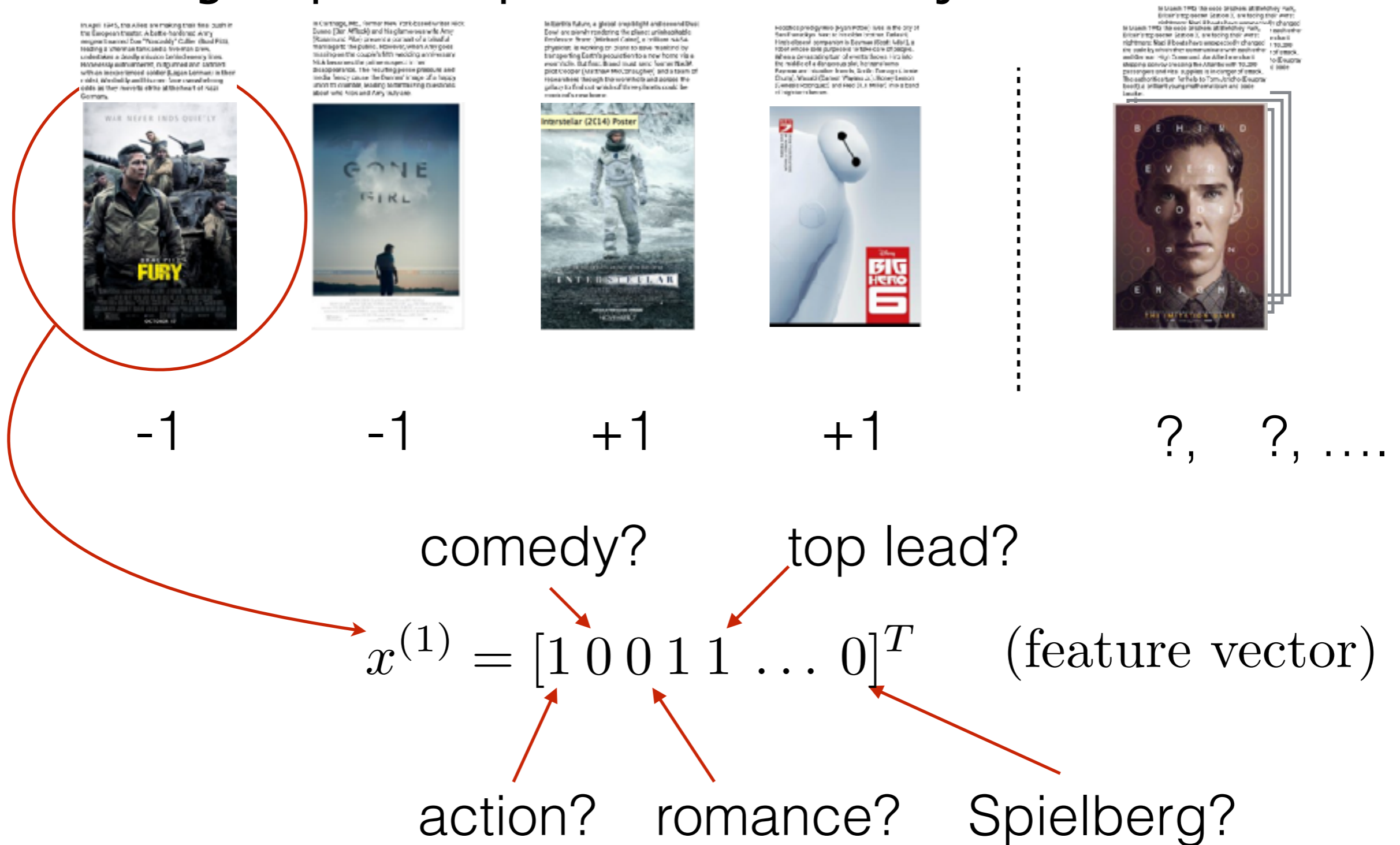

-1   -1   +1   +1   ?,   ?, ...

comedy?   top lead?

$$x^{(1)} = [1\ 0\ 0\ 1\ 1\ \ldots\ 0]^T \quad \text{(feature vector)}$$
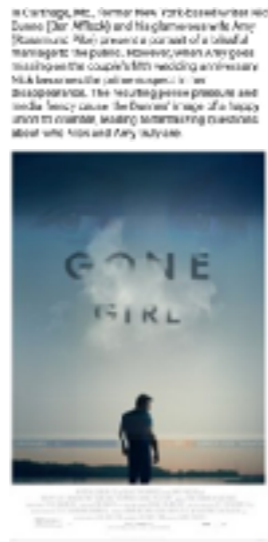
action?   romance?   Spielberg?

Supervised learning
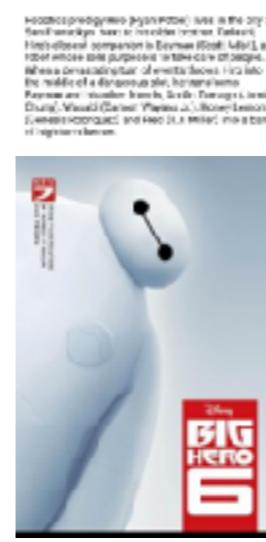
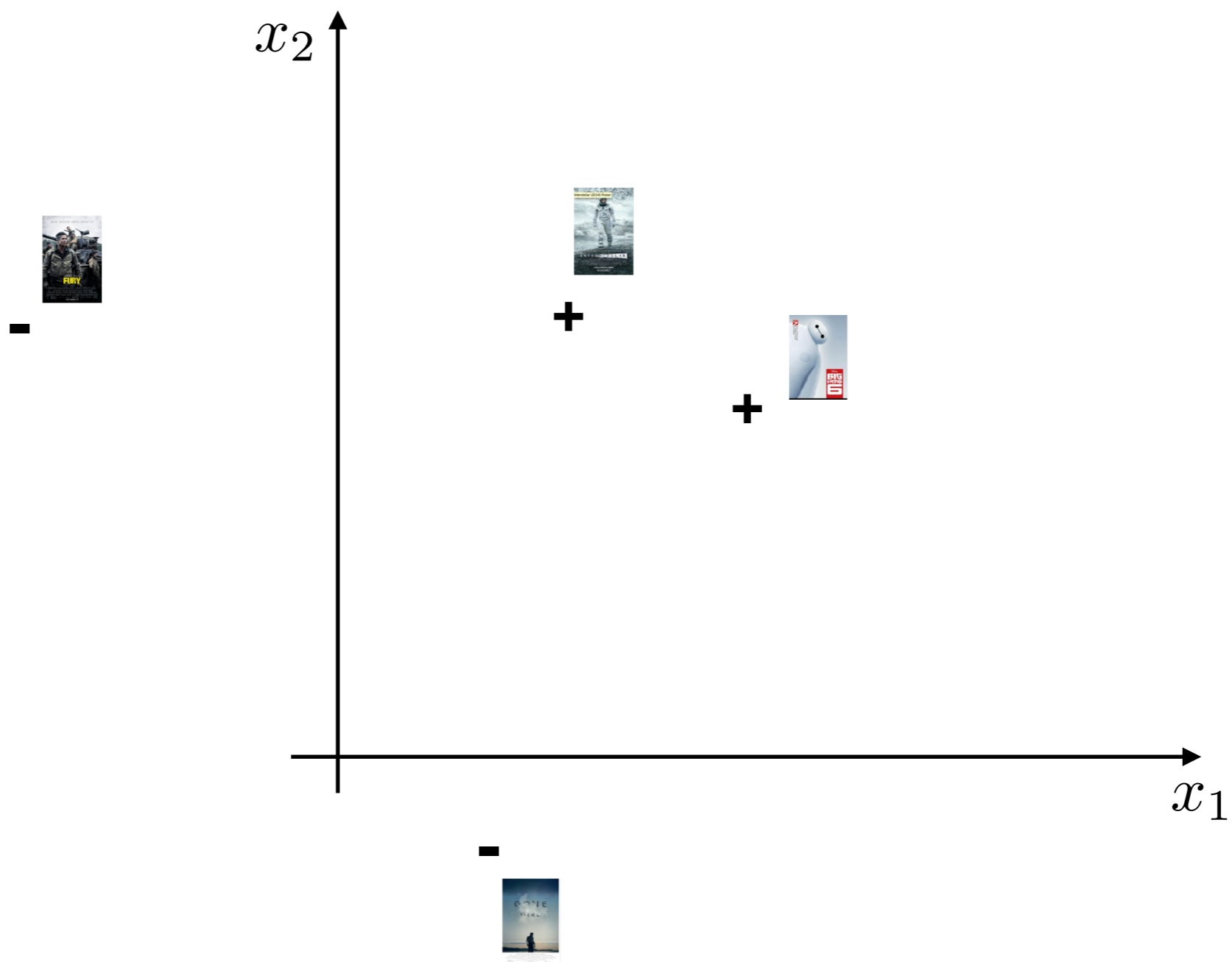‣ Learning to predict preferences from just a little data...

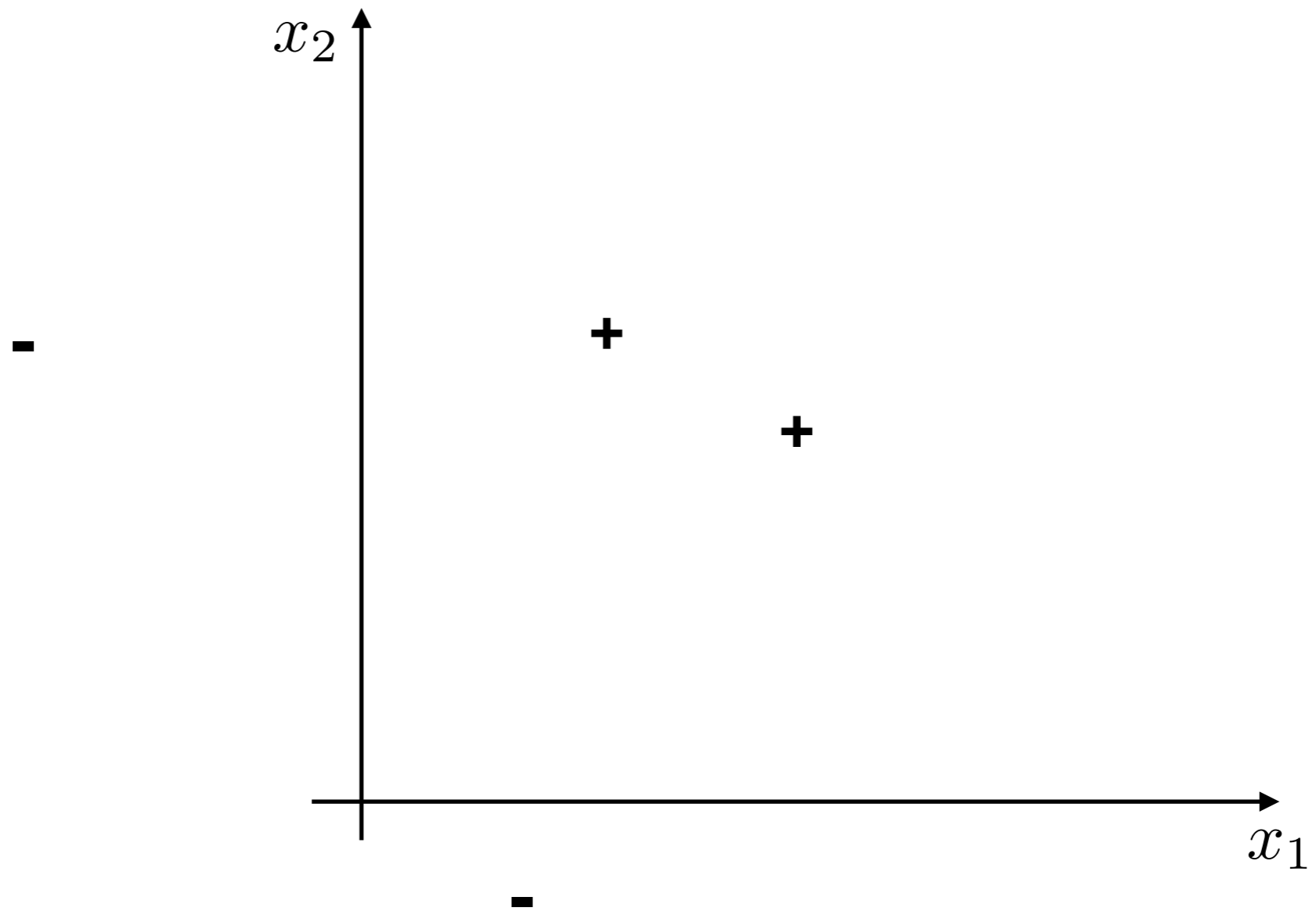| $x^{(1)}$	$x^{(2)}$	$x^{(3)}$	$x^{(4)}$	$x^{(5)}, x^{(6)}, \ldots$
-1	-1	+1	+1	?, ?, ...
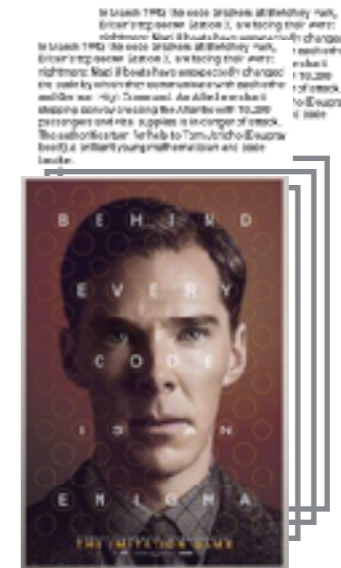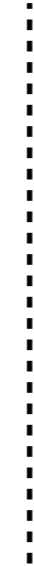
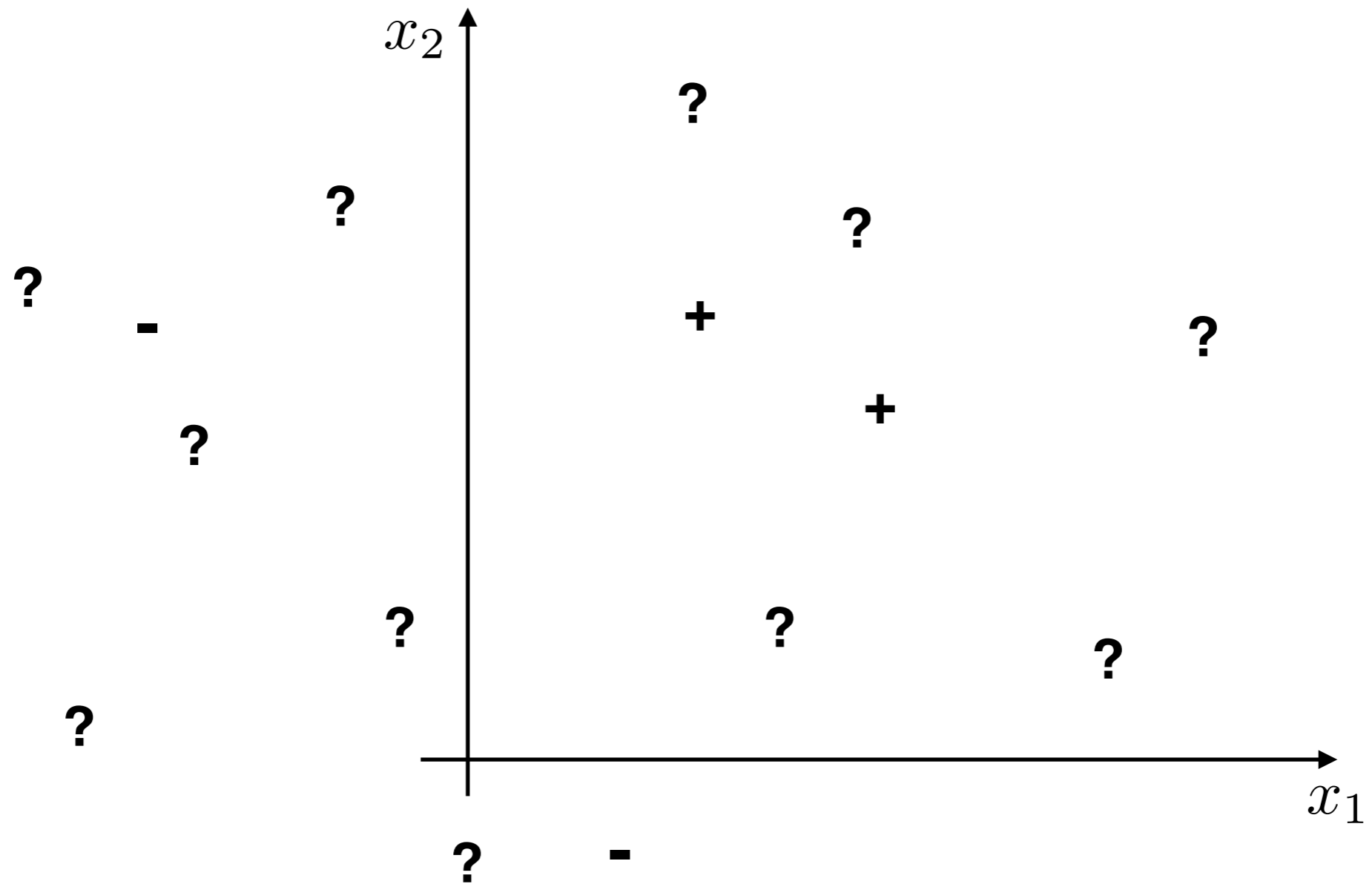Training set   Test set

Supervised learning
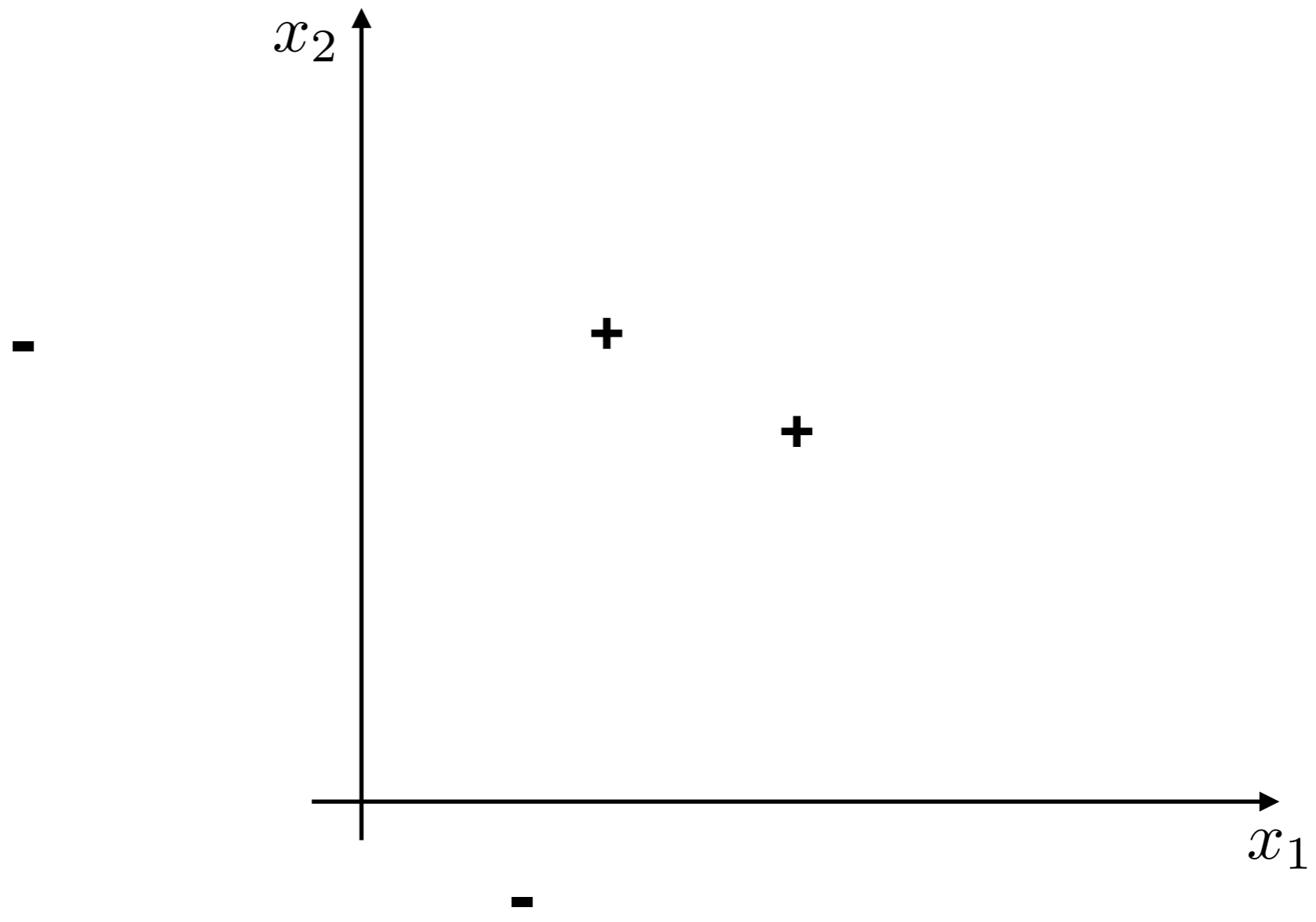
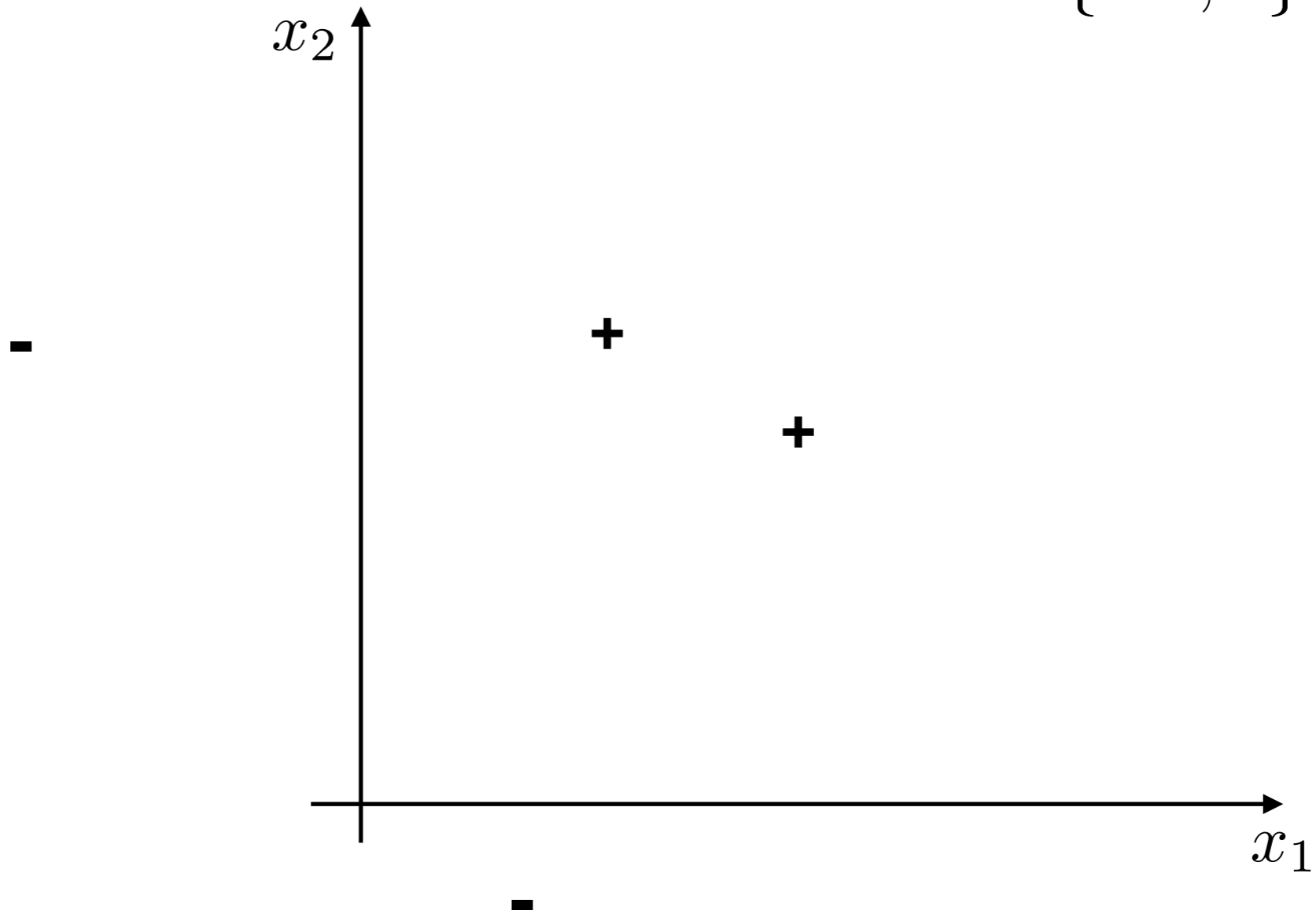# Supervised learning: training set

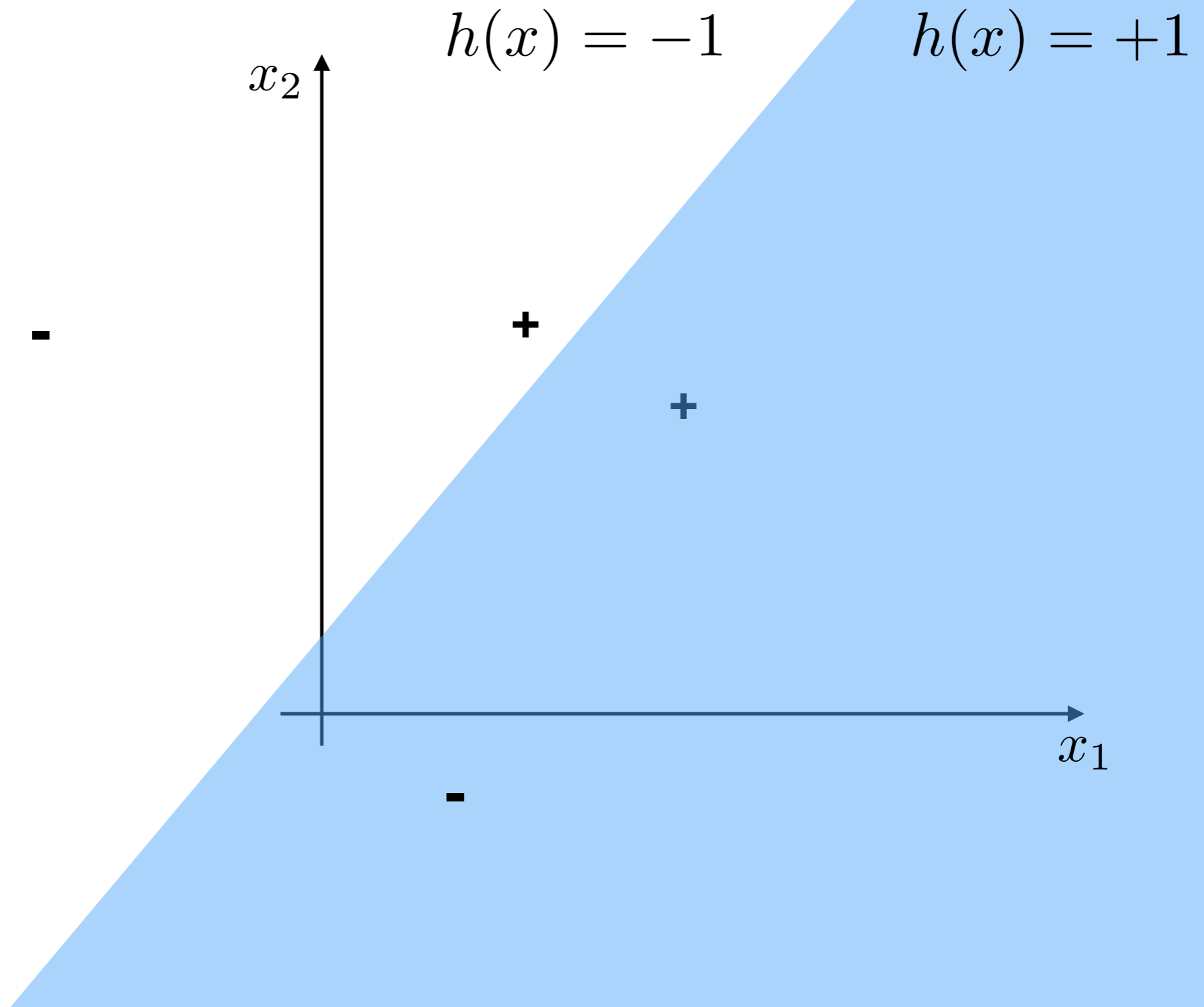# Supervised learning: test set

Supervised learning: training set

Supervised learning: classifier

$$h : \mathcal{X} \to \{-1, 1\}$$

Supervised learning: classifier
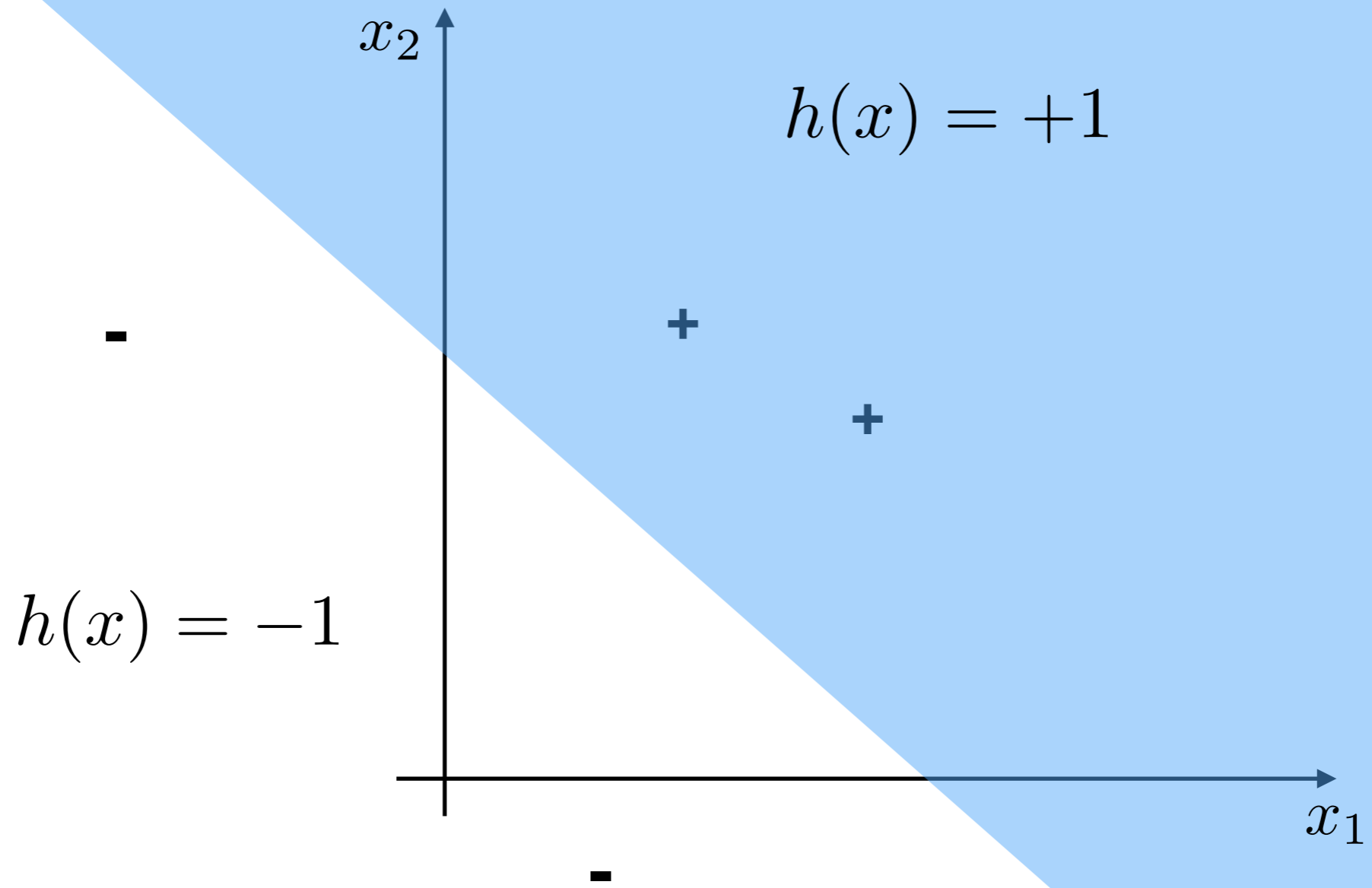
$h(x) = -1$ $h(x) = +1$

x_2

$-$

$+$

$+$

$-$

x_1

Supervised learning: classifier

x_2

$h(x) = +1$

$+$

$+$

$h(x) = -1$
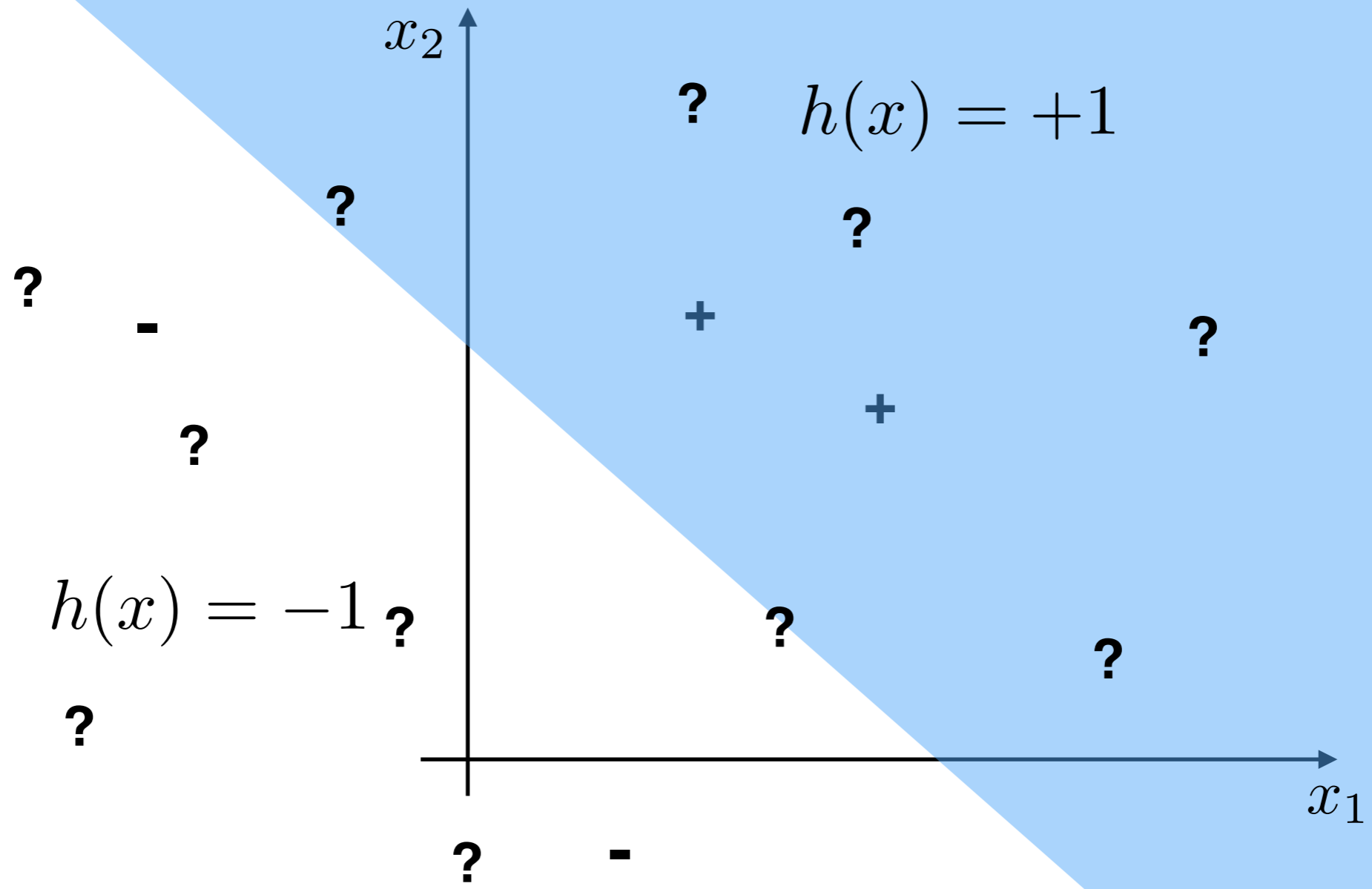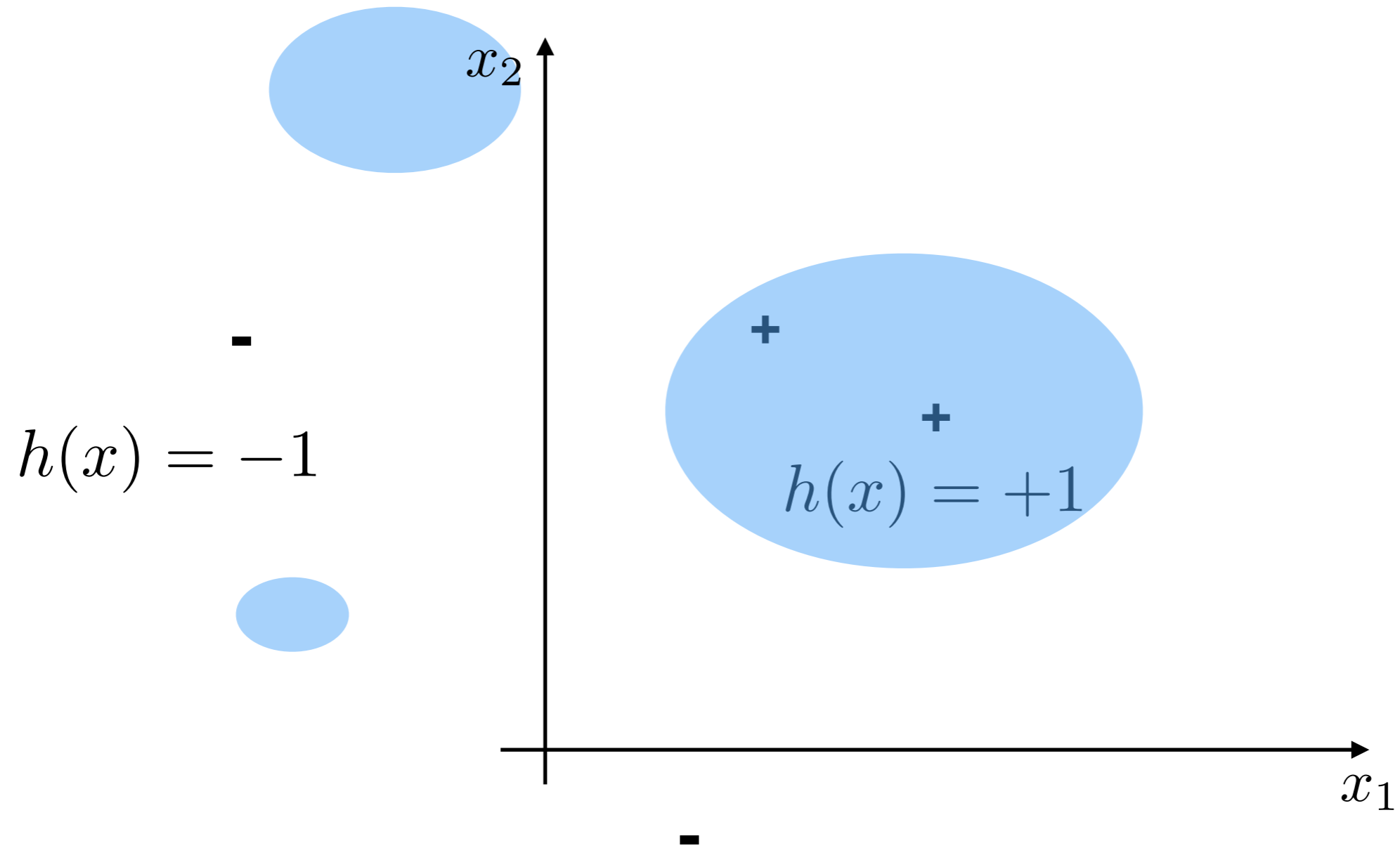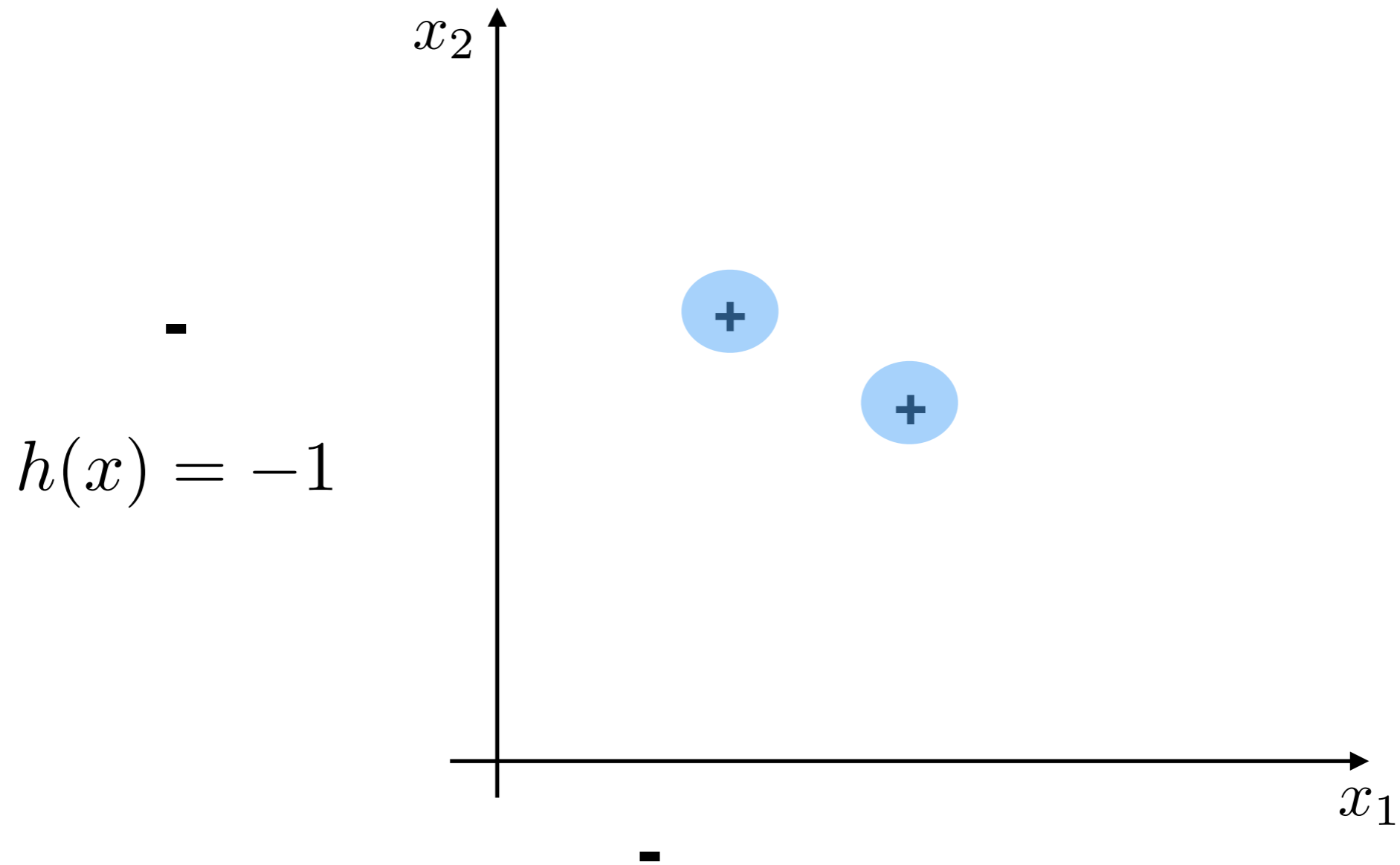
$-$
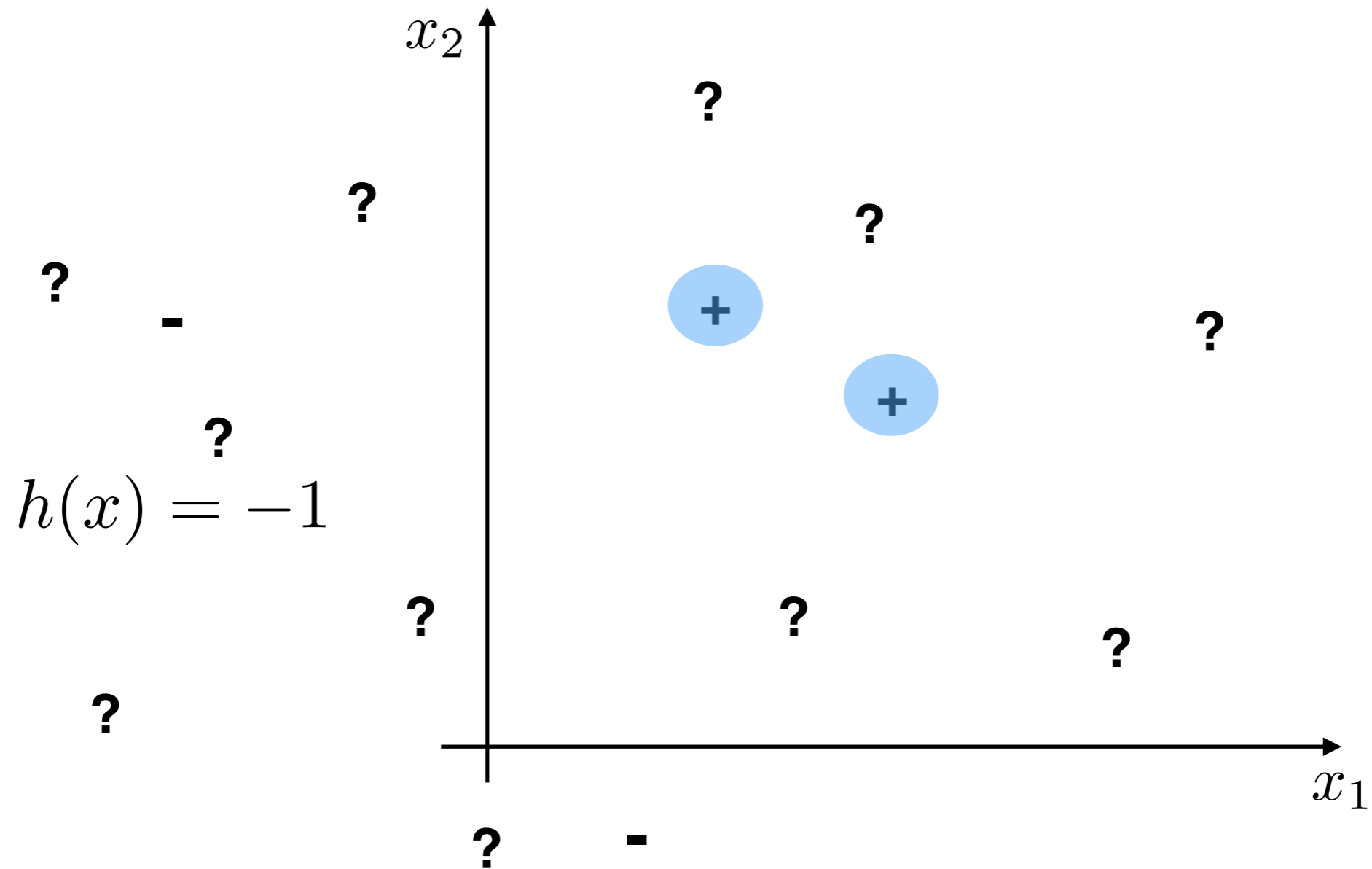
x_1

$-$

Supervised learning: classifier

Supervised learning: classifier

Supervised learning: classifier

Supervised learning: generalization

Supervised learning +

‣ Multi-way classification (e.g., three-way classification)

$$h\left(\vcenter{\hbox{}} \right) = \text{politics} \qquad h : \mathcal{X} \to \{\text{politics}, \text{sports}, \text{other}\}$$

‣ Regression

$$h\left(\vcenter{\hbox{}} \right) = \$1{,}349{,}000 \qquad h : \mathcal{X} \to \mathbb{R}$$

‣ Structured prediction

$$h\left(\vcenter{\hbox{}} \right) = \begin{array}{l}\text{A group of people} \\ \text{shopping at an} \\ \text{outdoor market}\end{array} \qquad h : \mathcal{X} \to \{\text{English sentences}\}$$

Types of machine learning

‣ Supervised learning
  - prediction based on examples of correct behavior

‣ Unsupervised learning
  - no explicit target, only data, goal to model/discover

‣ Semi-supervised learning
  - supplement limited annotations with unsupervised learning

‣ Active learning
  - learn to query the examples actually needed for learning

‣ Transfer learning
  - how to apply what you have learned from A to B

‣ Reinforcement learning
  - learning to act, not just predict; goal to optimize the consequences of actions

‣ Etc.

Key things to understand

‣ Posing supervised machine learning problems

‣ Supervised classification

‣ The role of training/test sets

‣ A classifier

‣ A set of classifiers

‣ Errors, generalization