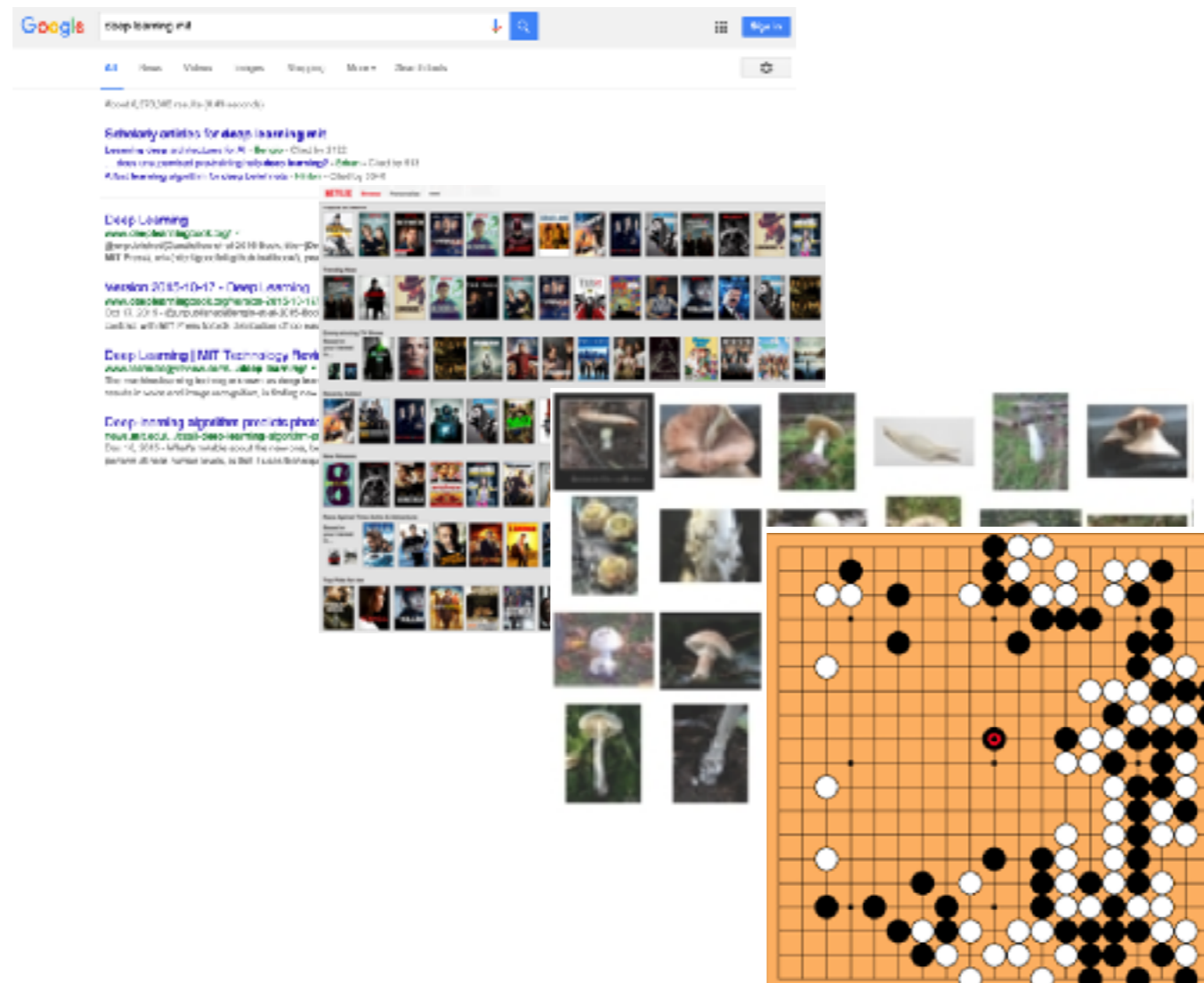


# Machine Learning

## 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

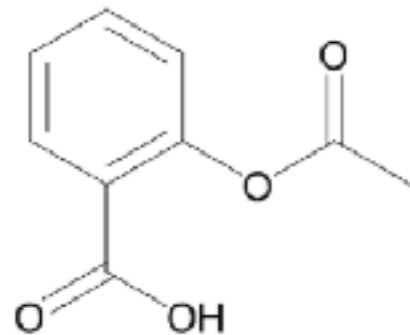
- ▶ Also collision avoidance, monitoring, medical risk, etc.

# Prediction problems

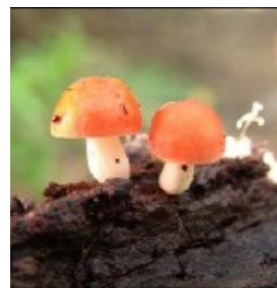
- ▶ About properties we don't yet know



would I like this movie?



soluble in water?



what is the image about?

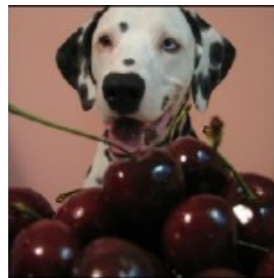
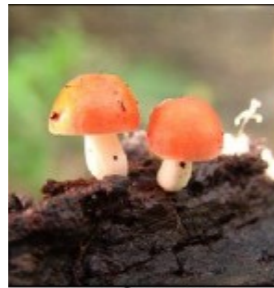
“ML is very cool”

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

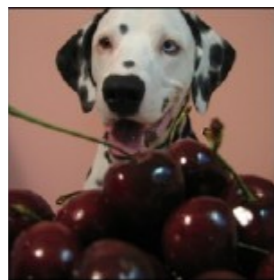
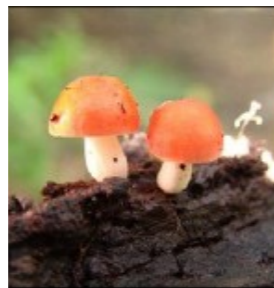
cherry

...

# 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

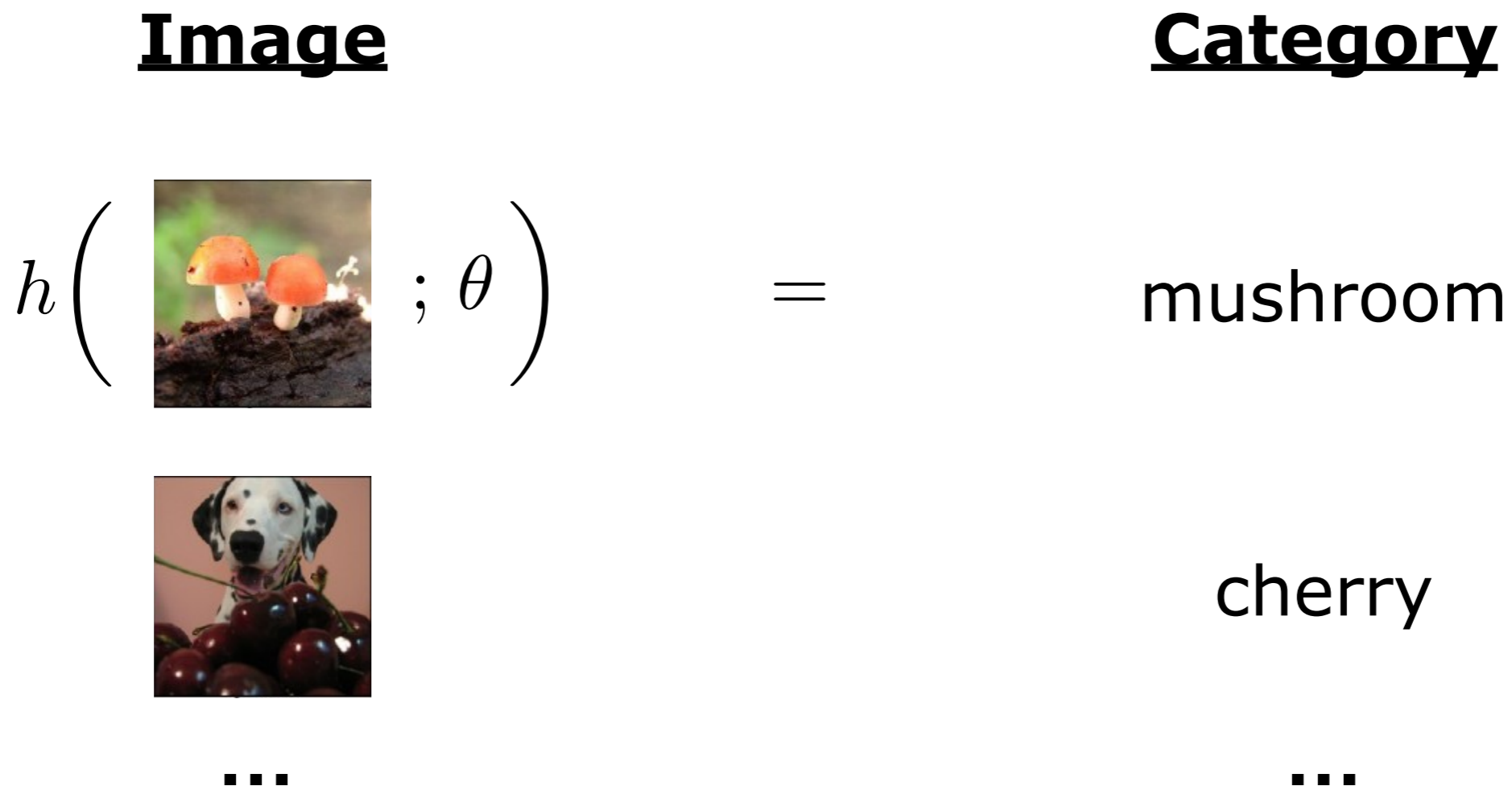
cherry

...

- ▶ 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)



- ▶ 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

$h(\text{Is it real? ; } \theta)$

Will it continue?

For how long?

...

## Spanish

¿Es real?

¿Continuará?

¿Por cuanto tiempo?

...

- ▶ Already in production for some language pairs (Google)

# A concrete example

- ▶ Learning to predict preferences from just a little data...

In April 1945, the Allies are making their final push in the European theater. A battle-hardened Army sergeant named Dan "Hacksaw" Ryker (Brad Pitt) leads a platoon of soldiers in a mission to liberate a concentration camp. However, when a German soldier (Jesse Plemons) is killed, Ryker is forced to make a choice between saving the soldier's life and completing the mission. The film is a powerful and emotional war drama that explores the complexities of war and the human cost of conflict.



In Carnegie, etc. (some may remember the book) a young man named Nick (Ryan Reynolds) is a successful entrepreneur who has built a fortune in the tech industry. However, when a major scandal erupts, he is forced to confront the consequences of his actions and the impact on his family. The film is a gripping and thought-provoking drama that explores the complexities of power, greed, and the human cost of success.



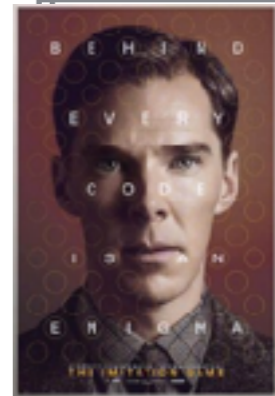
In the future, a global earthquake and several other disasters are wreaking havoc on the planet. A team of astronauts (led by Matthew McConaughey) is sent on a mission to find a new habitable planet. However, the mission is fraught with danger and the crew must overcome insurmountable odds to survive. The film is a thrilling and visually stunning sci-fi adventure that explores the limits of human exploration and the unknowns of space.



In the city of San Francisco, a young boy named Hiro (Ryan Reynolds) is a brilliant and rebellious inventor. He is the only one who can communicate with a powerful and sentient robot named Baymax (Paul Giamatti). Together, they embark on a journey to save the city from a deadly virus. The film is a heartwarming and action-packed animated adventure that explores the themes of friendship, courage, and the power of technology.



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# A concrete example

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



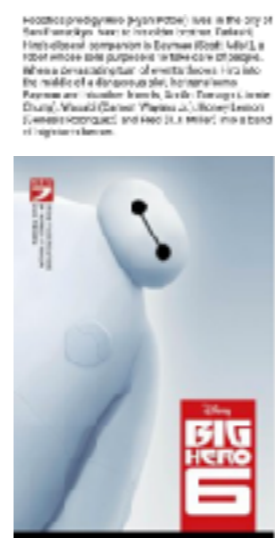
-1



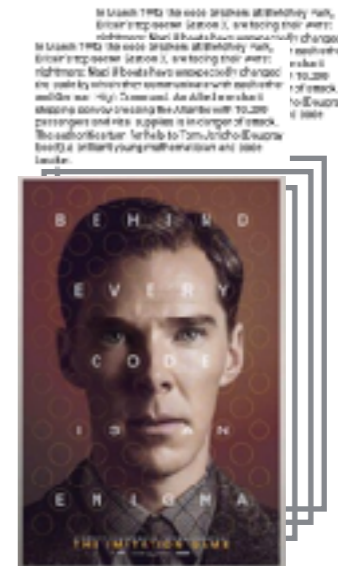
-1



+1



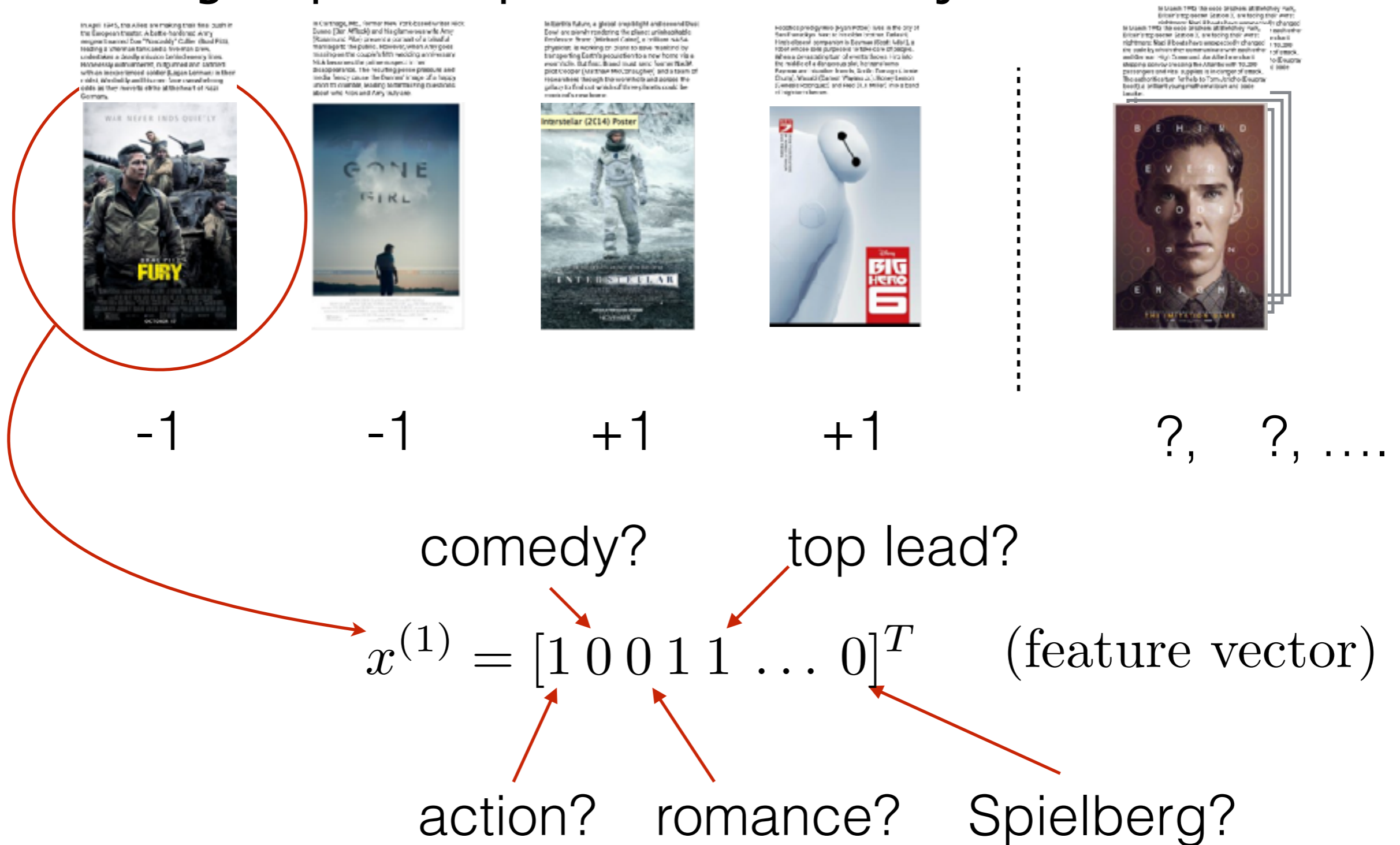
+1



?, ?, ....

# A concrete example

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



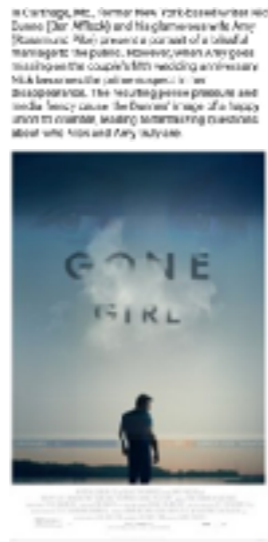
# Supervised learning

- ▶ Learning to predict preferences from just a little data...



$x^{(1)}$

-1



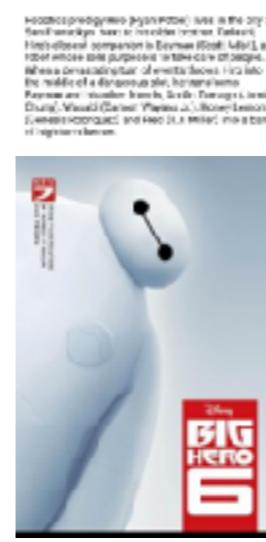
$x^{(2)}$

-1



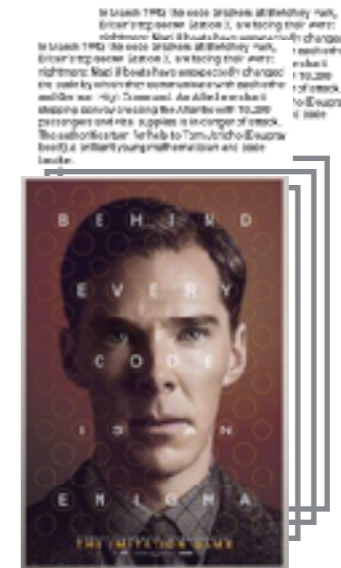
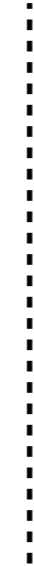
$x^{(3)}$

+1



$x^{(4)}$

+1



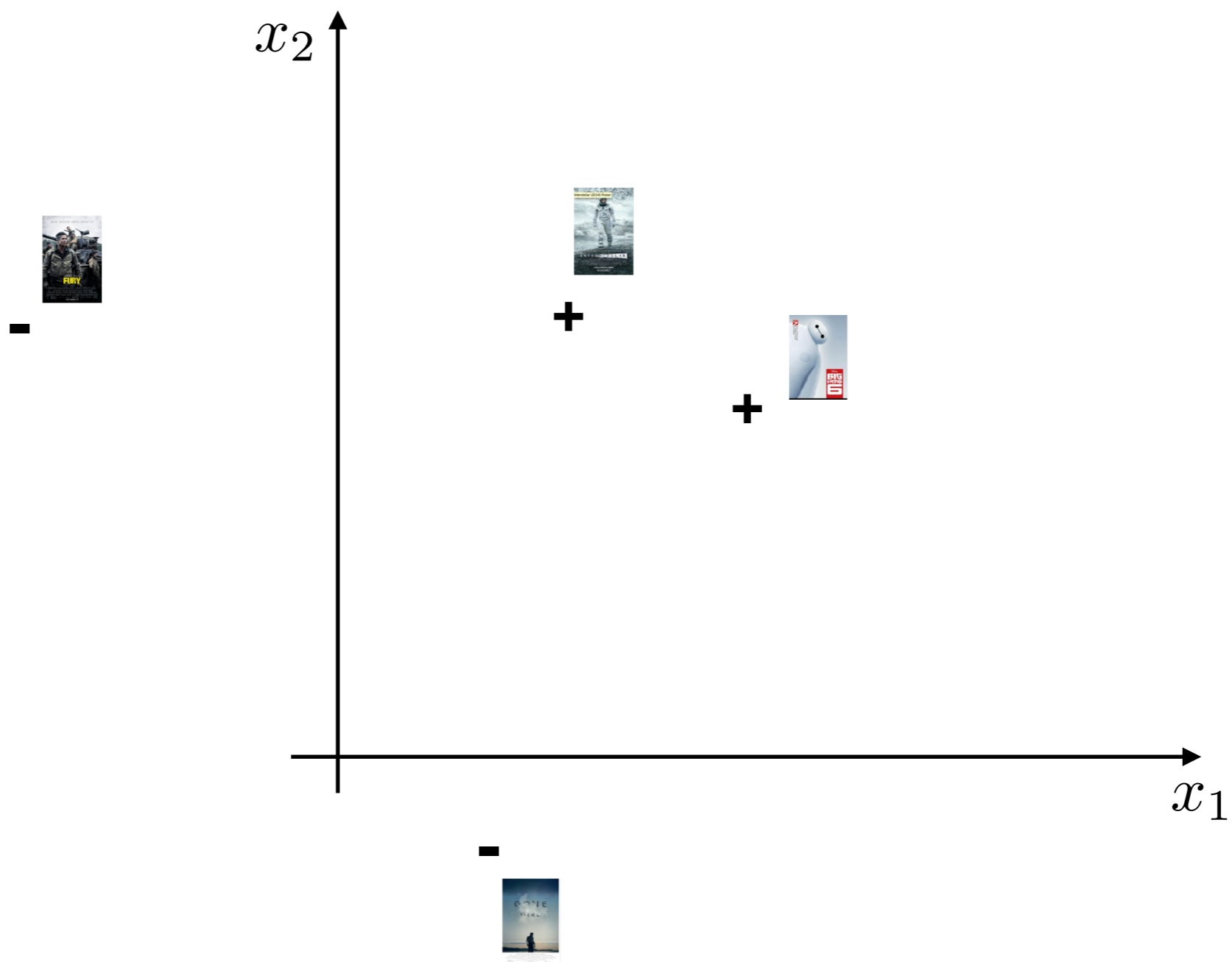
$x^{(5)}, x^{(6)}, \dots$

?, ?, ....

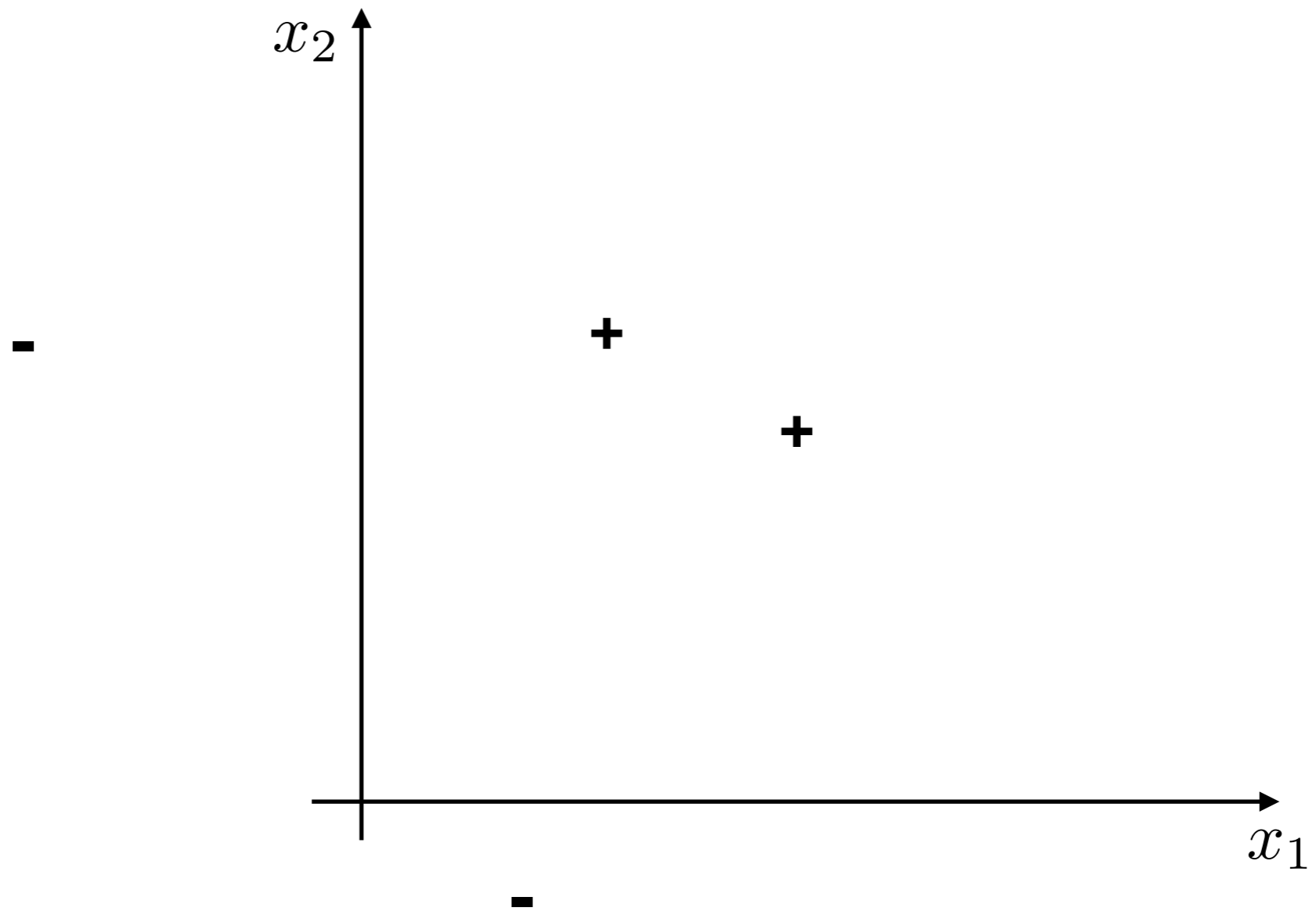
Training set

Test set

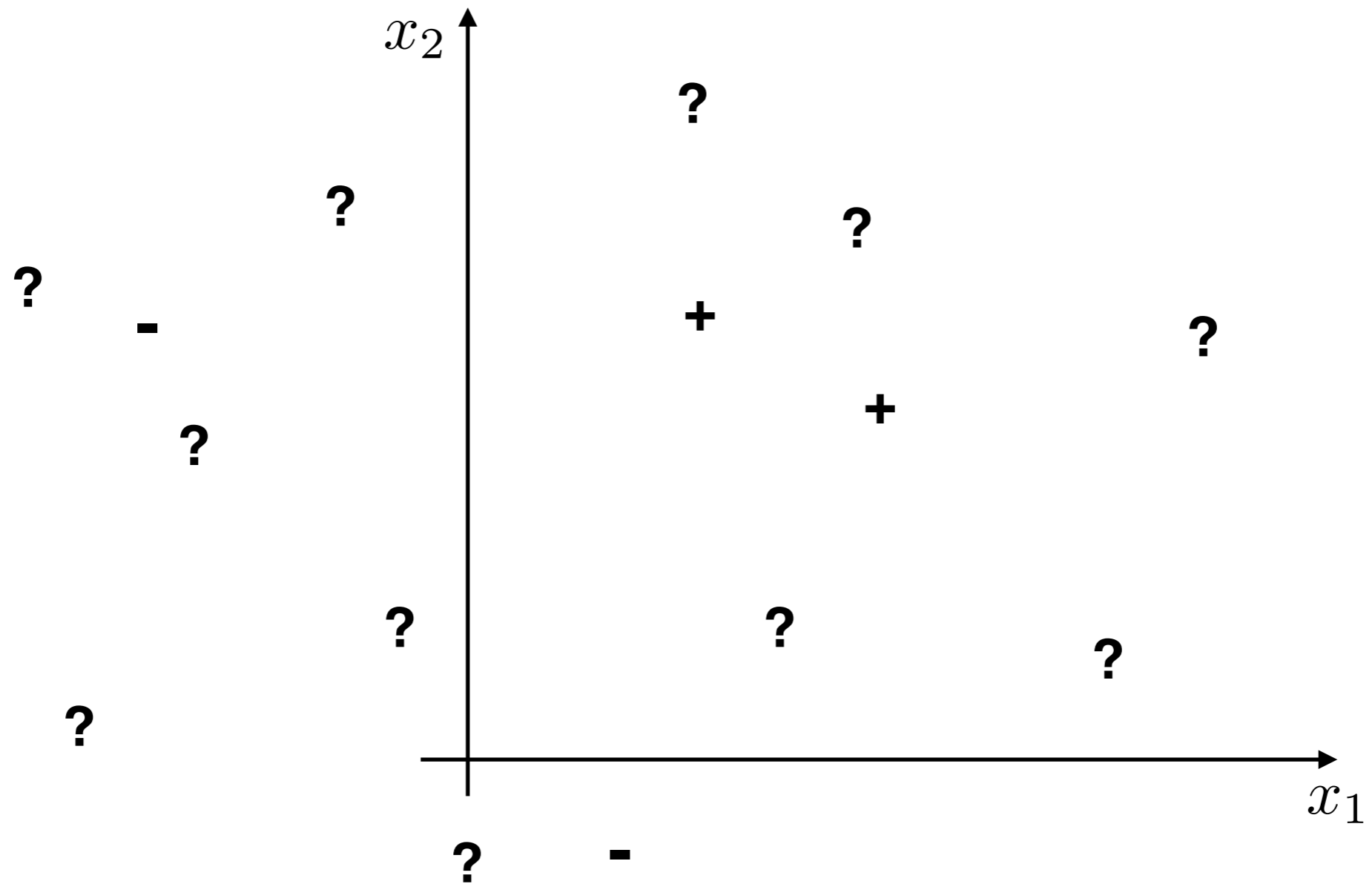
# Supervised learning



# Supervised learning: training set

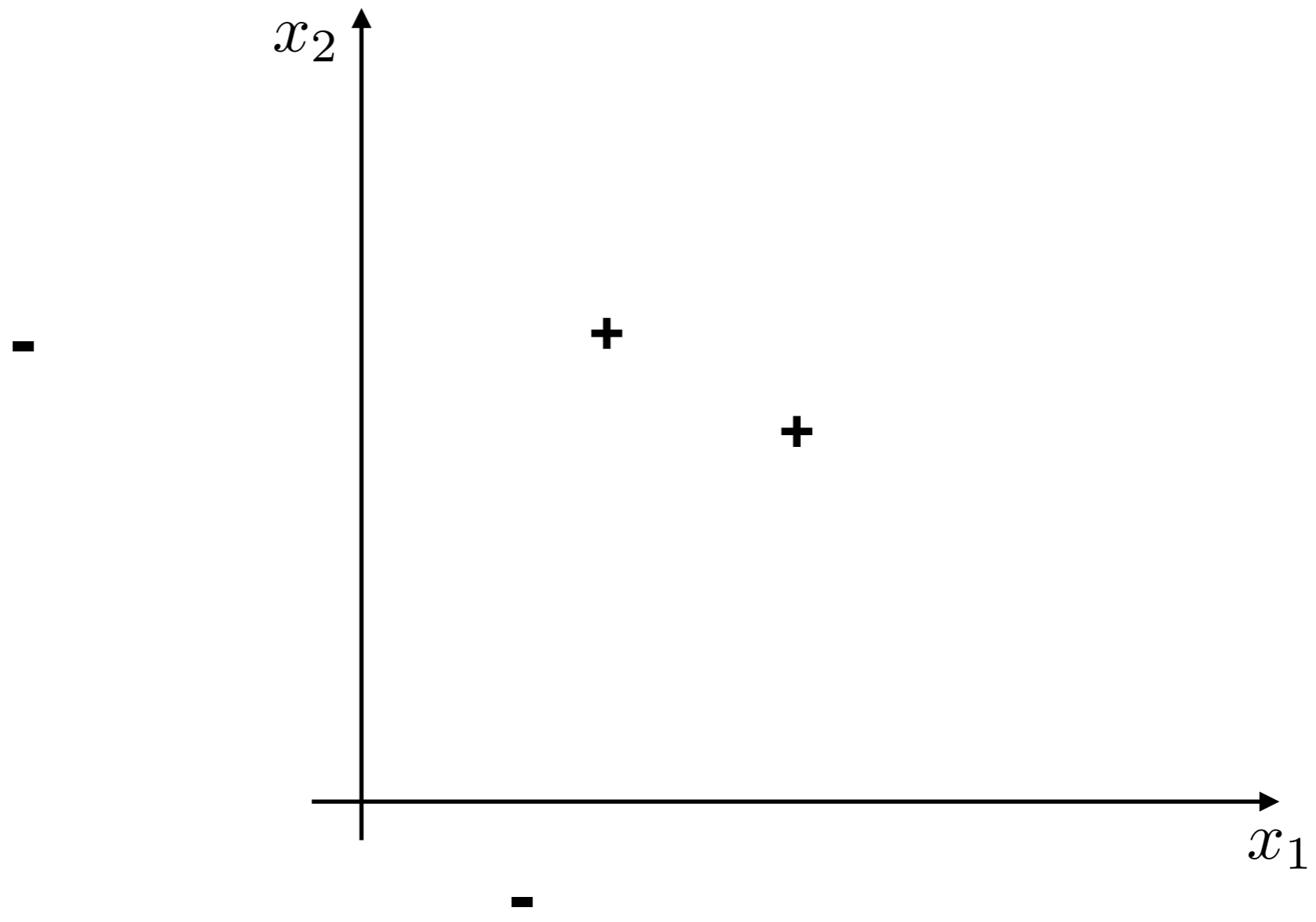


# Supervised learning: test set



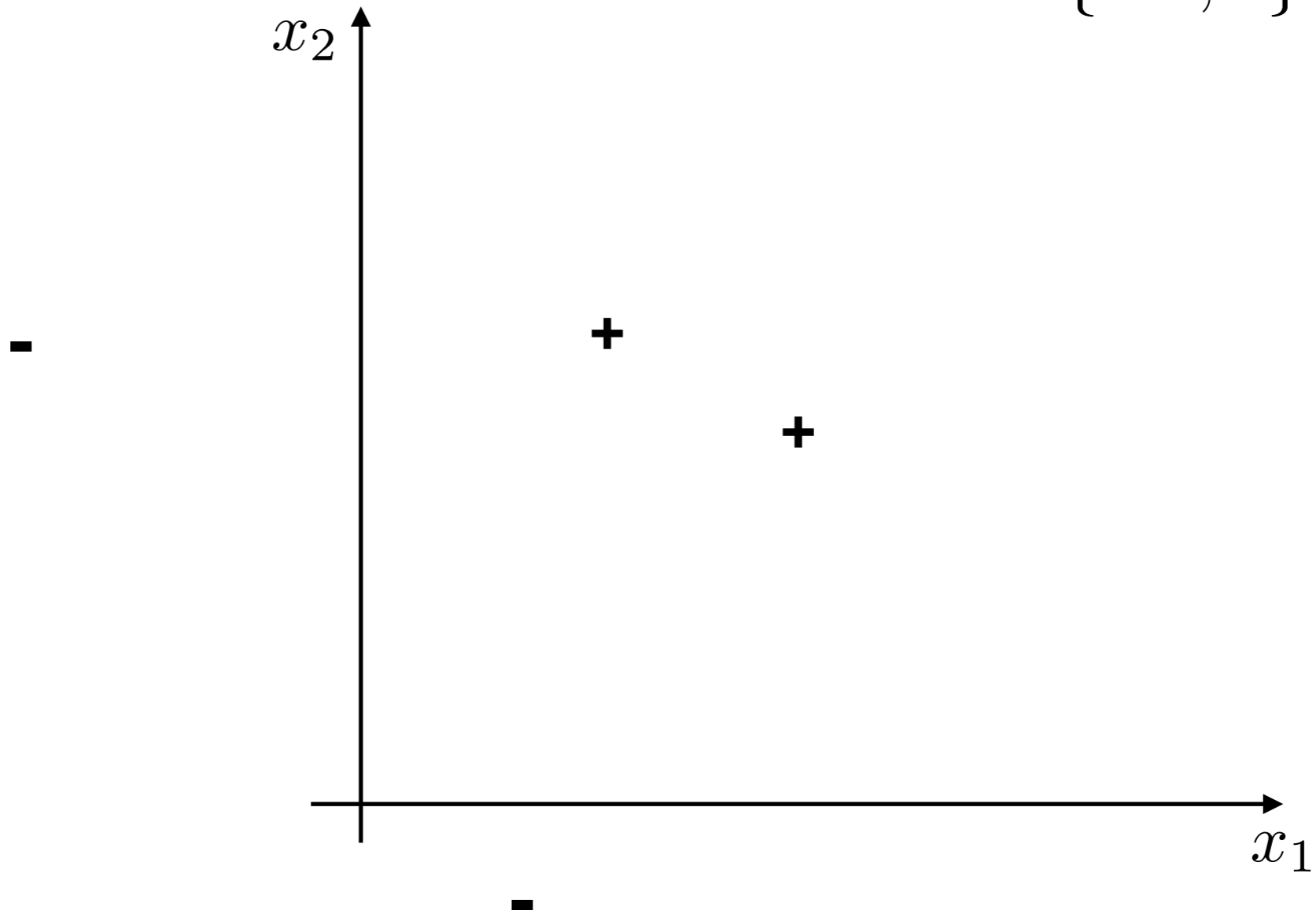


# Supervised learning: training set

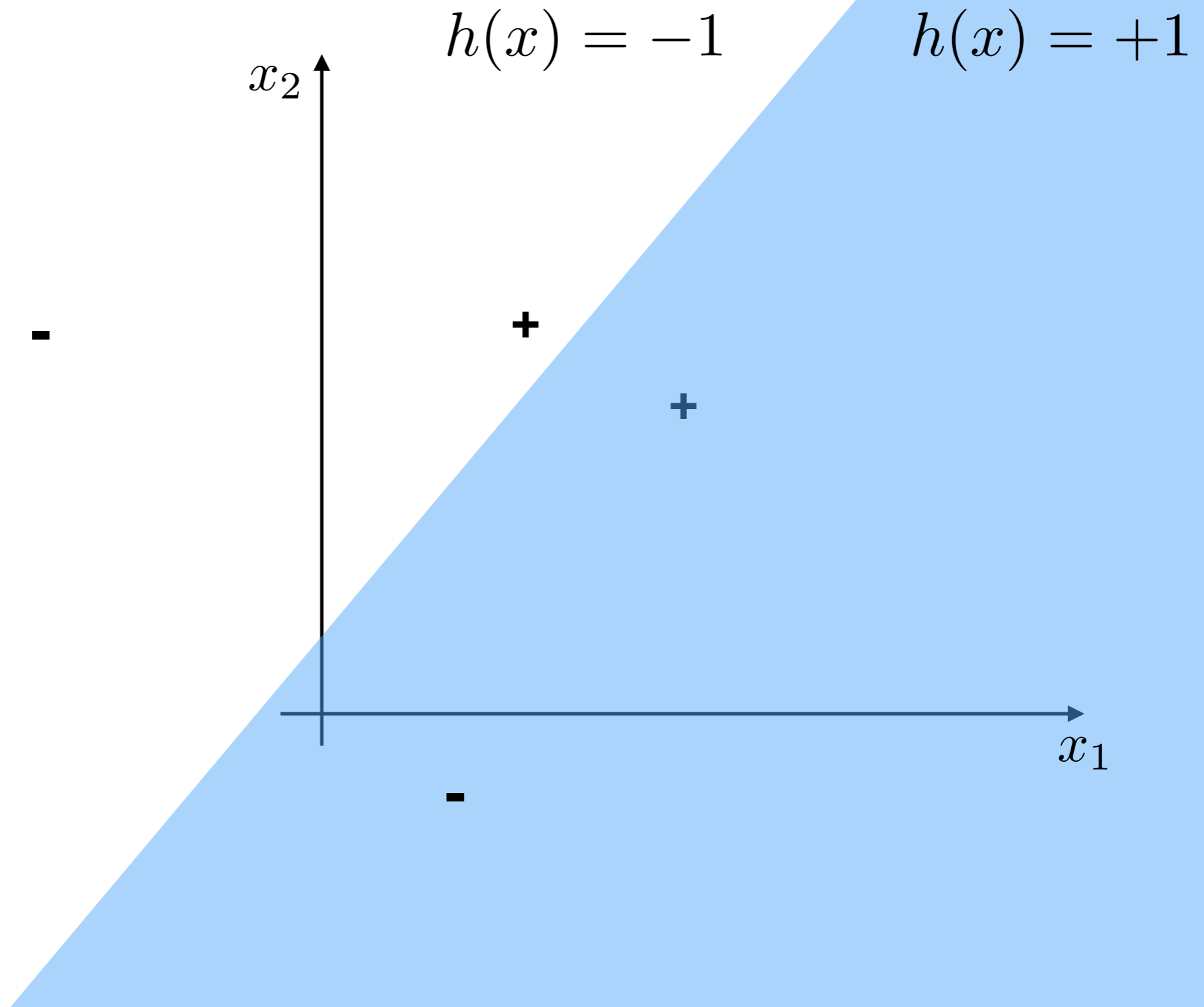


# Supervised learning: classifier

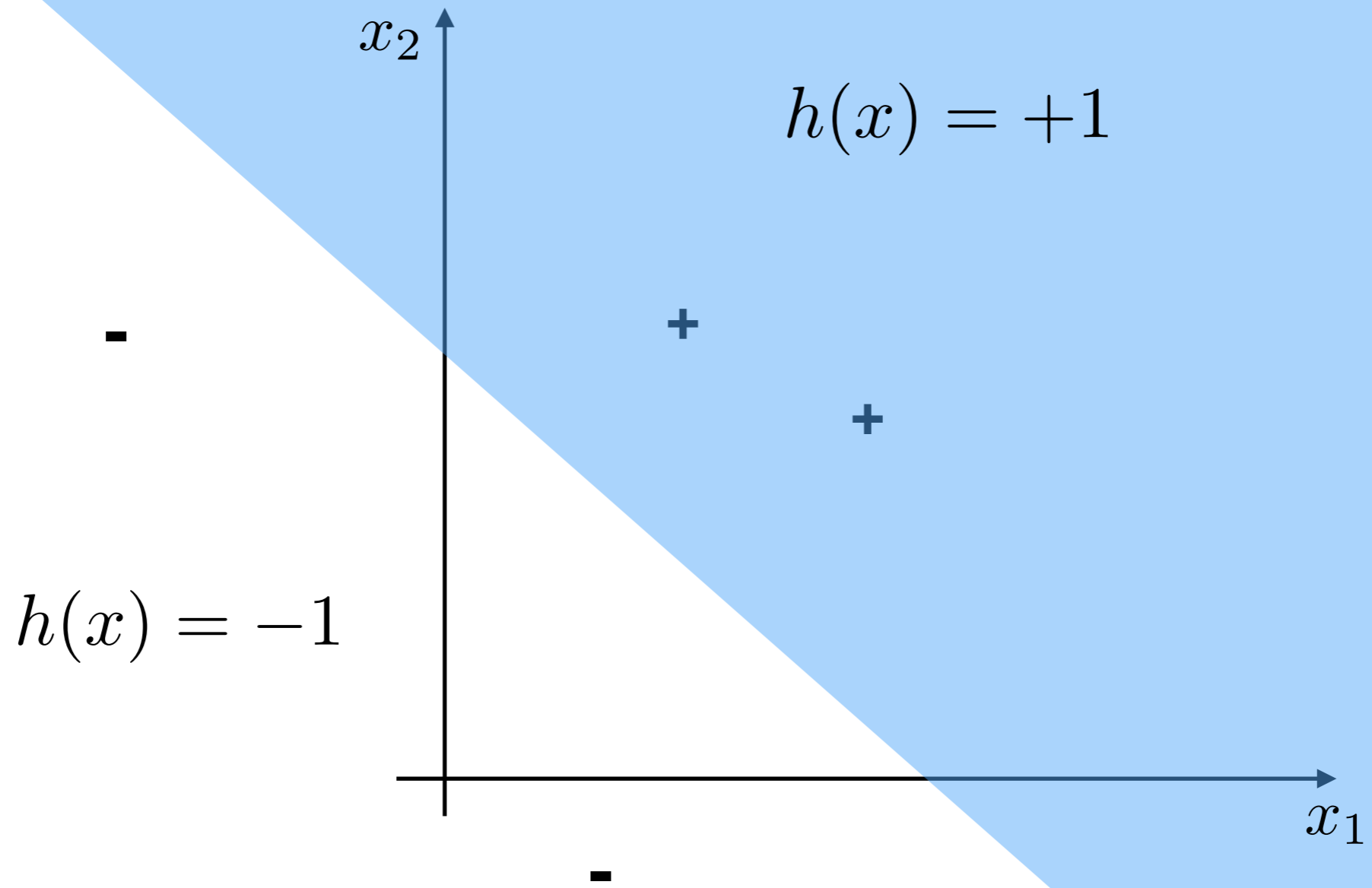
$$h : \mathcal{X} \rightarrow \{-1, 1\}$$



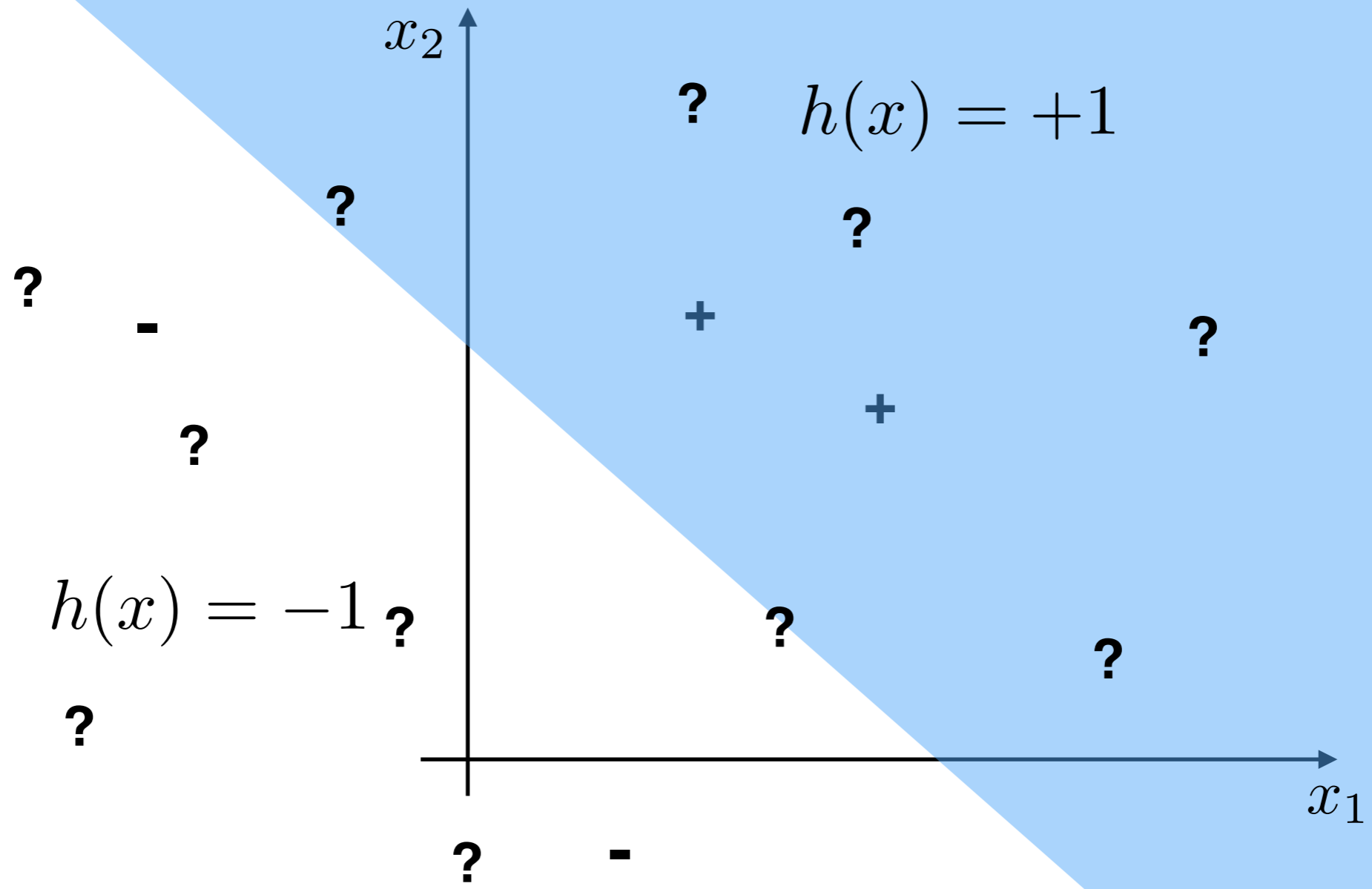
# Supervised learning: classifier



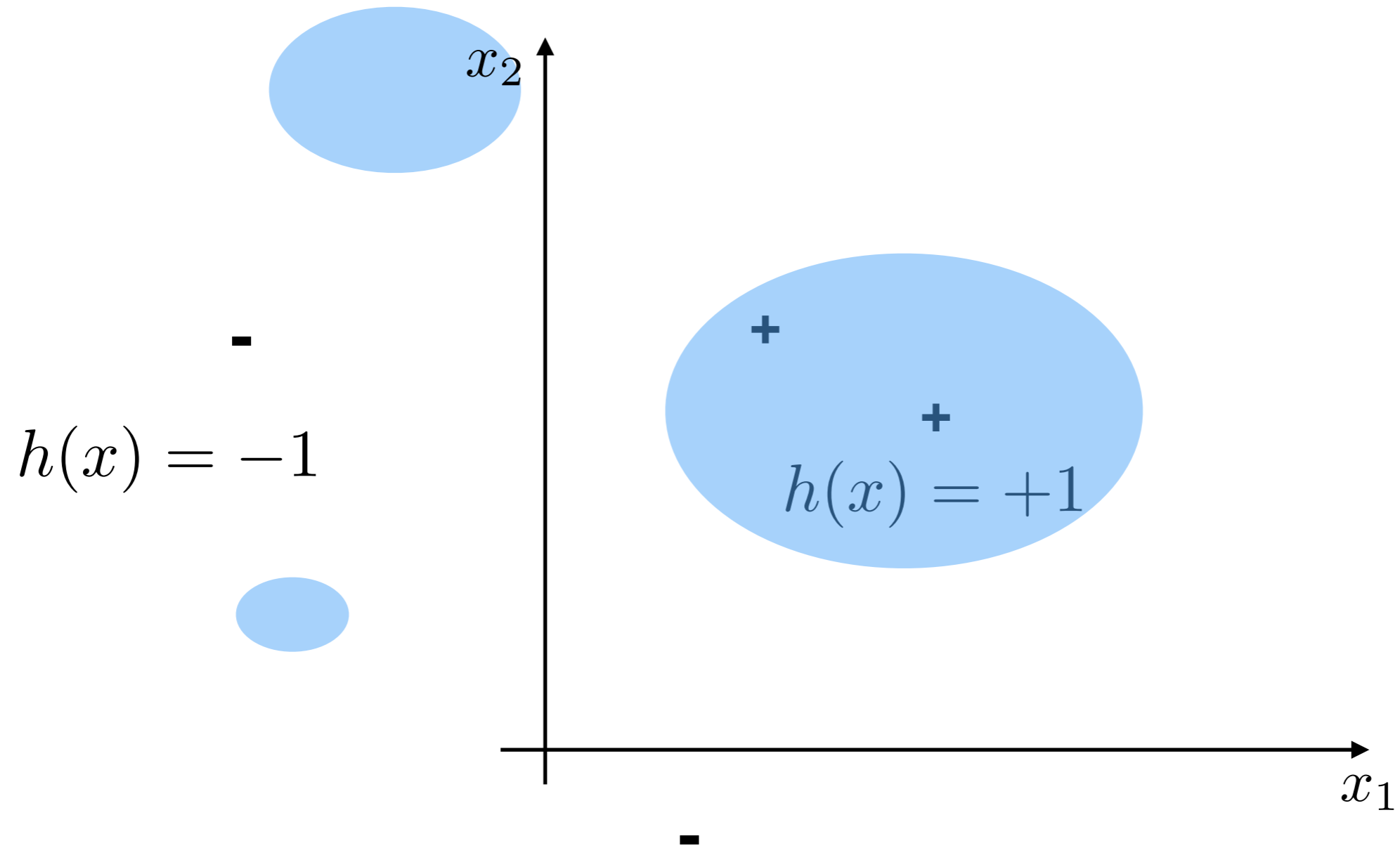
# Supervised learning: classifier



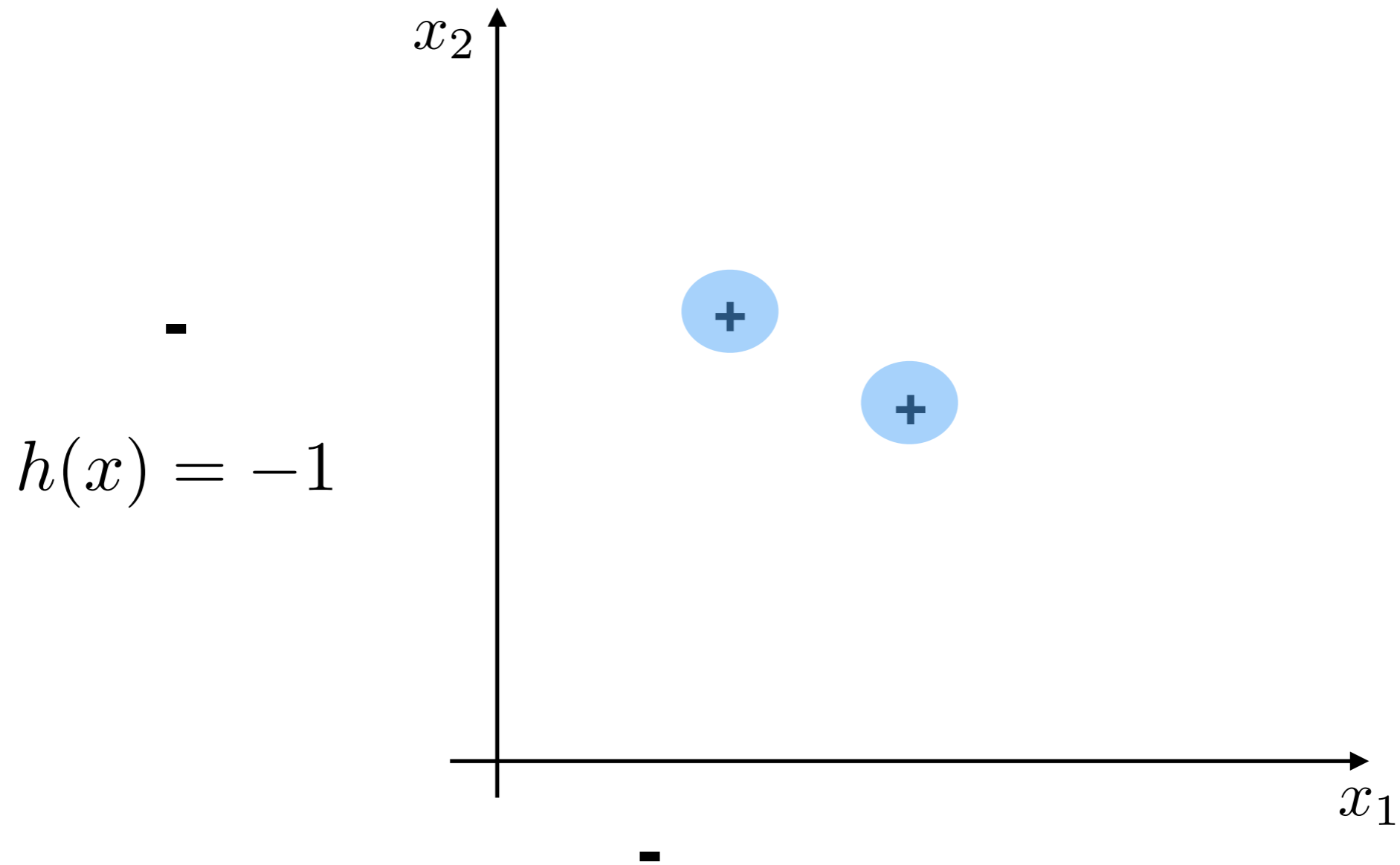
# Supervised learning: classifier



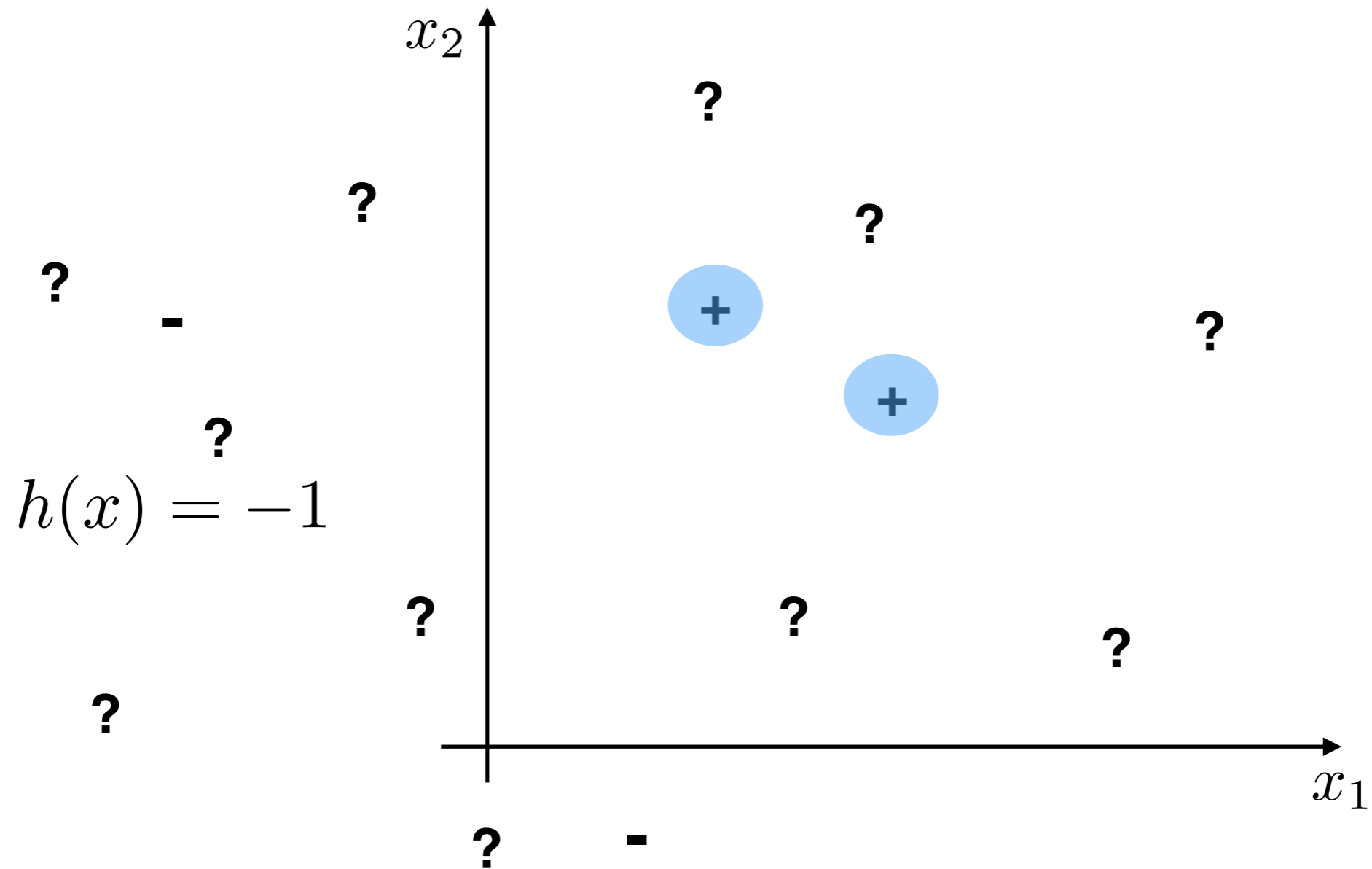
# Supervised learning: classifier



# Supervised learning: classifier




# Supervised learning: generalization






# Supervised learning +


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

$$h \left( \text{NEWS} \right) = \text{politics} \quad h : \mathcal{X} \rightarrow \{\text{politics, sports, other}\}$$


- ▶ Regression

$$h \left( \text{Living Room} \right) = \$1,349,000 \quad h : \mathcal{X} \rightarrow \mathbb{R}$$


- ▶ Structured prediction

$$h \left( \text{Market} \right) = \text{A group of people shopping at an outdoor market} \quad h : \mathcal{X} \rightarrow \{\text{English sentences}\}$$


# 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