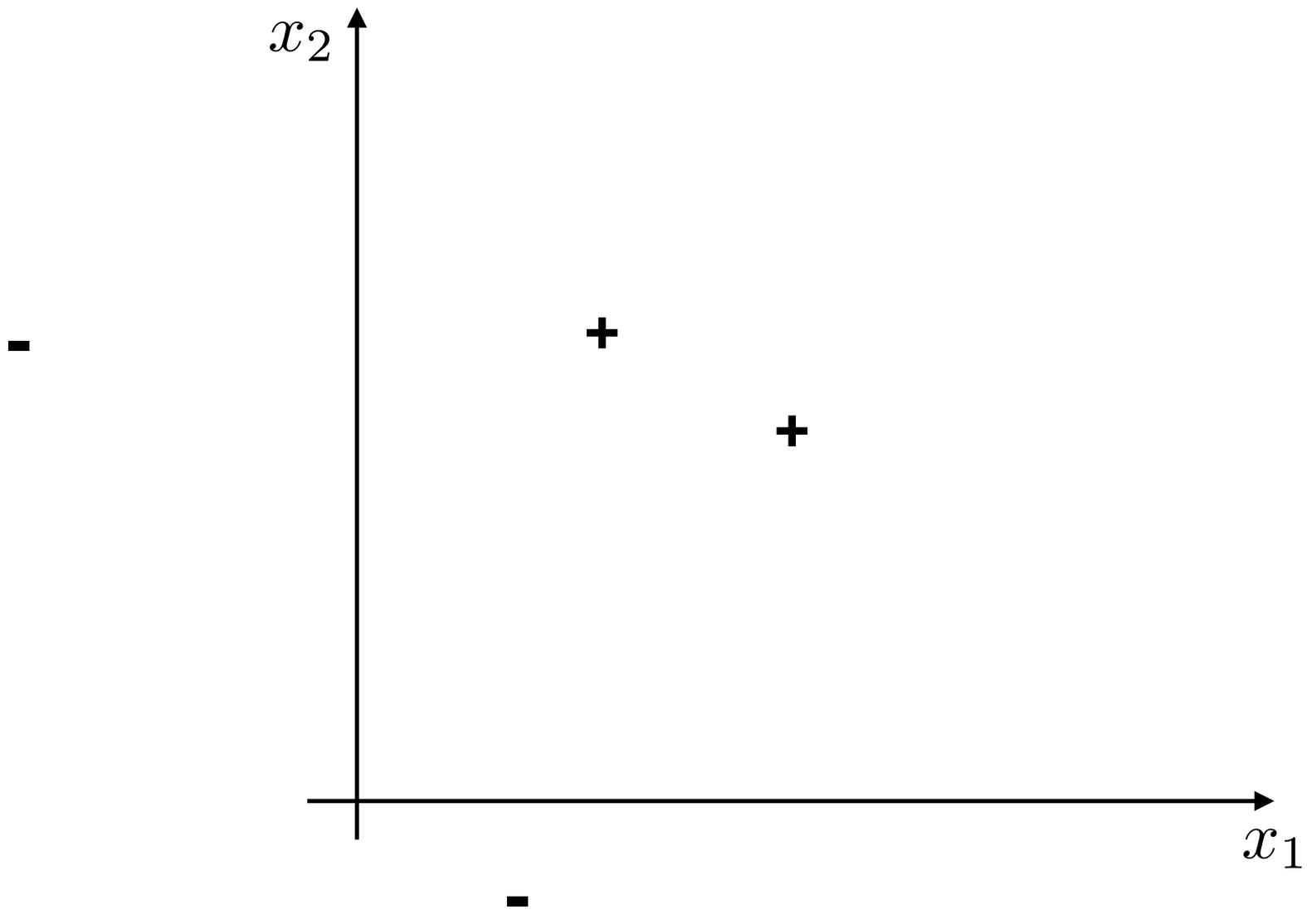
Machine Learning
Lecture 2

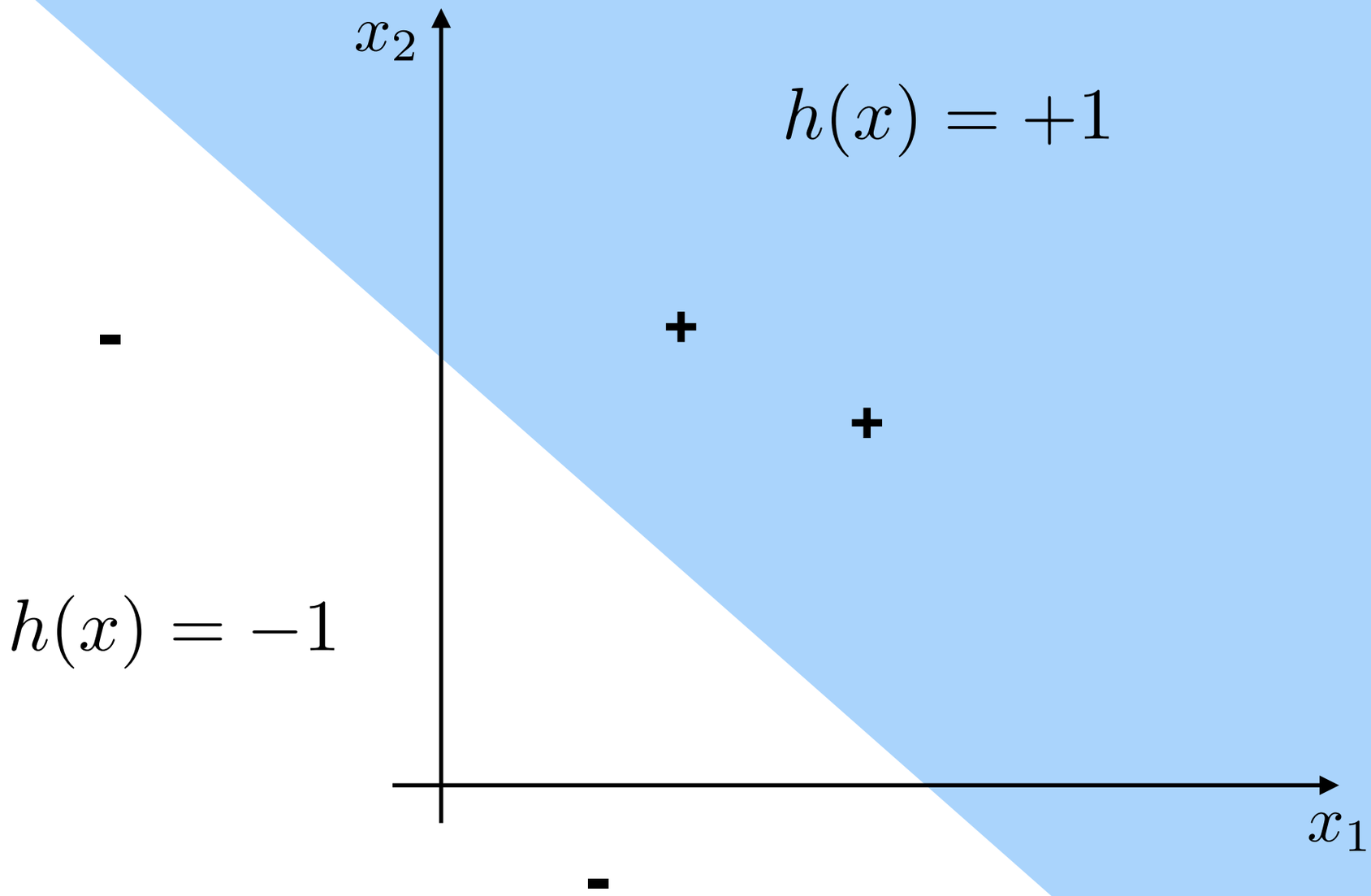
Review of basic concepts

- Feature vectors, labels
- Training set
- Classifier
- Training error
- Test error
- Set of classifiers

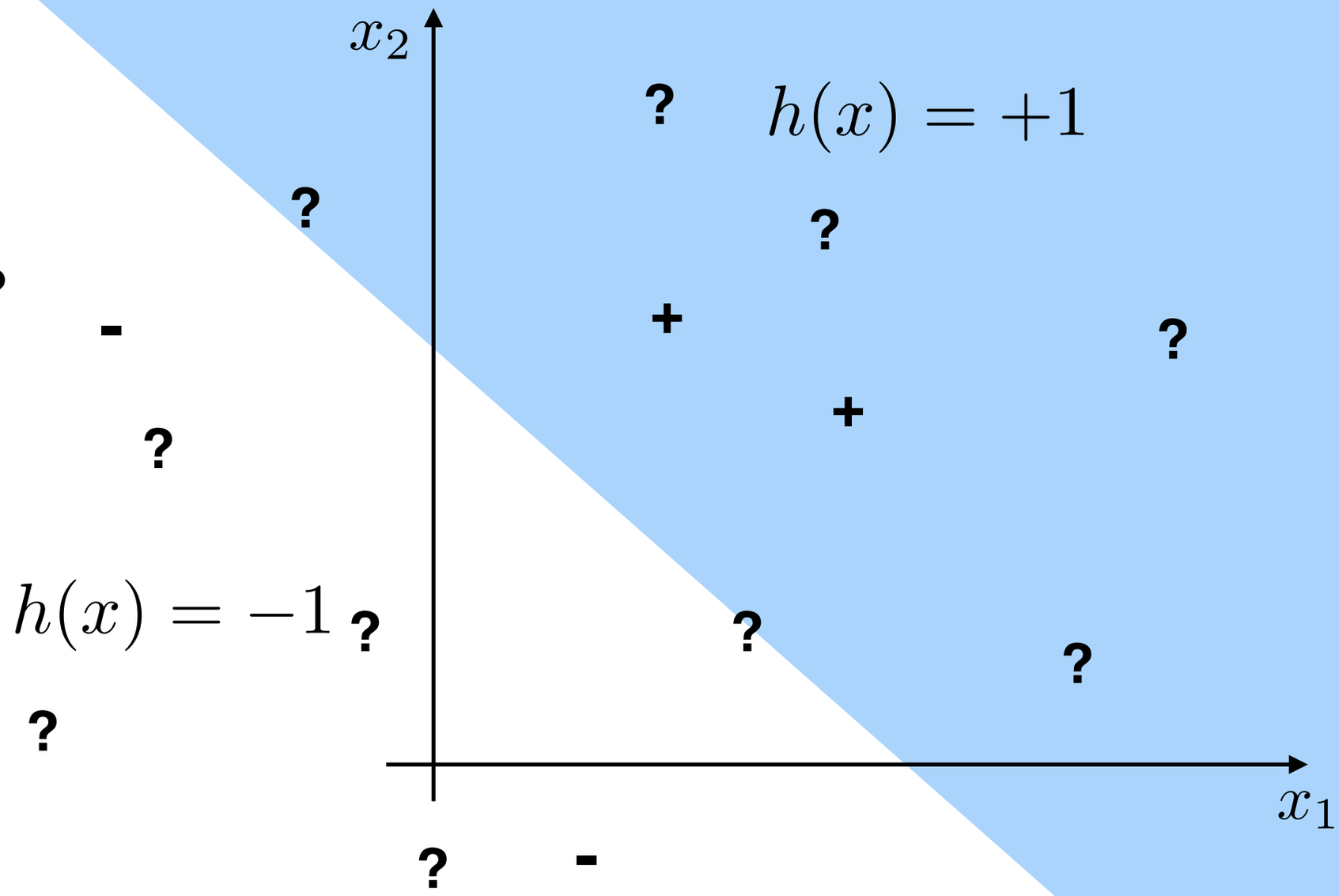
Review: training set



Review: a classifier



Review: test set



This lecture

- The set of linear classifiers
- Linear separation
- Perceptron algorithm

Linear classifiers

Linear classifiers through origin

Linear classifiers

Linear separation: ex

Linear separation: ex

Linear separation: ex

Linear separation

Definition:
Training examples $S_n = \{(x^{(i)}, y^{(i)}\}), i = 1, \ldots, n\}$ are *linearly separable* if there exists a parameter vector $\hat{\theta}$ and offset parameter $\hat{\theta}_0$ such that $y^{(i)}(\hat{\theta} \cdot x^{(i)} + \hat{\theta}_0) > 0$ for all $i = 1, ..., n$.

Learning linear classifiers

- Training error for a linear classifier (through origin)

Learning linear classifiers

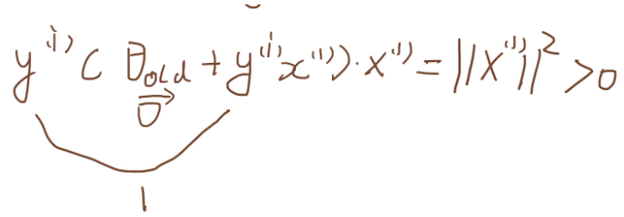
- Training error for a linear classifier

Learning algorithm: perceptron

$$\theta = 0 \text{ (vector)}$$

if $y^{(i)}(\theta \cdot x^{(i)}) \leq 0$ **then**

$$\theta = \theta + y^{(i)} x^{(i)}$$



Learning algorithm: perceptron

$\theta = 0$ (vector)

for $i = 1, \ldots, n$ **do**

  if $y^{(i)}(\theta \cdot x^{(i)}) \leq 0$ **then**

    $\theta = \theta + y^{(i)} x^{(i)}$

Learning algorithm: perceptron

procedure PERCEPTRON($\{(x^{(i)}, y^{(i)}), i = 1, \ldots, n\}$, T)

$\theta = 0$ (vector)

for $t = 1, \ldots, T$ **do**

for $i = 1, \ldots, n$ **do**

if $y^{(i)}(\theta \cdot x^{(i)}) \leq 0$ **then**

$\theta = \theta + y^{(i)} x^{(i)}$

return θ

Perceptron algorithm: ex

Perceptron (with offset)

1: **procedure** PERCEPTRON($\{(x^{(i)}, y^{(i)}), i = 1, \ldots, n\}$, T)
2: $\theta = 0$ (vector), $\theta_0 = 0$ (scalar)
3: **for** $t = 1, \ldots, T$ **do**
4: **for** $i = 1, \ldots, n$ **do**
5: **if** $y^{(i)}(\theta \cdot x^{(i)} + \theta_0) \leq 0$ **then**
6: $\theta = \theta + y^{(i)} x^{(i)}$
7: $\theta_0 = \theta_0 + y^{(i)}$
8: **return** θ, θ_0

Key things to understand

- Parametric families (sets) of classifiers
- The set of linear classifiers
- Linear separation
- Perceptron algorithm