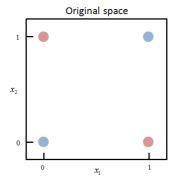
## **Introduction to Machine Learning**

# Neural Networks XOR-Problem





#### Learning goals

 Example problem a single neuron can not solve but a single hidden layer net can

### **EXAMPLE: XOR PROBLEM**

Suppose we have four data points

$$X = \{(0,0)^{\top}, (0,1)^{\top}, (1,0)^{\top}, (1,1)^{\top}\}$$

 The XOR gate (exclusive or) returns true, when an odd number of inputs are true:

<i>X</i> <sub>1</sub>	<i>X</i> <sub>2</sub>	XOR = y
0	0	0
0	1	1
1	0	1
1	1	0

• Can you learn the target function with a logistic regression model?



### **NEURAL NETWORKS: OPTIMIZATION**

- In this simple example we actually "guessed" the values of the parameters for W, b, u and c.
- That won't work for more sophisticated problems!
- We will learn later about iterative optimization algorithms for automatically adapting weights and biases.
- An added complication is that the loss function is no longer convex. Therefore, there might not exist a single minimum.

