

# Decision Boundaries and Linear Separability

## Linearly Separable

Classes can be separated by straight line/plane

VS

## Non-Linearly Separable

Requires curved boundary



XOR Problem: Classic example of non-linear separability

Real-world: Most datasets are not perfectly separable

### Solutions:

Feature Transformation

Kernel Methods

Non-Linear Models



### Linear Classifiers

Fast, interpretable, good baseline



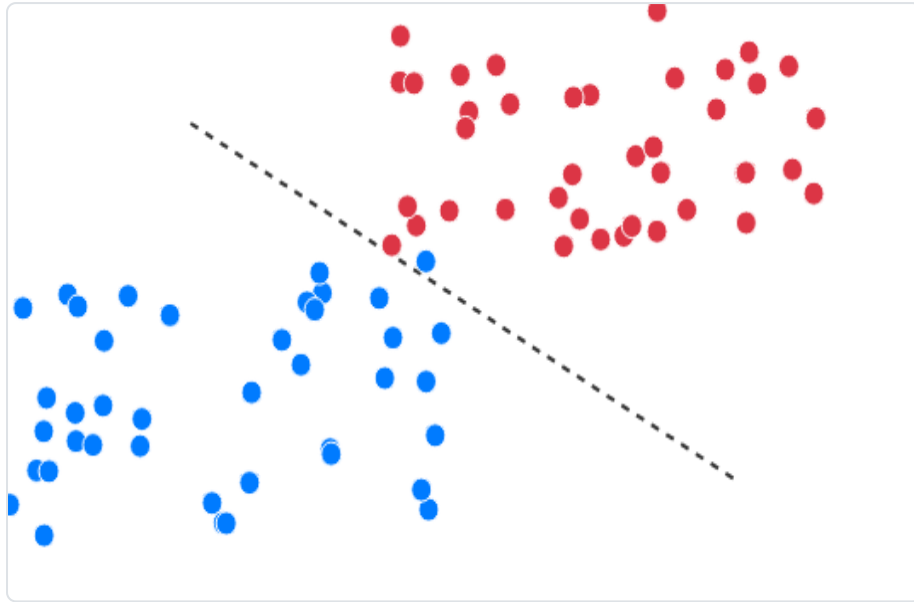
### When to Use

High-dimensional data, large datasets



## 2D Decision Boundary Visualization

### ✓ Linearly Separable (2D)



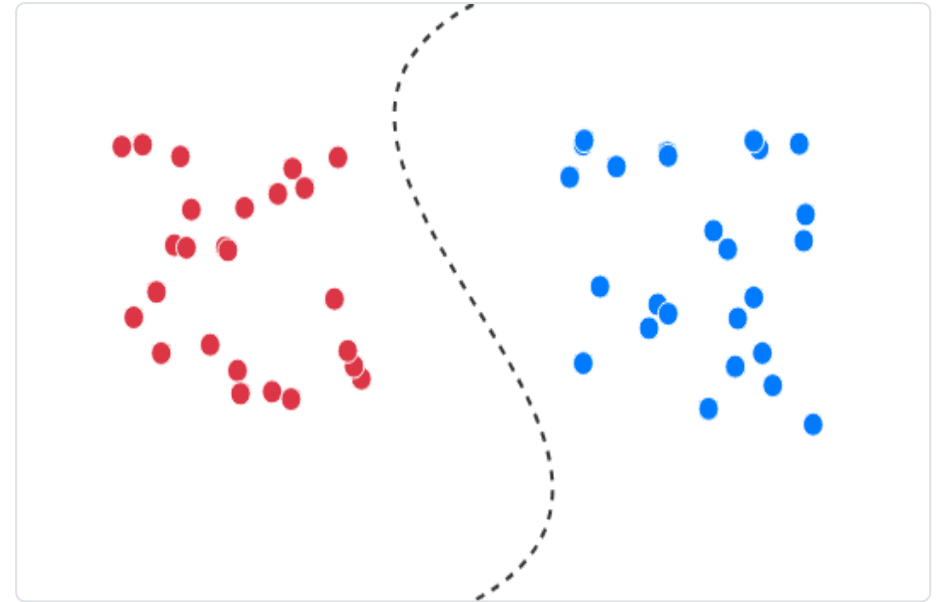
● Class A ● Class B

Generate Data

Clear

A single straight line can perfectly separate the two classes

### ✗ Non-Linearly Separable (XOR)



● Class A ● Class B

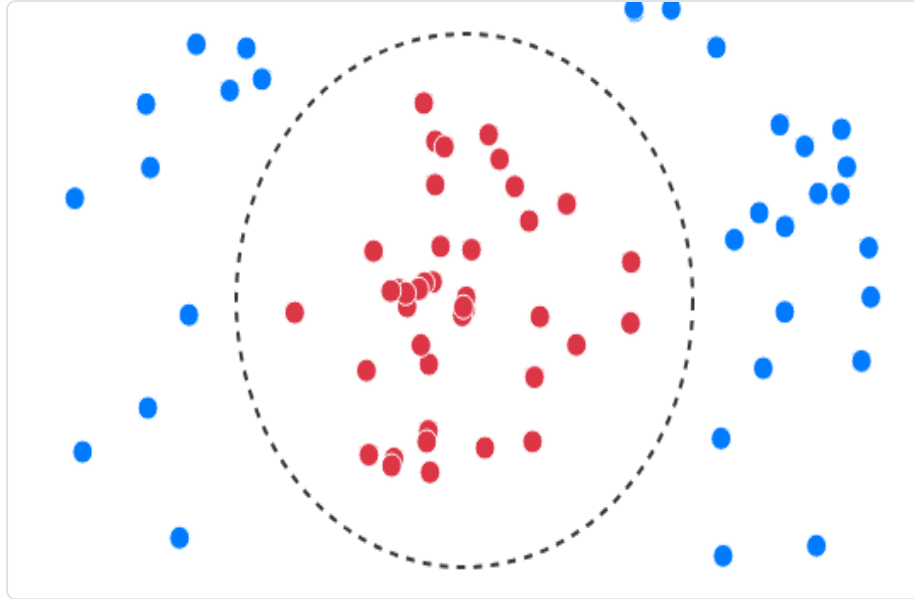
Generate XOR

Clear

XOR pattern requires a curved (non-linear) boundary

### ✗ Non-Linearly Separable (Circles)

### ✗ Non-Linearly Separable (Moons)

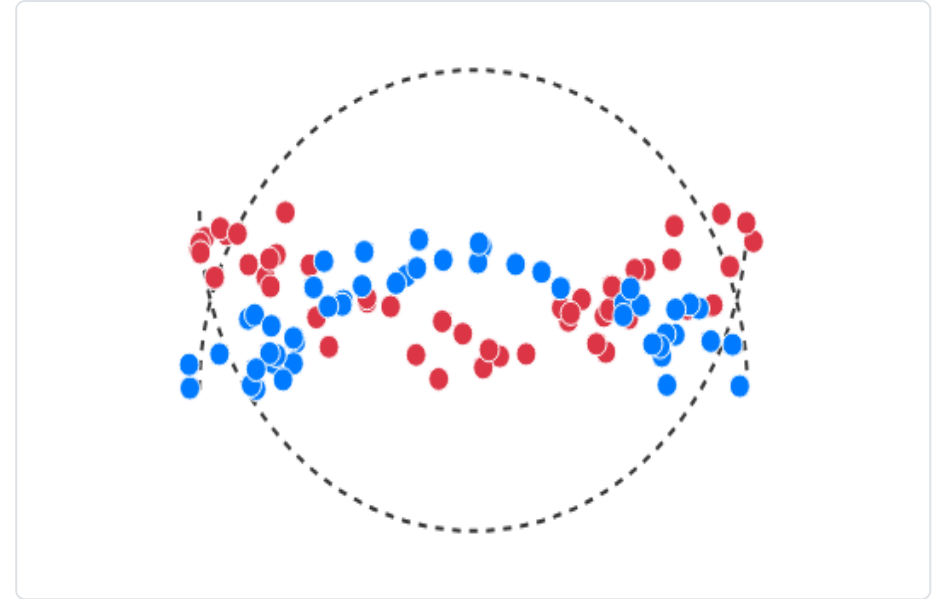


● Inner Class ● Outer Class

Generate Circles

Clear

Concentric circles require a circular boundary



● Class A ● Class B

Generate Moons

Clear

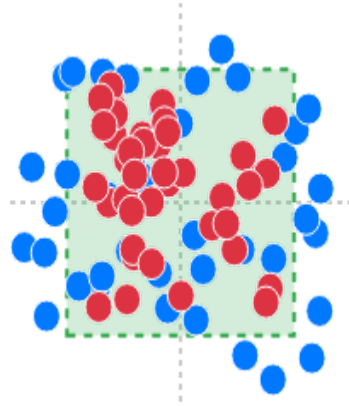
Interleaved crescent shapes require a complex boundary



## 3D Decision Boundary Visualization

✓ Linearly Separable (3D)

✗ Non-Linearly Separable (3D Spheres)



● Class A ● Class B

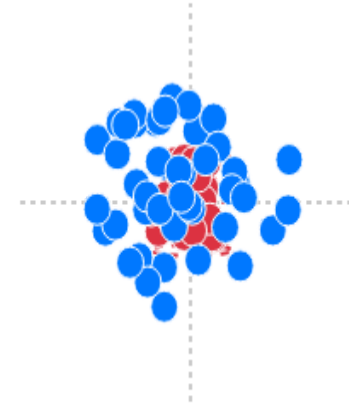
Generate Data

Rotate View

Stop

Clear

A single plane can separate classes in 3D space



● Inner Class ● Outer Class

Generate Spheres

Rotate View

Stop

Clear

Concentric spheres require a spherical boundary surface