

A Visual Introduction to Geometric Data Analysis

Henry Adams and Lara Kassab

Geometry: Education, Art, and Research
Banff International Research Station, Feb 19-21, 2021

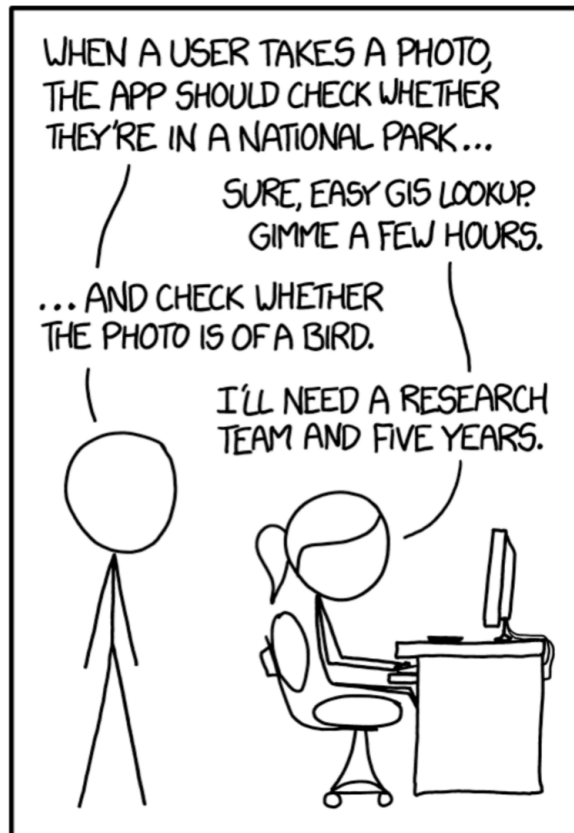
Artificial Intelligence

People telling me AI is going
to destroy the world

My neural network

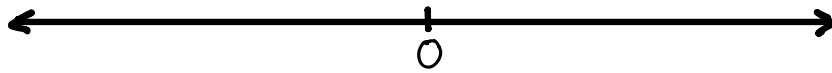


Artificial Intelligence

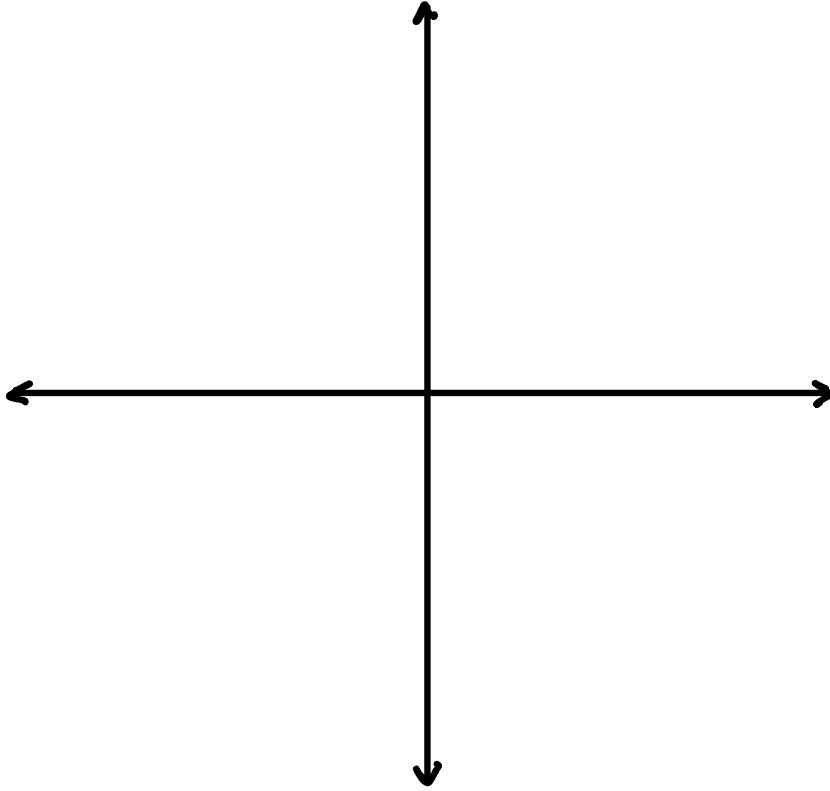


IN CS, IT CAN BE HARD TO EXPLAIN
THE DIFFERENCE BETWEEN THE EASY
AND THE VIRTUALLY IMPOSSIBLE.

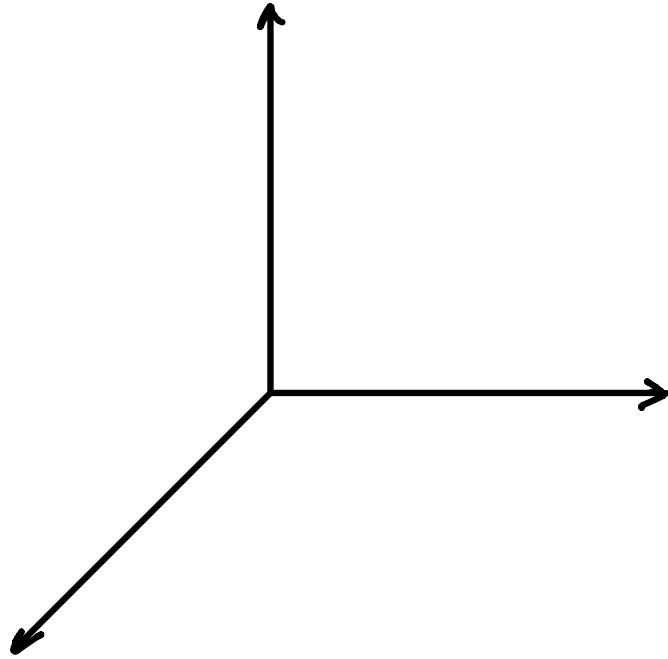
High-Dimensional Data



High-Dimensional Data



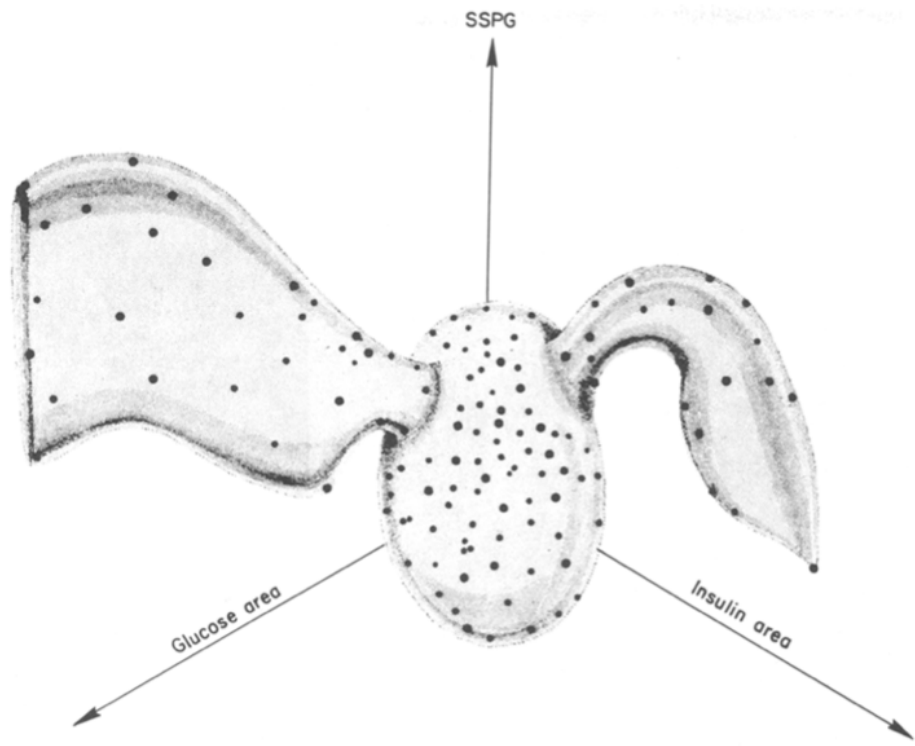
High-Dimensional Data



High-Dimensional Data

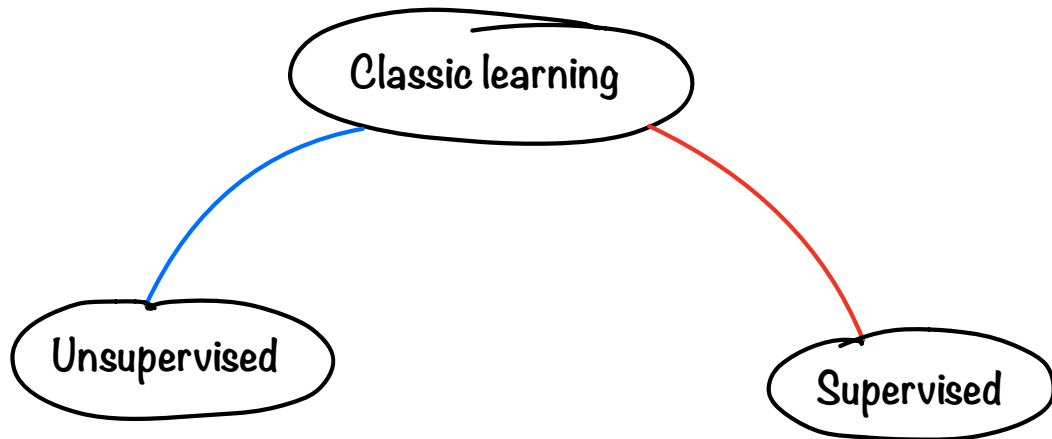
Example: Diabetes study

145 points in 5-dimensional space

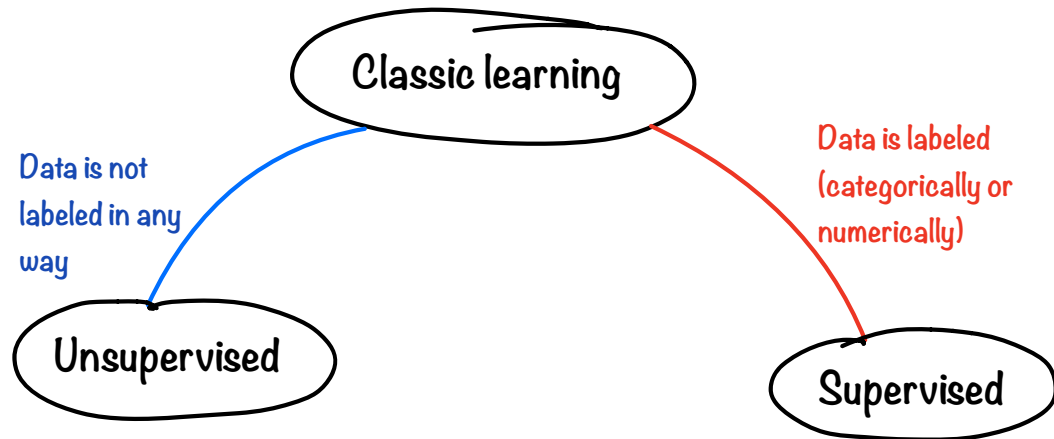


An attempt to define the nature of chemical diabetes using a multidimensional analysis by G. M. Reaven and R. G. Miller, 1979

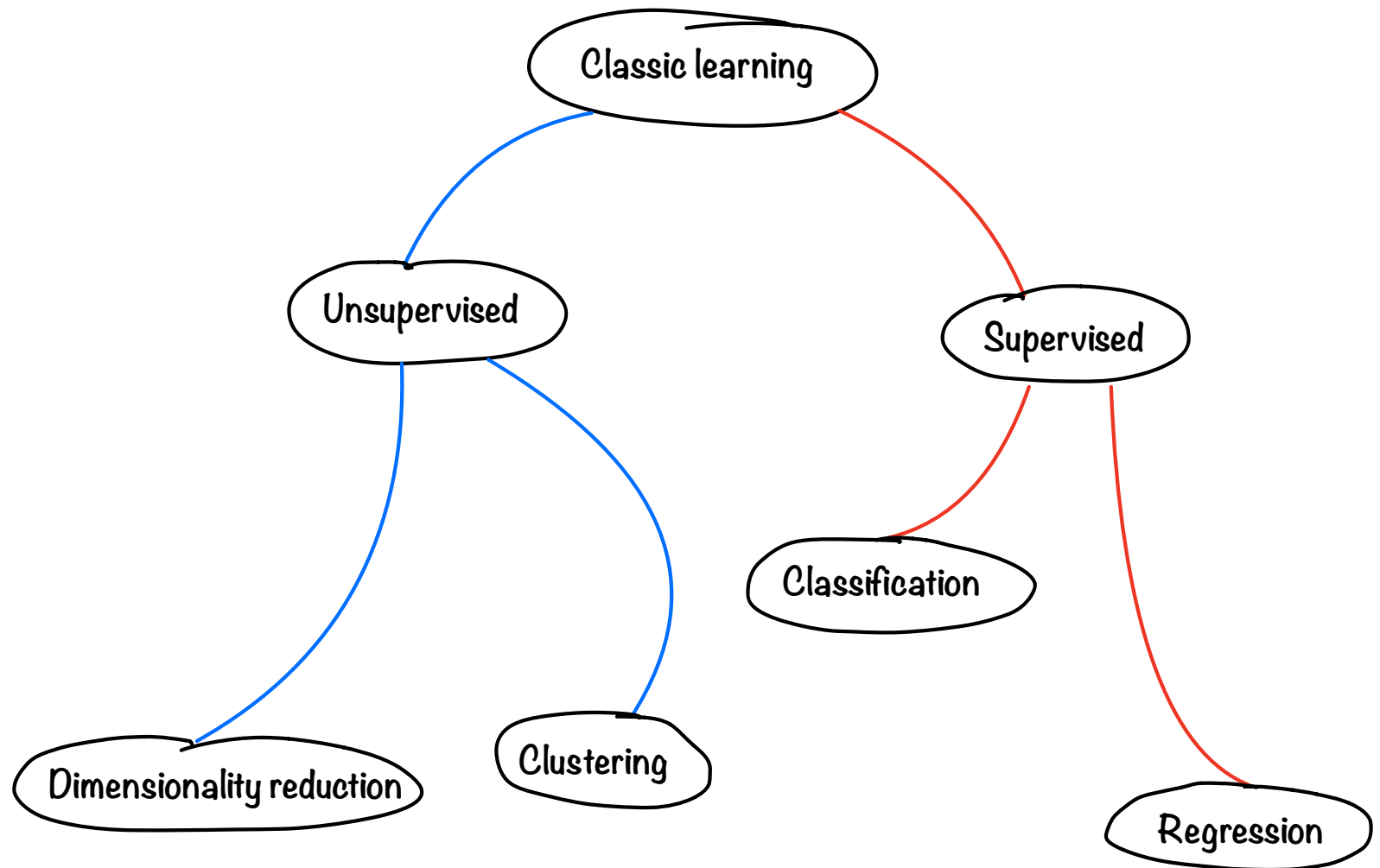
A Visual Introduction to Classic Machine Learning



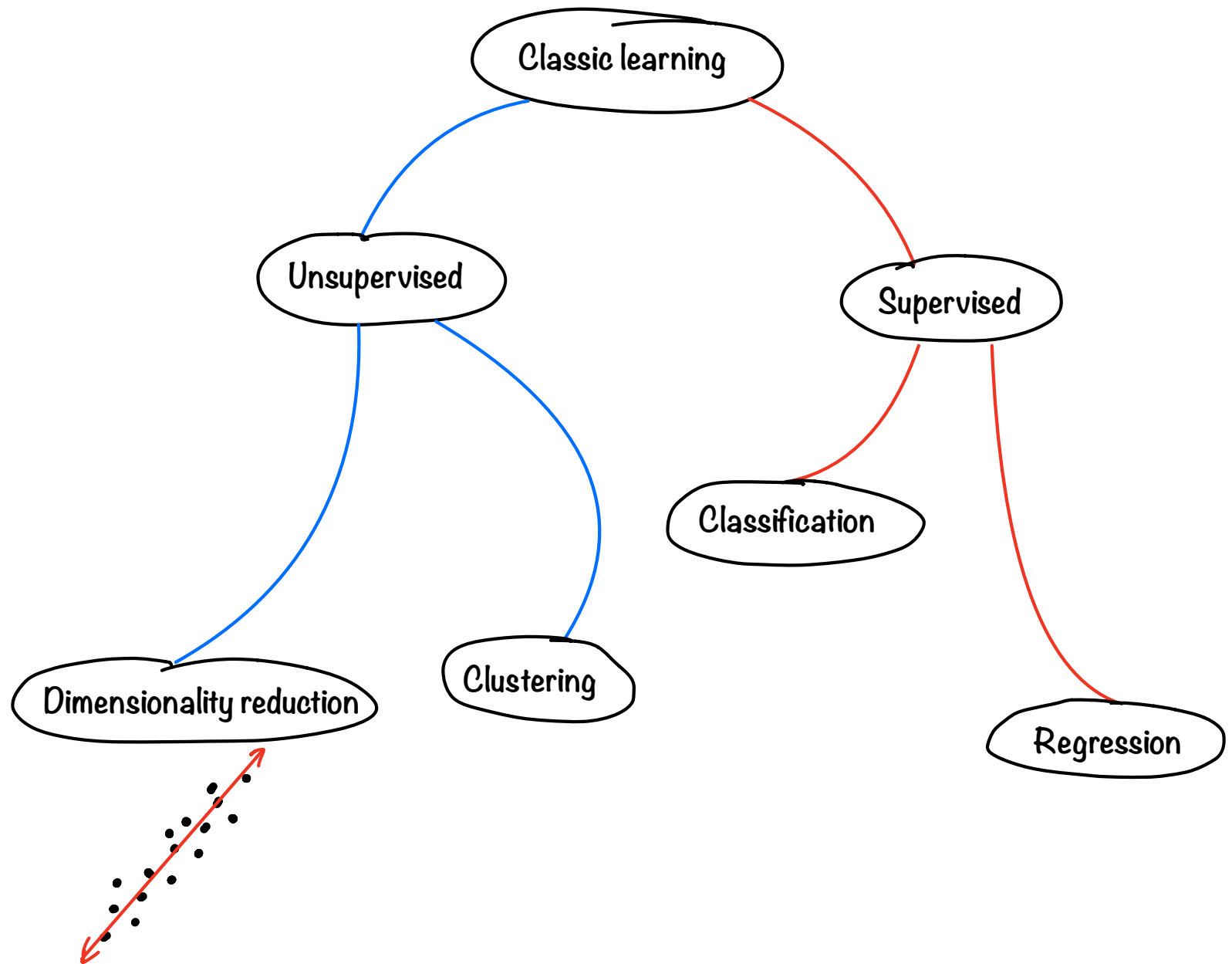
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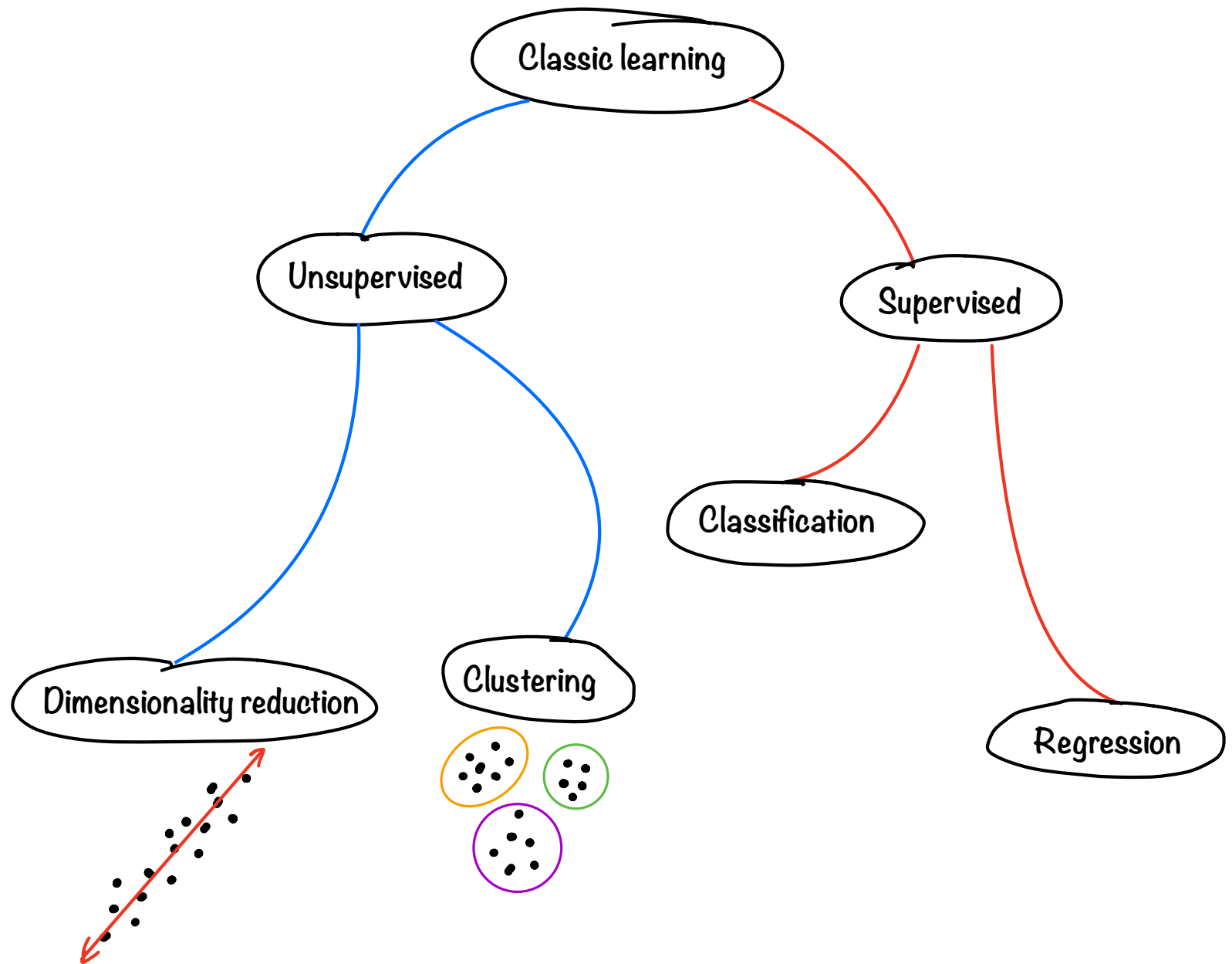
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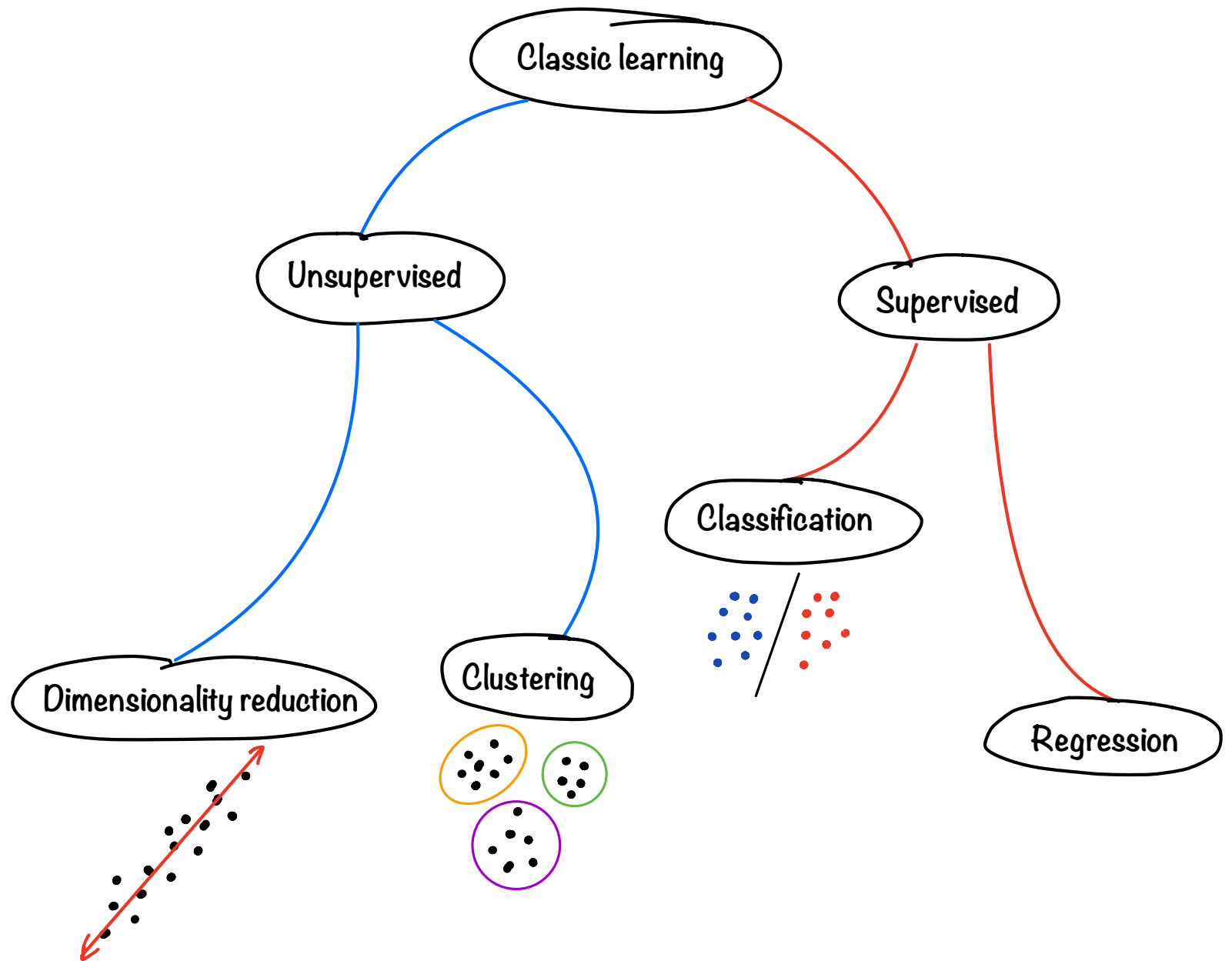
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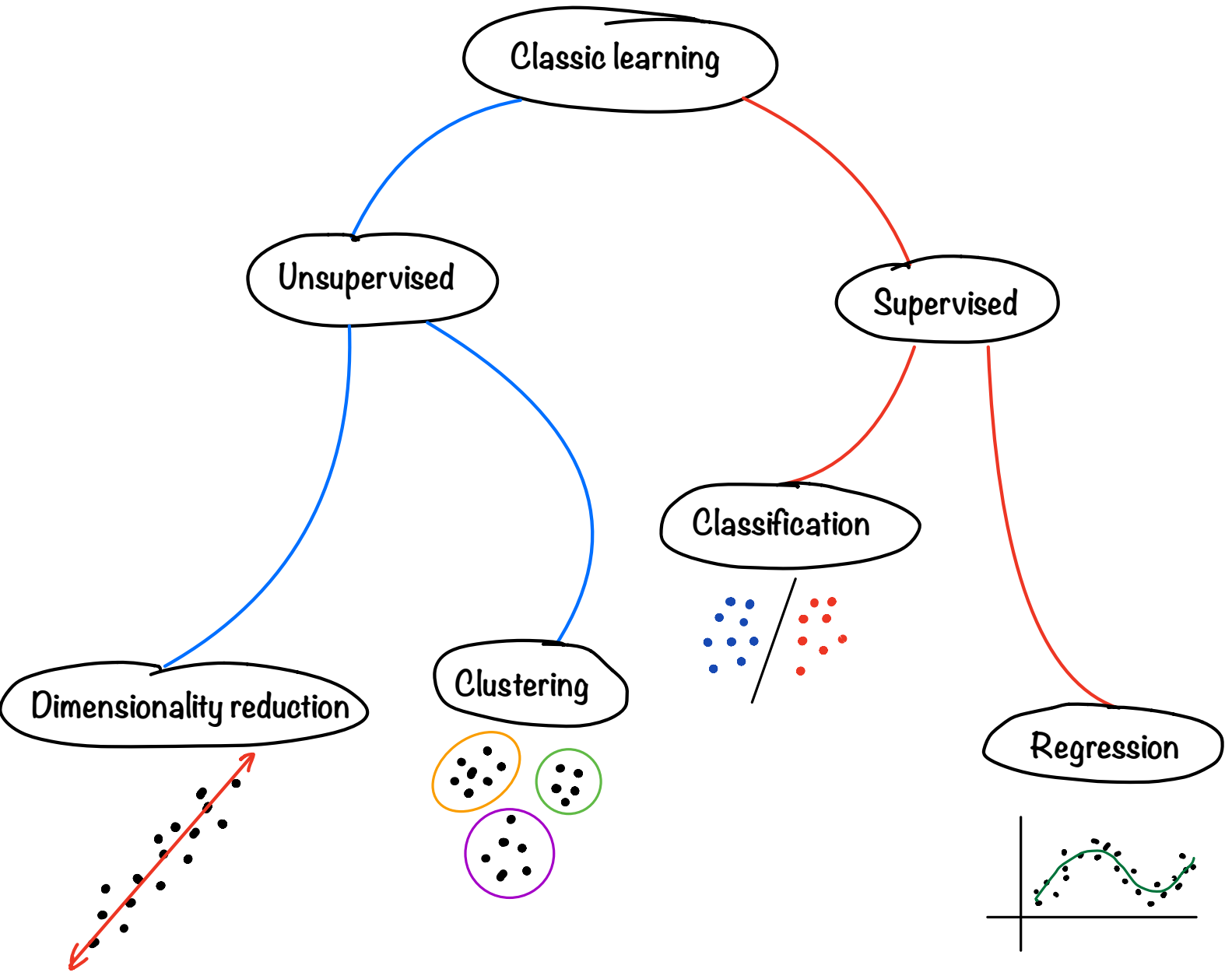
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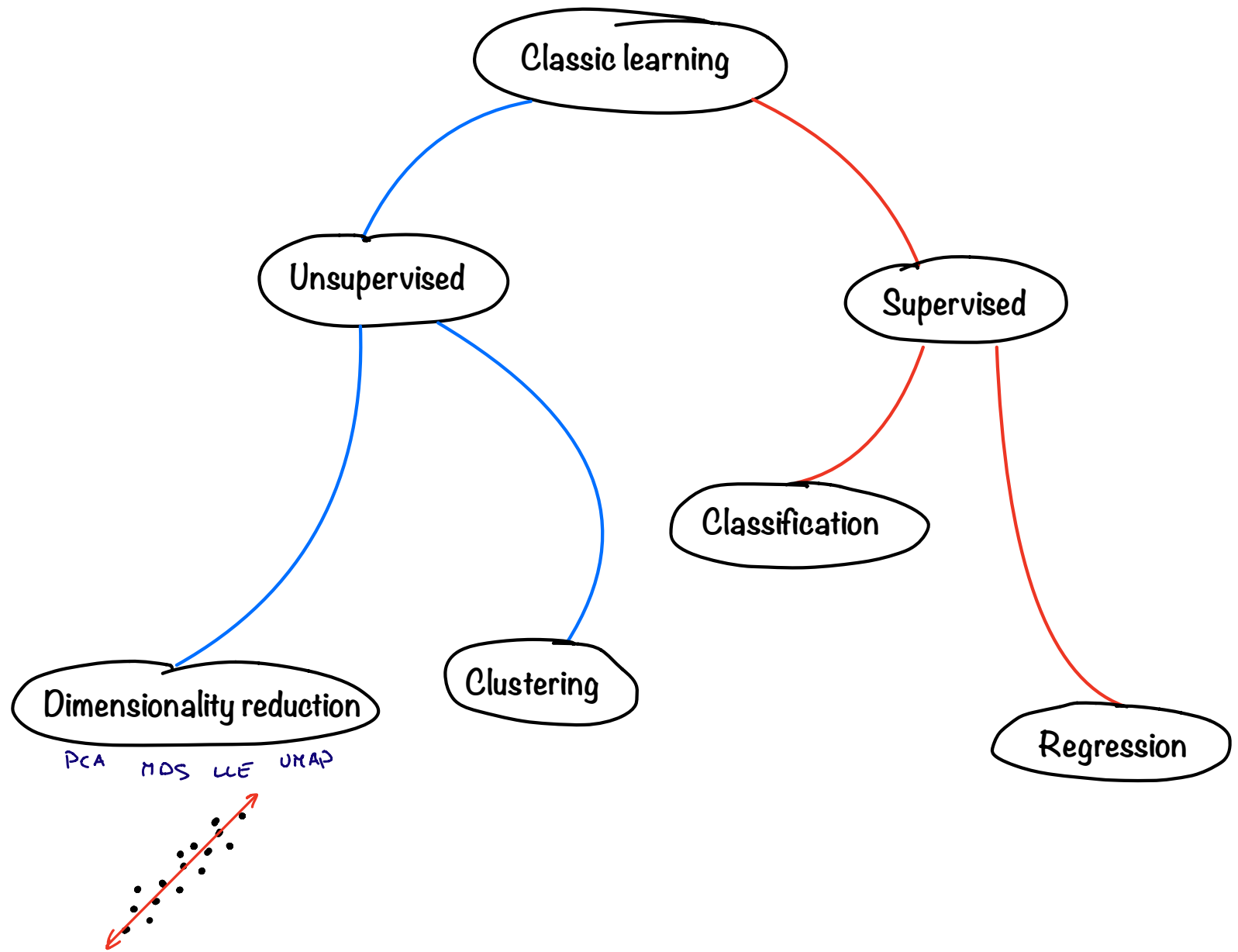
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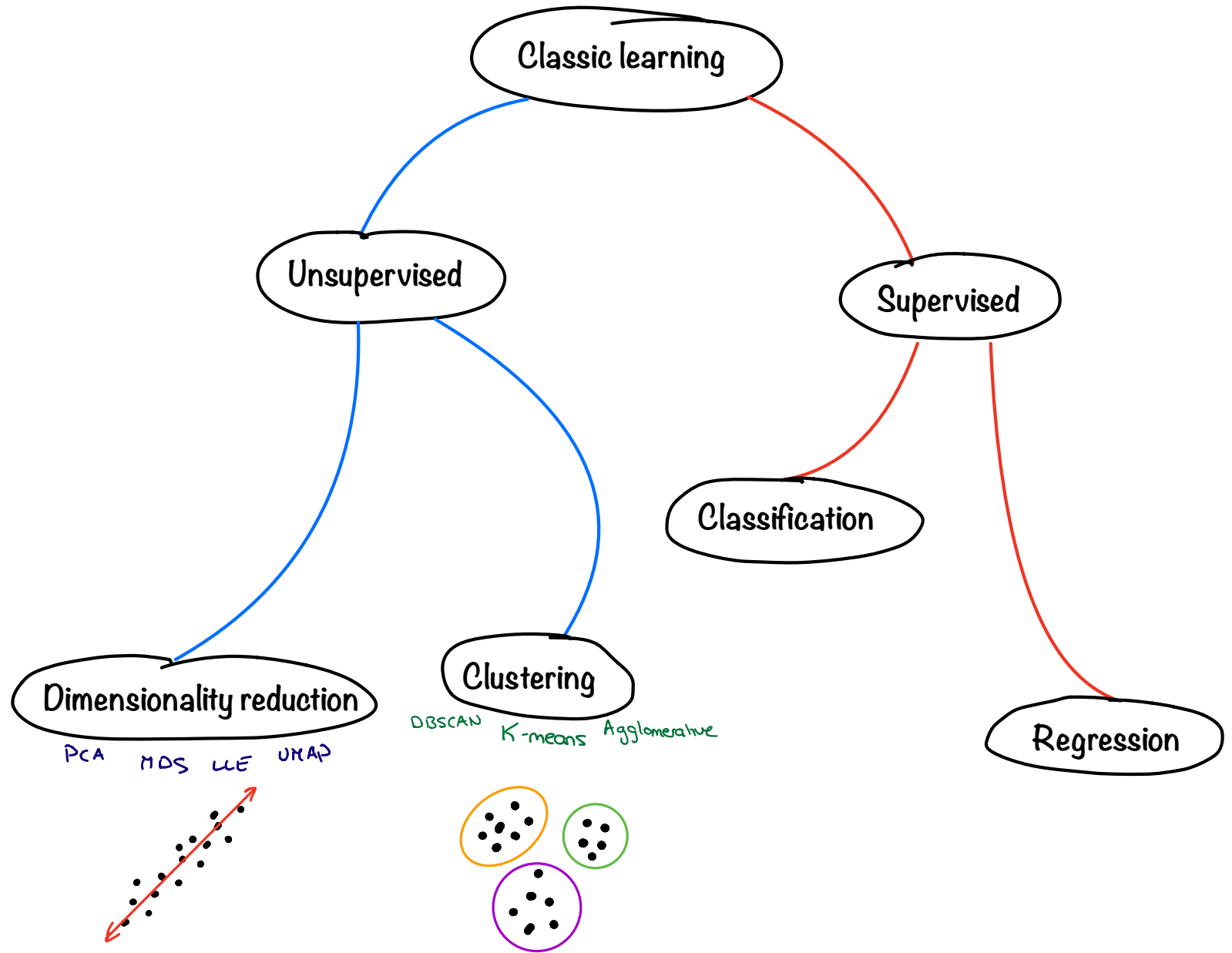
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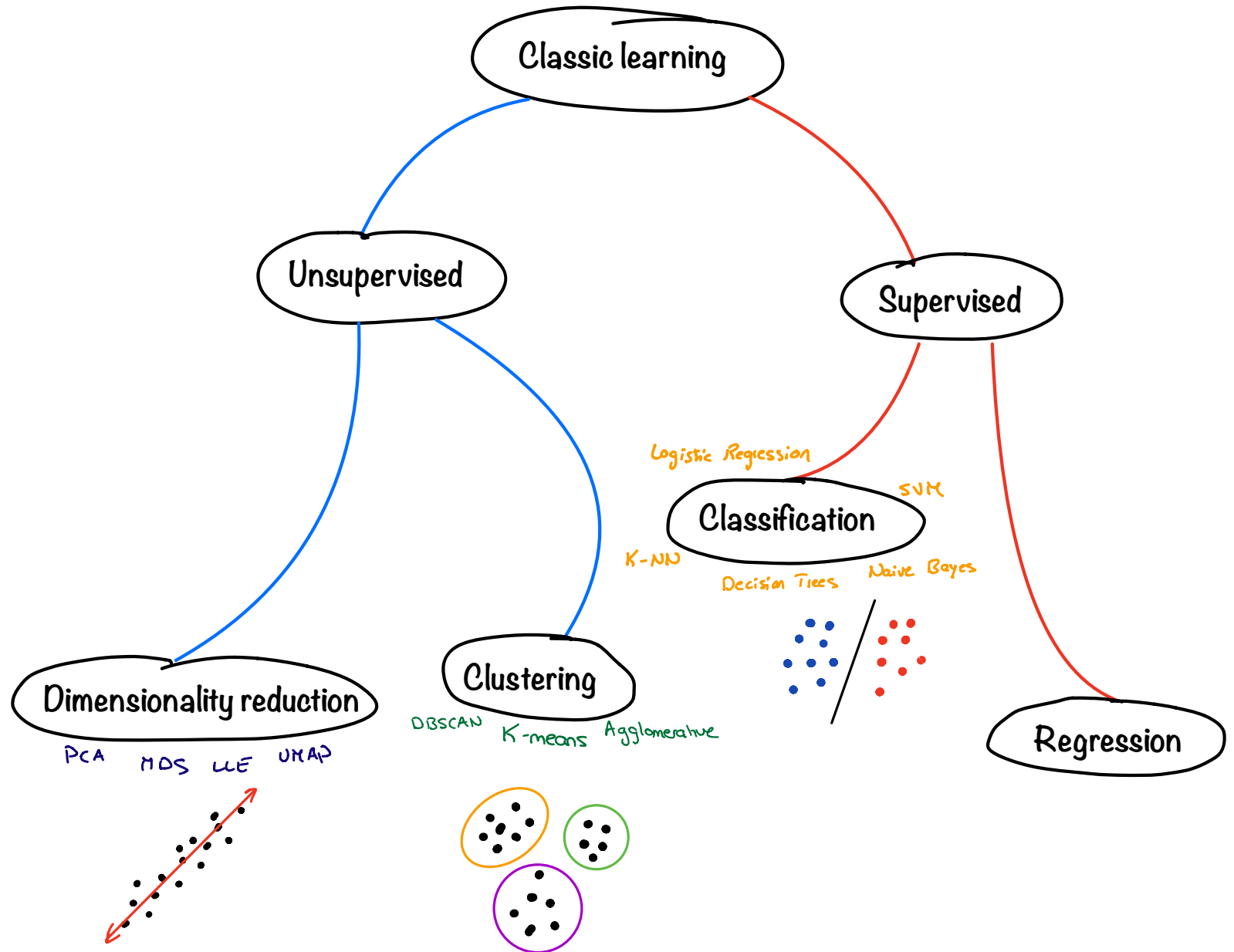
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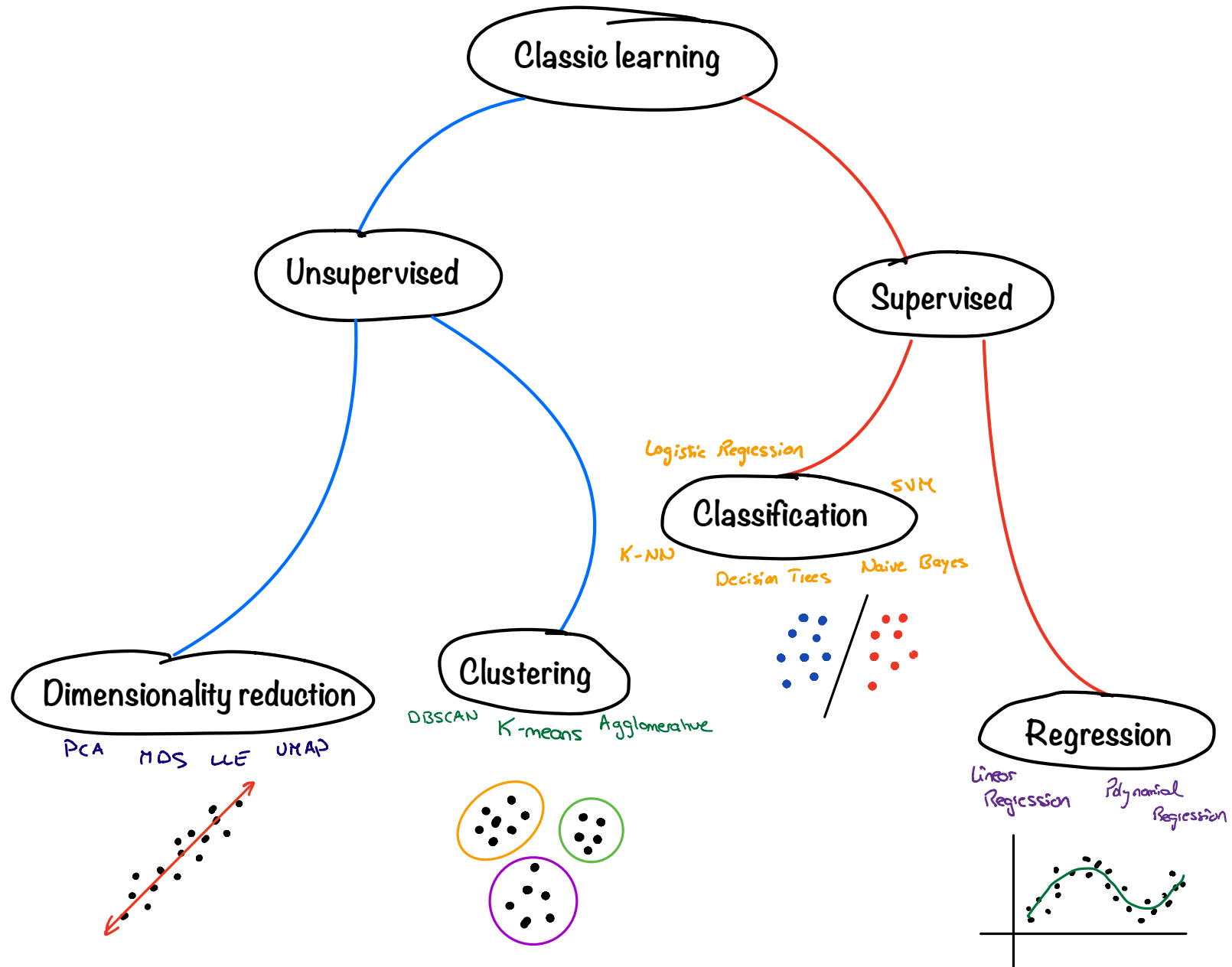
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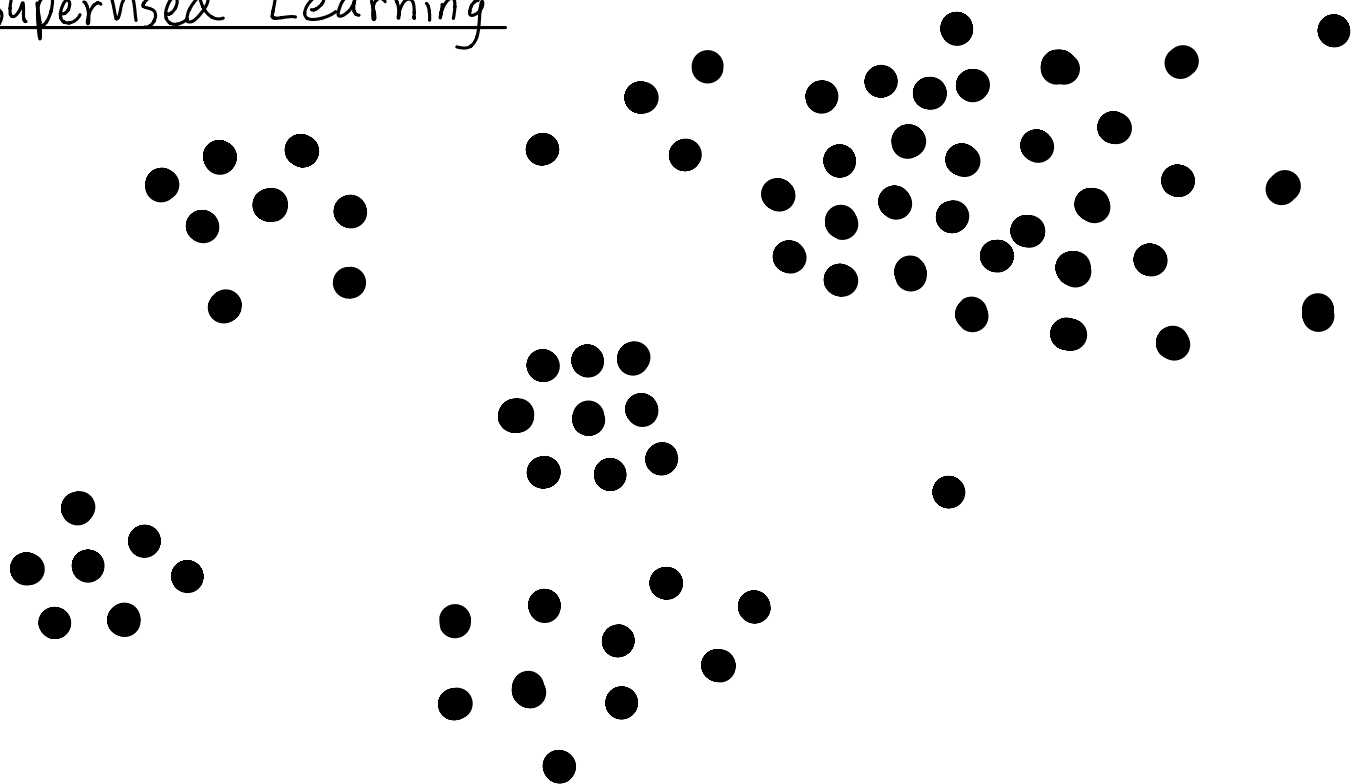
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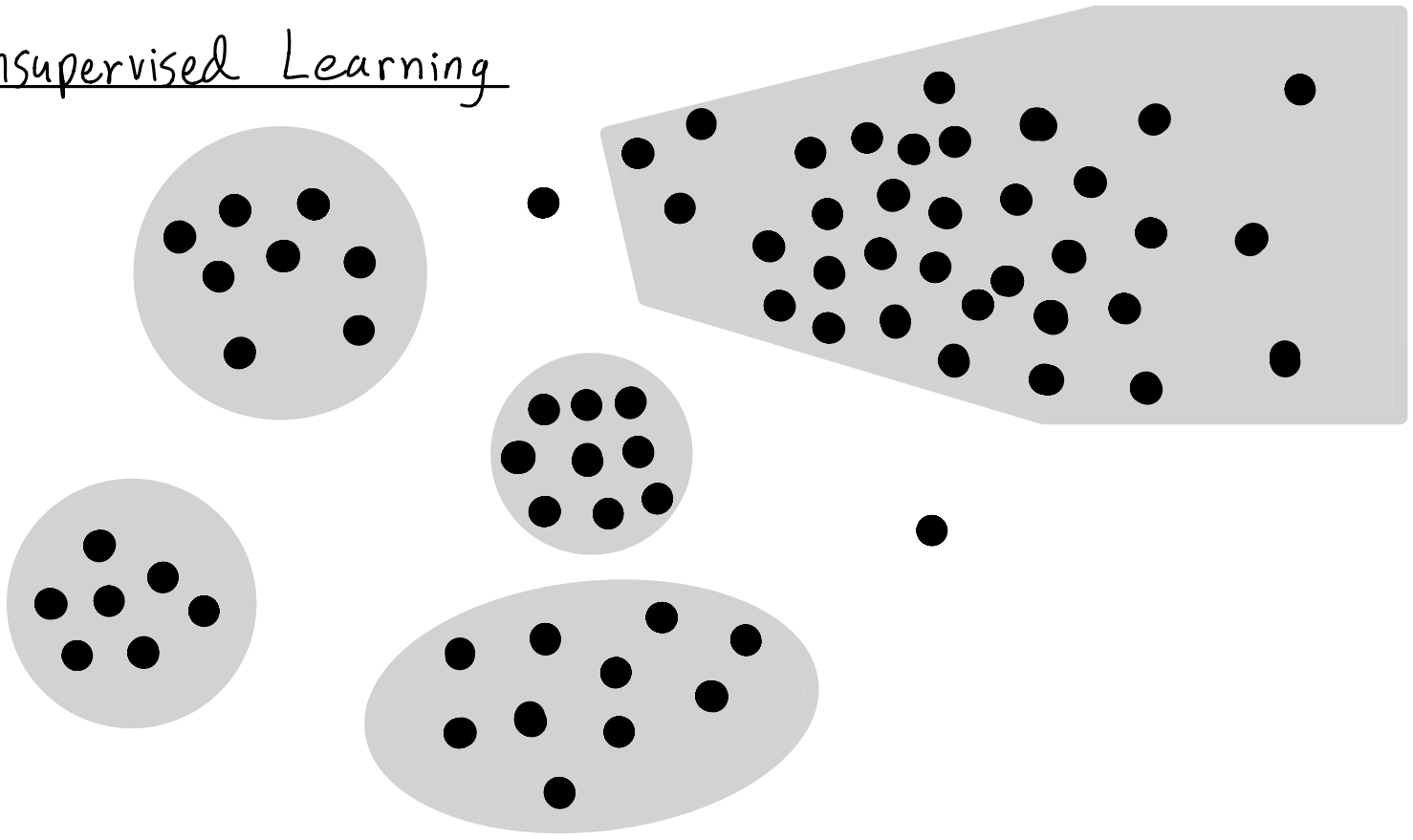
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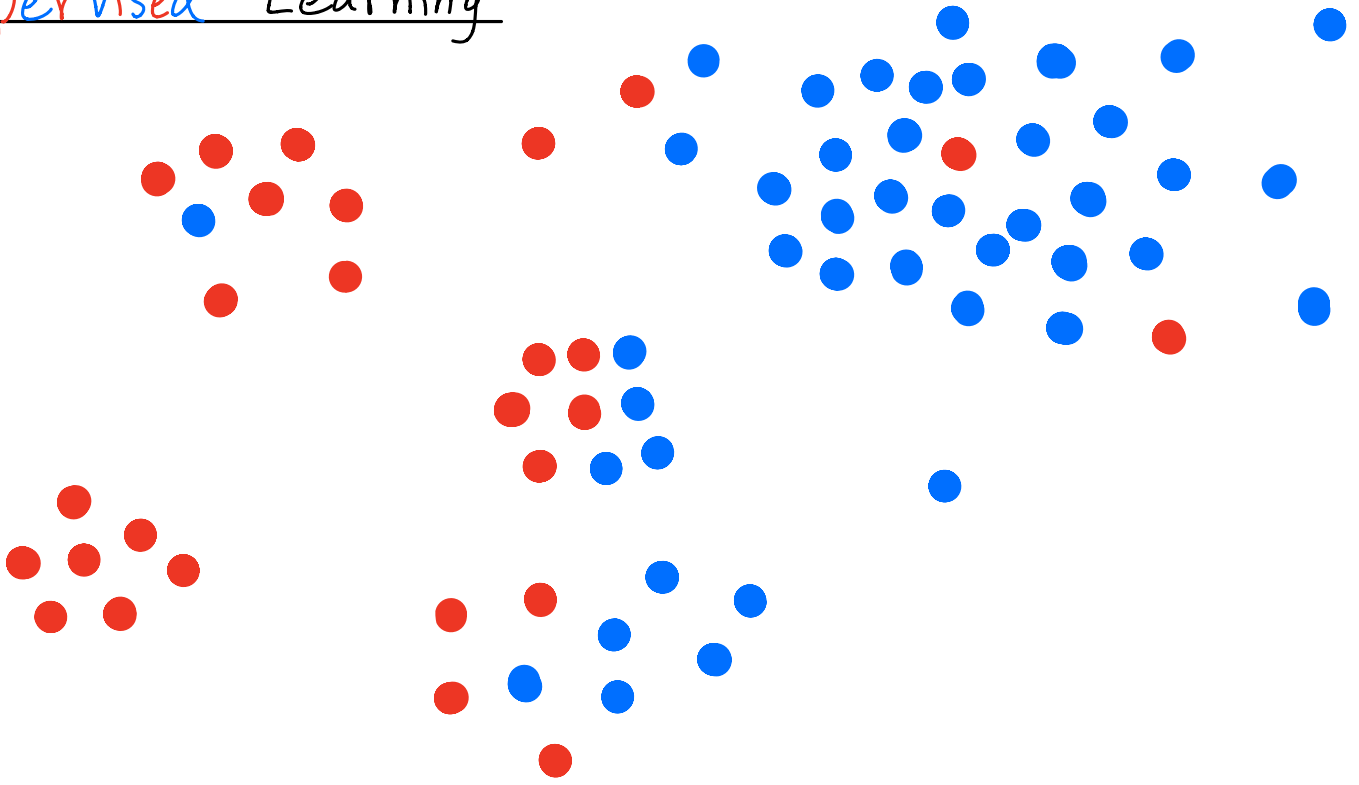
Unsupervised Learning



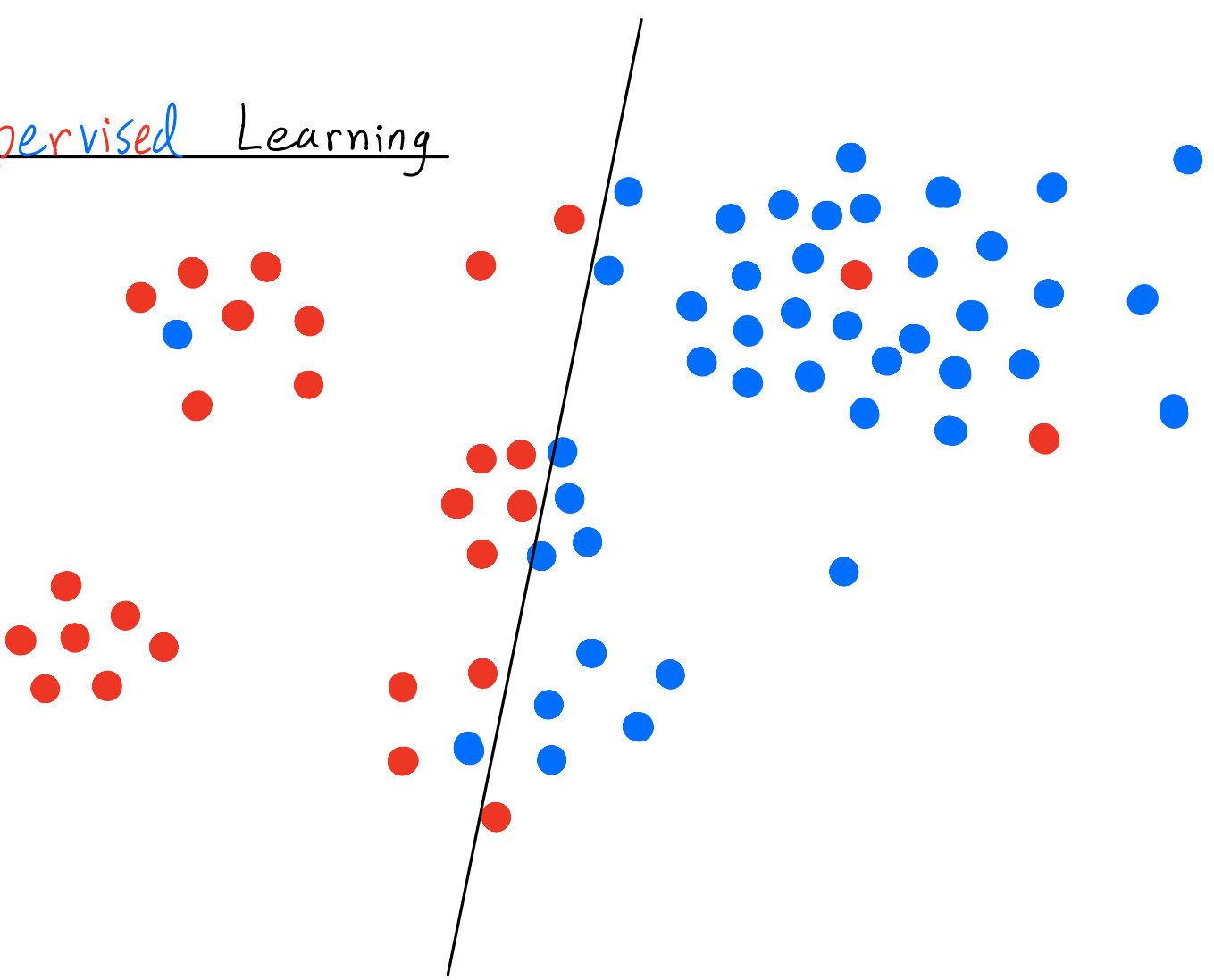
Unsupervised Learning



Supervised Learning



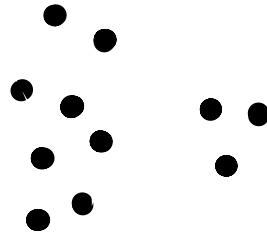
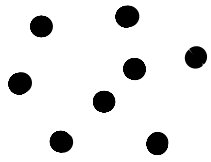
Supervised Learning



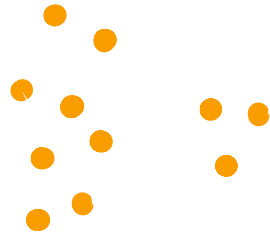
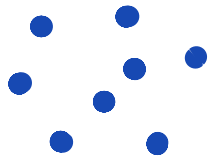
Unsupervised Learning

Clustering

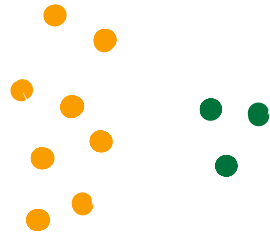
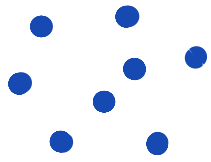
Clustering



Clustering



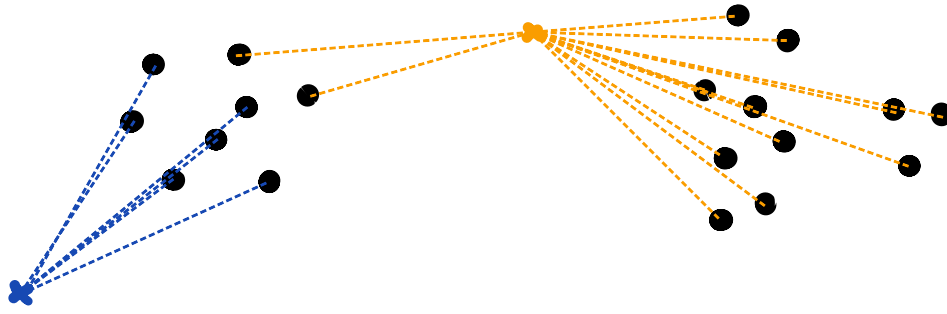
Clustering



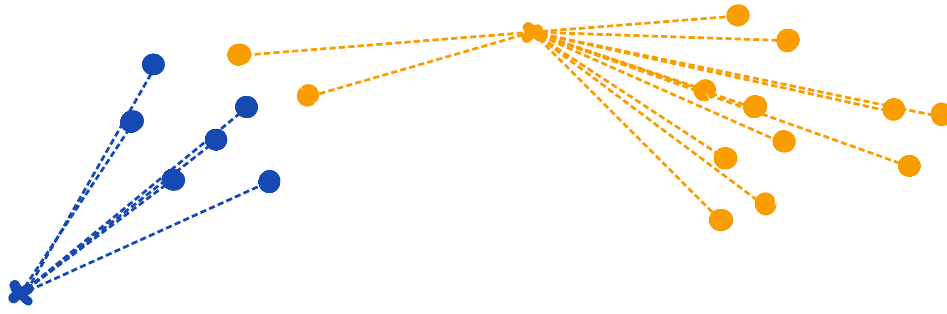
K-means Clustering



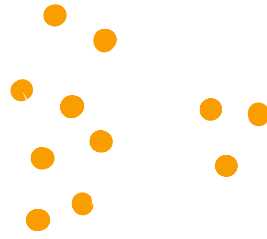
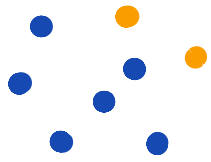
K-means Clustering



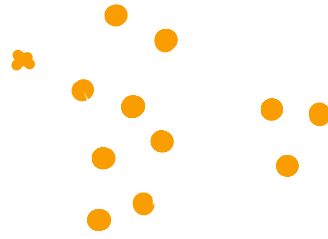
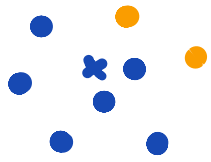
K-means Clustering



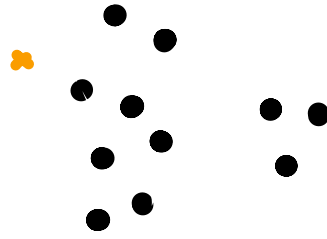
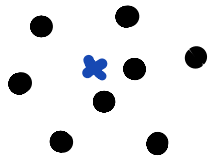
K-means Clustering



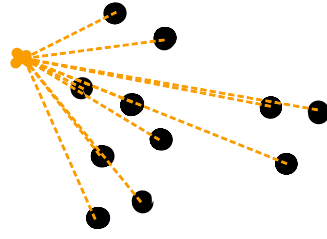
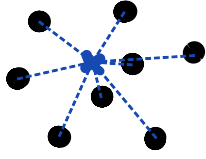
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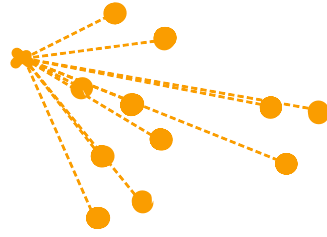
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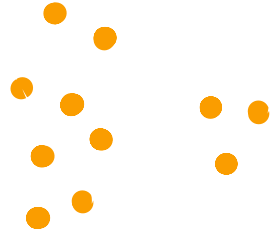
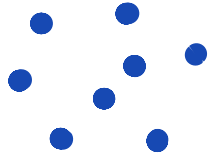
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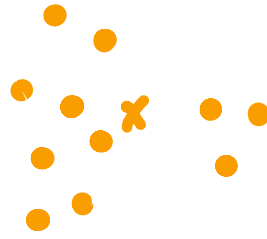
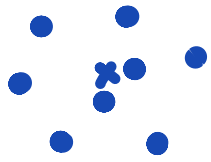
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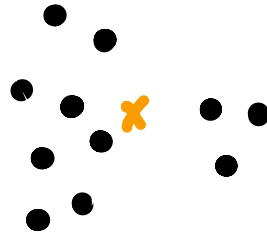
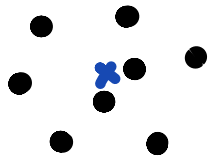
K-means Clustering



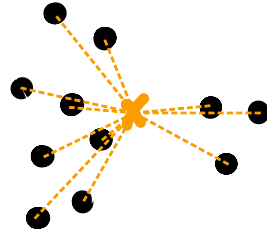
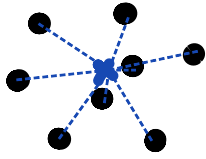
K-means Clustering



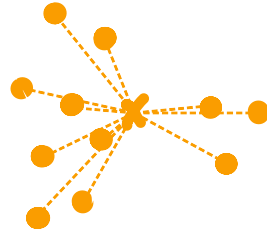
K-means Clustering



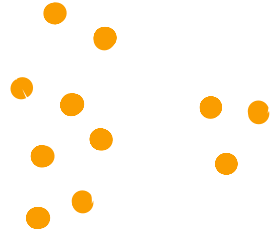
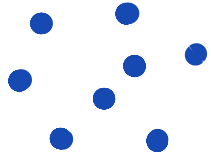
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K-means Clustering



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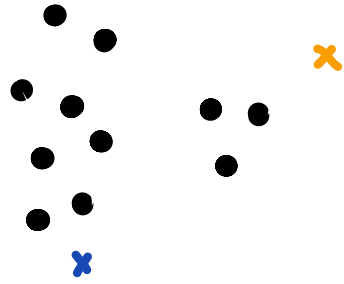
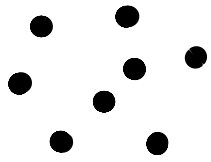
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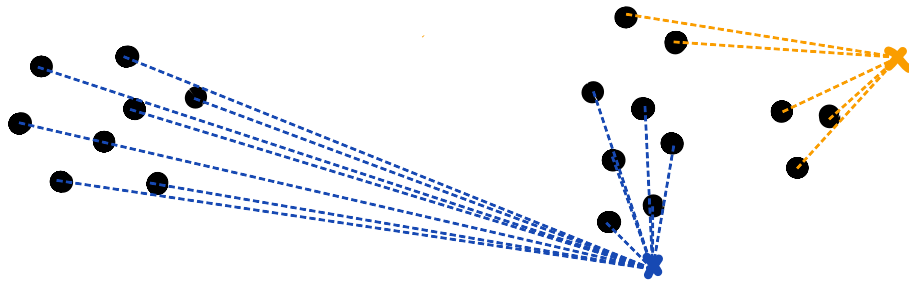
x

Let's try again with different initial centers.

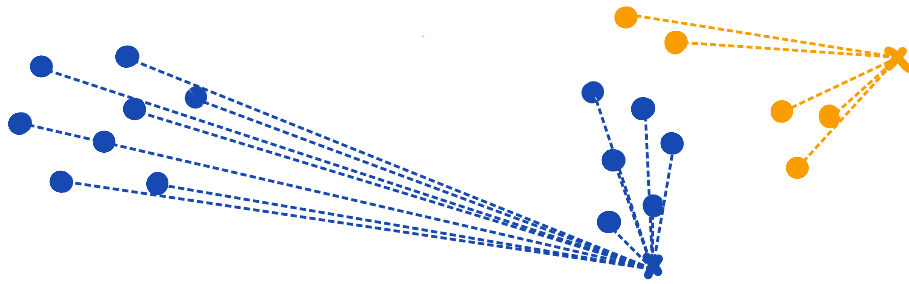
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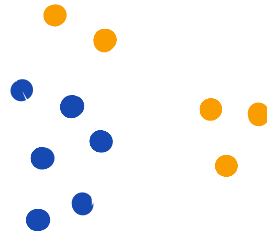
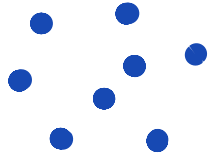
K-means Clustering



K-means Clustering



K-means Clustering



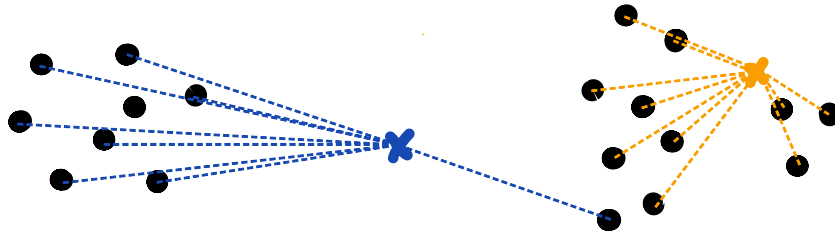
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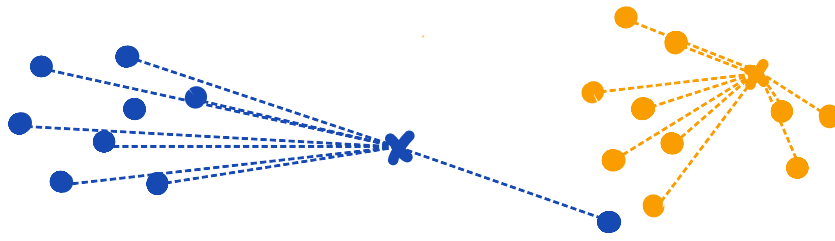
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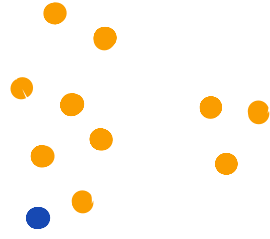
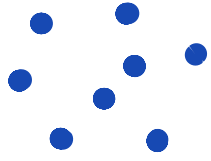
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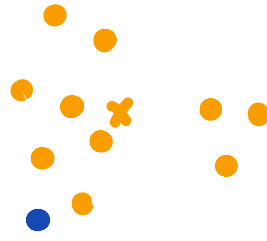
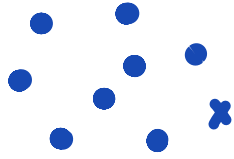
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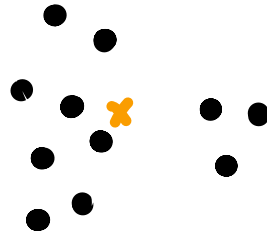
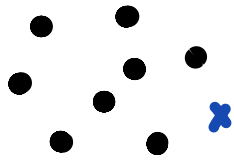
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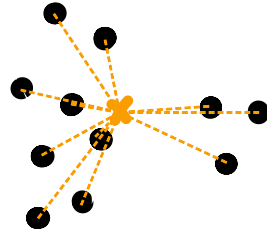
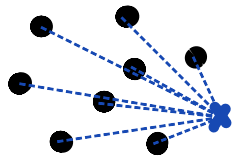
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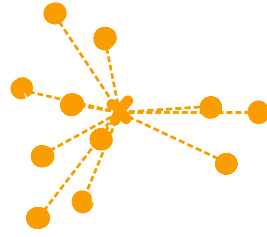
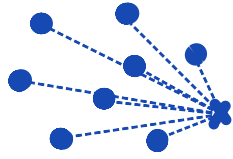
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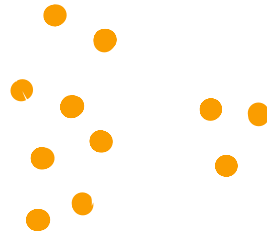
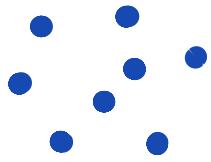
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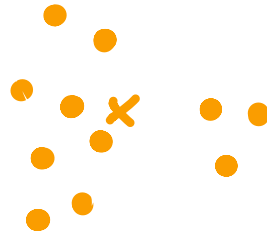
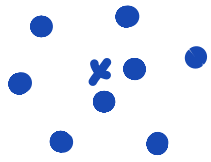
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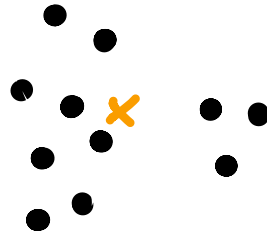
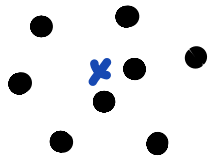
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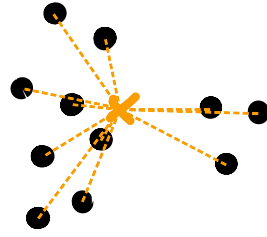
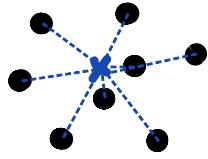
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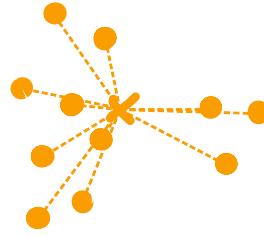
K-means Clustering



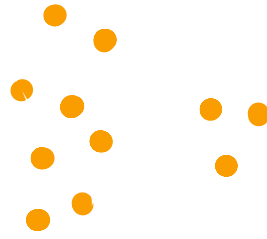
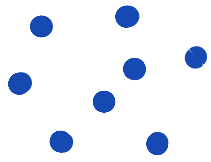
K-means Clustering



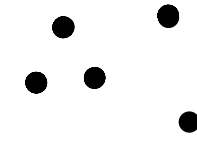
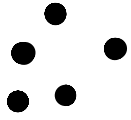
K-means Clustering



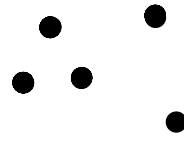
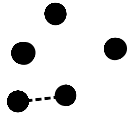
K-means Clustering



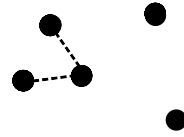
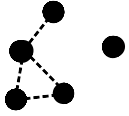
Single-linkage Clustering



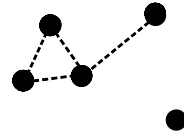
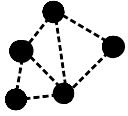
Single-linkage Clustering



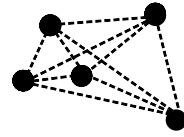
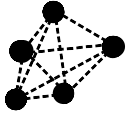
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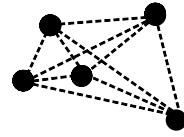
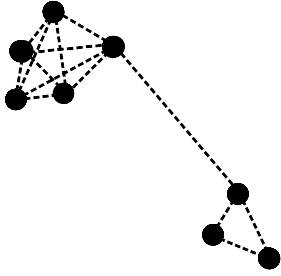
Single-linkage Clustering



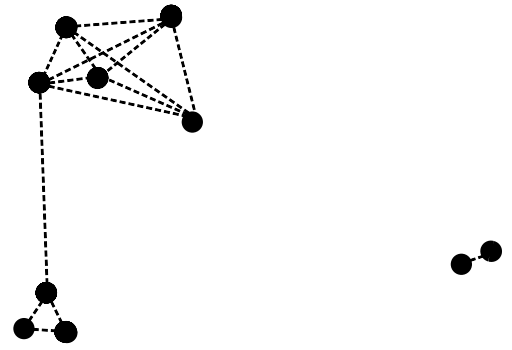
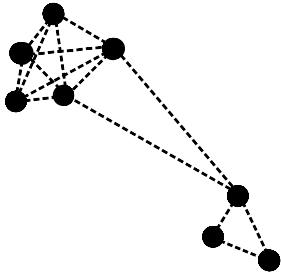
Single-linkage Clustering



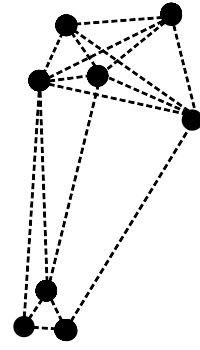
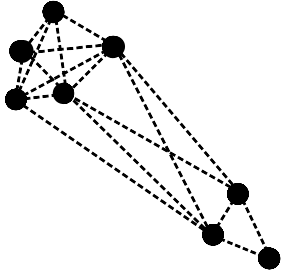
Single-linkage Clustering



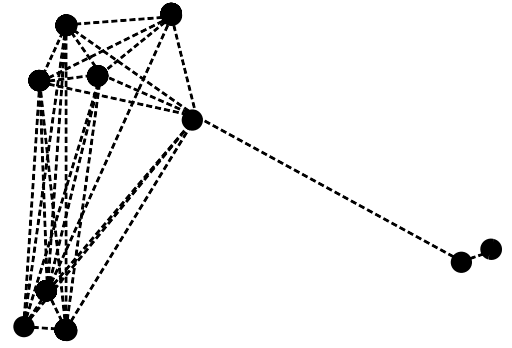
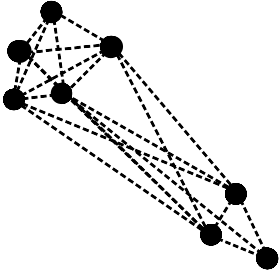
Single-linkage Clustering



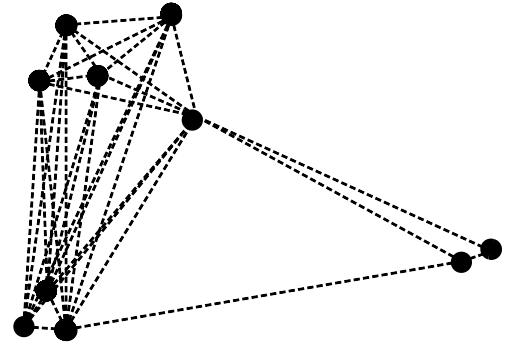
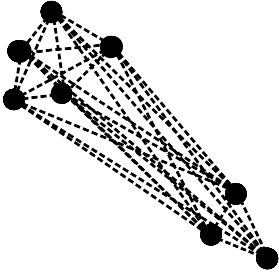
Single-linkage Clustering



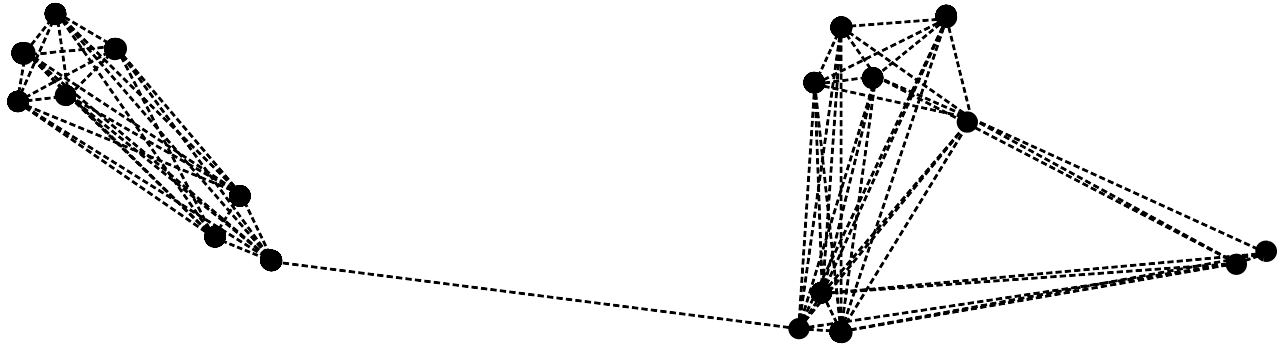
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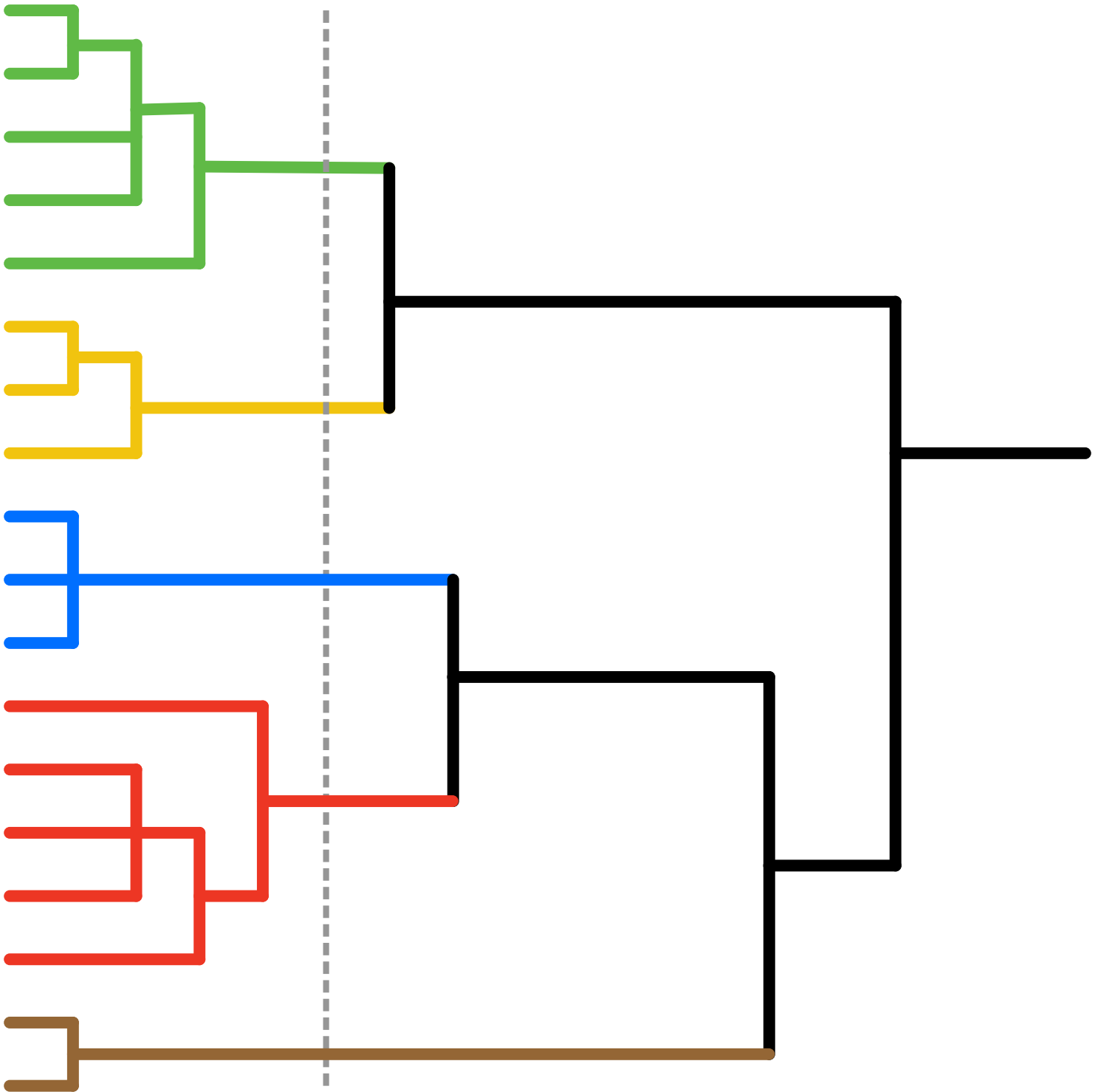
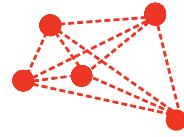
Single-linkage Clustering



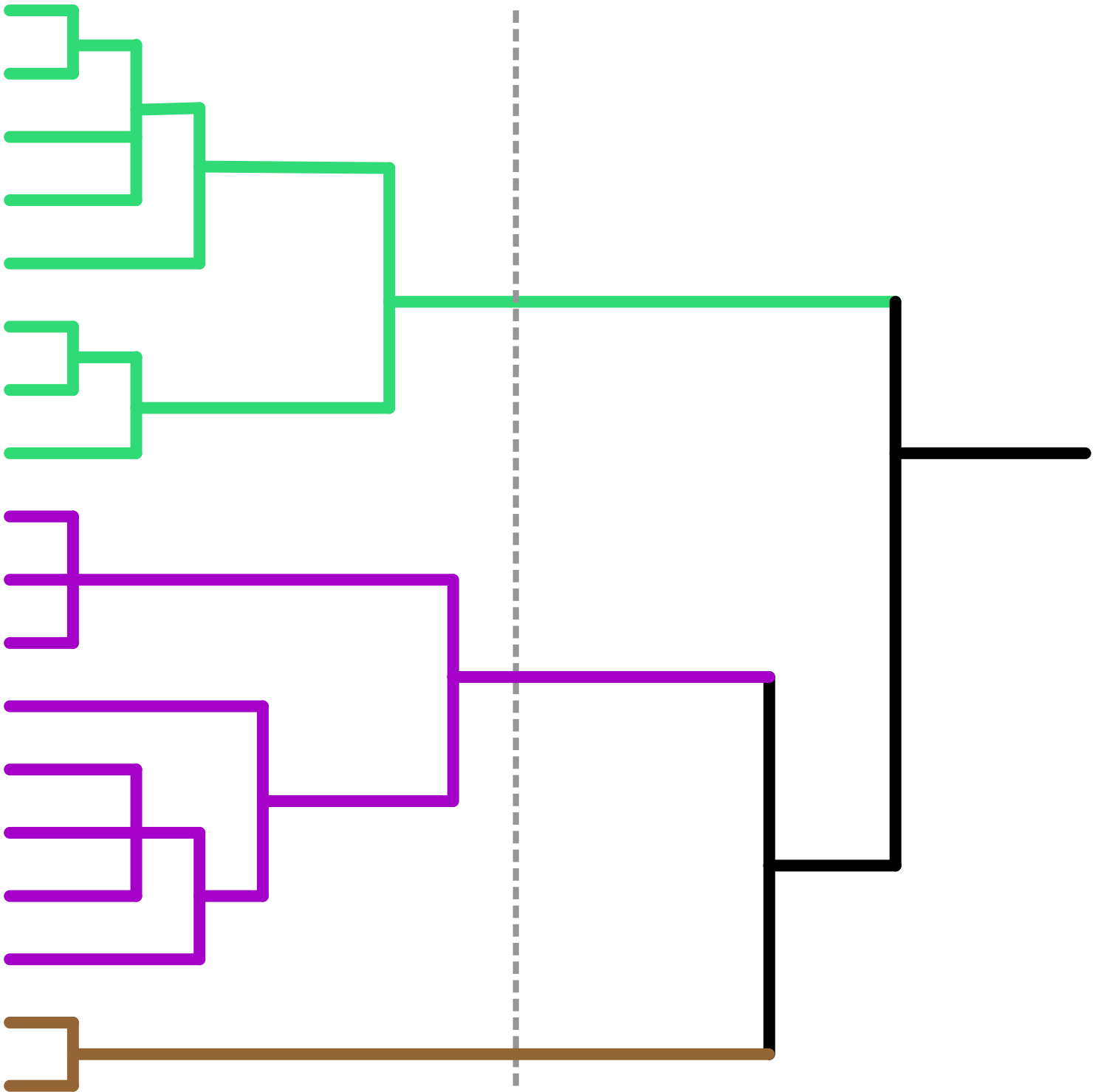
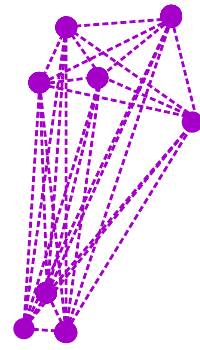
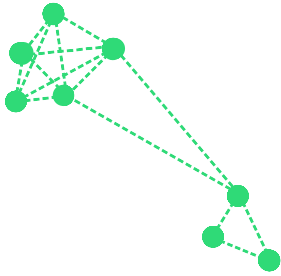
Single-linkage Clustering



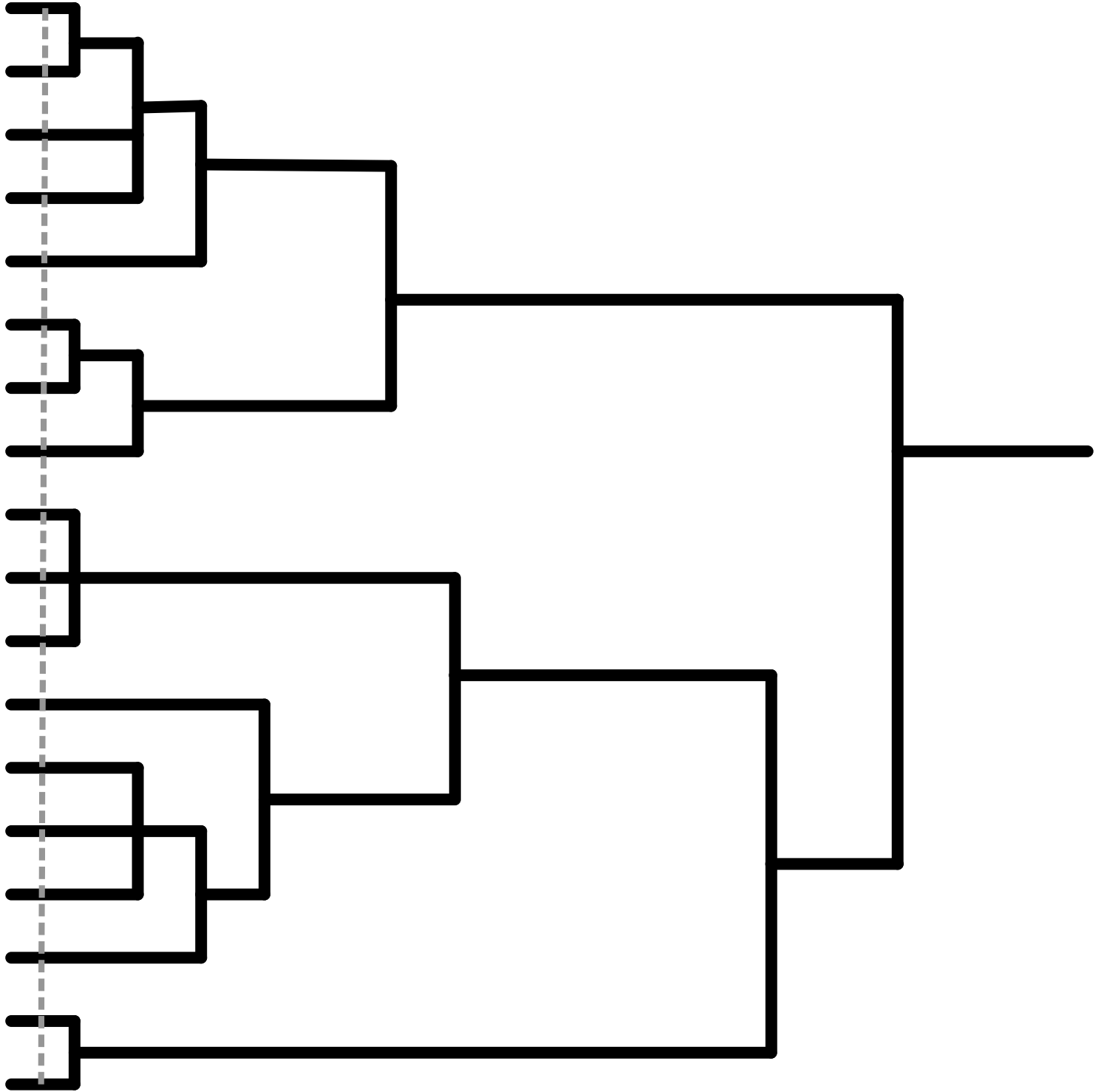
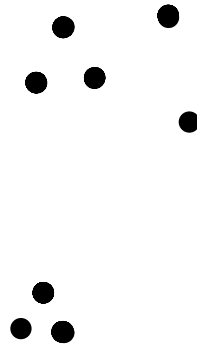
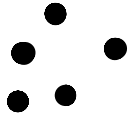
Single-linkage Clustering



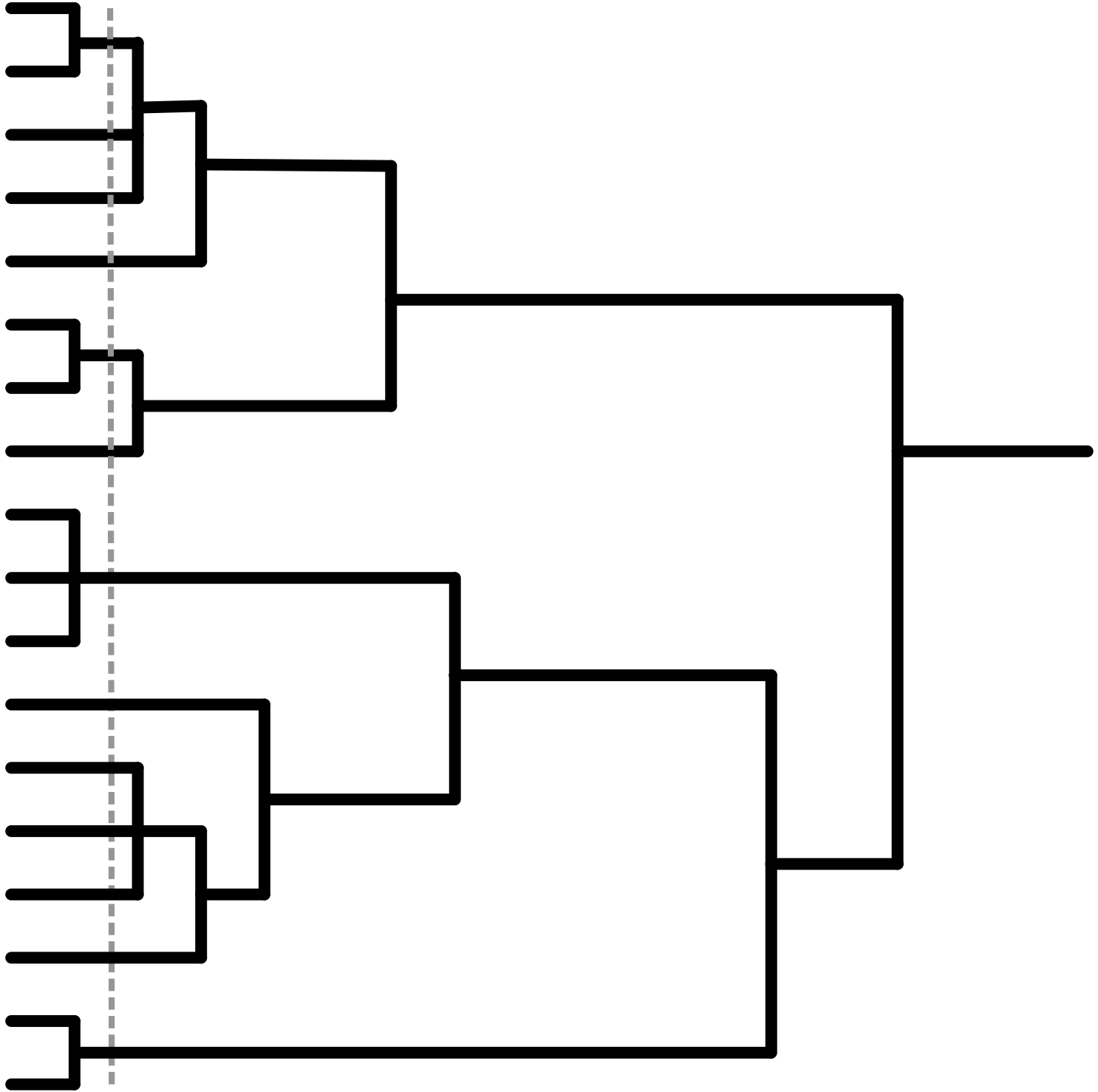
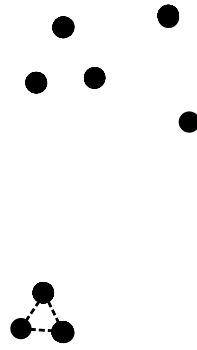
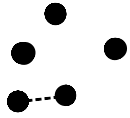
Single-linkage Clustering



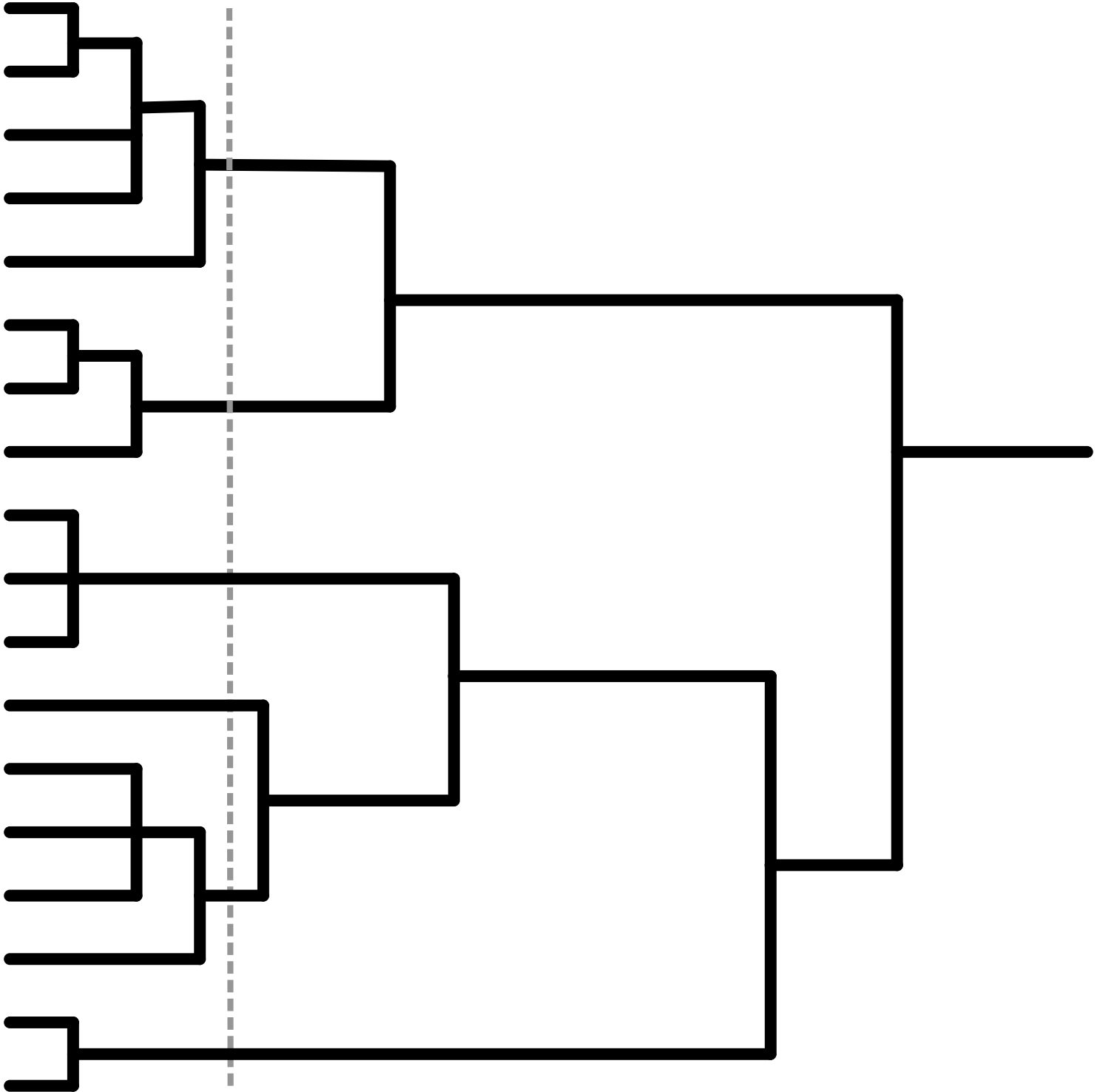
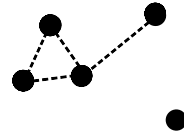
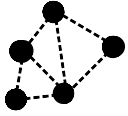
Single-linkage Clustering



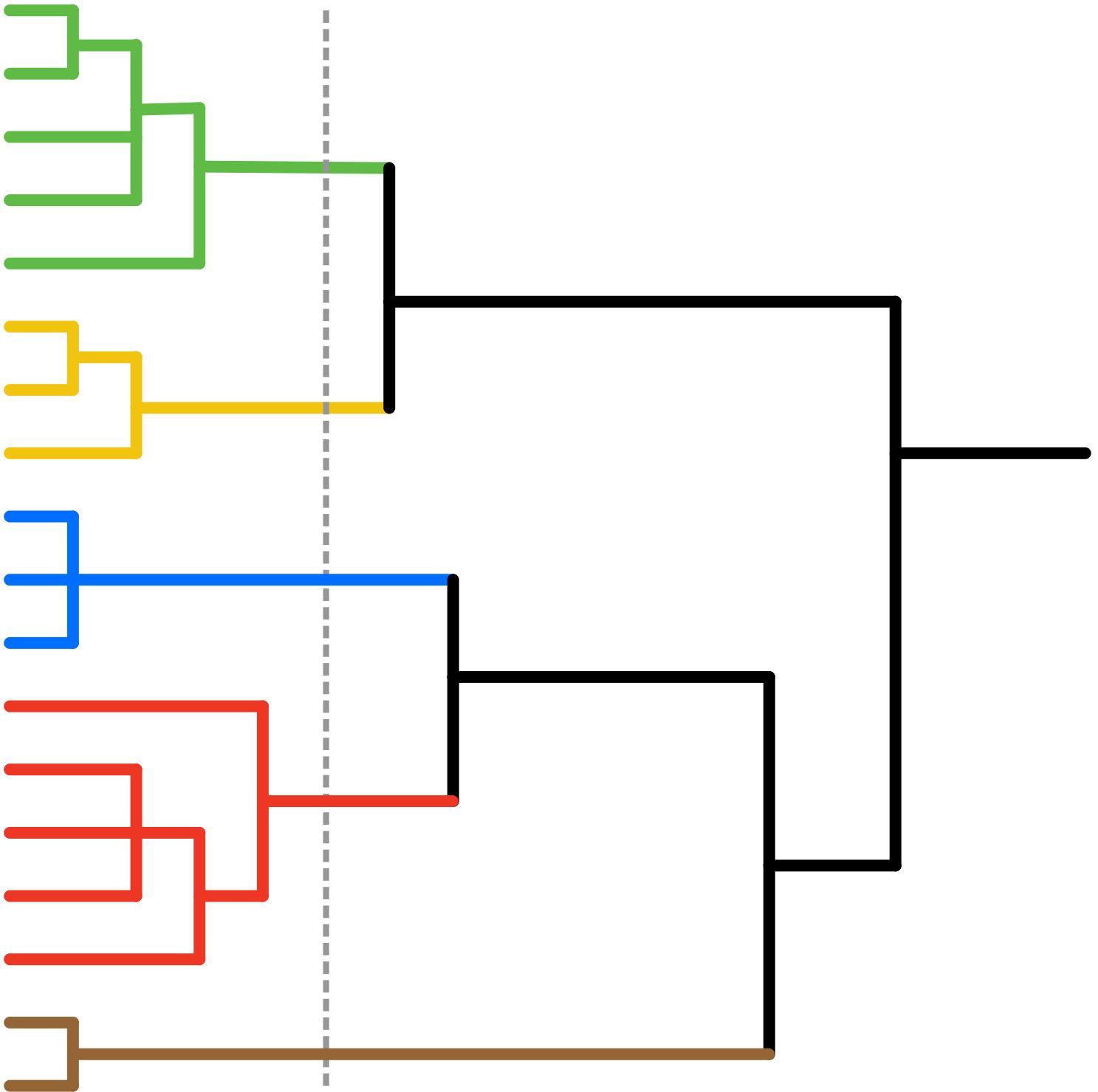
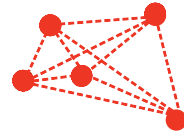
Single-linkage Clustering



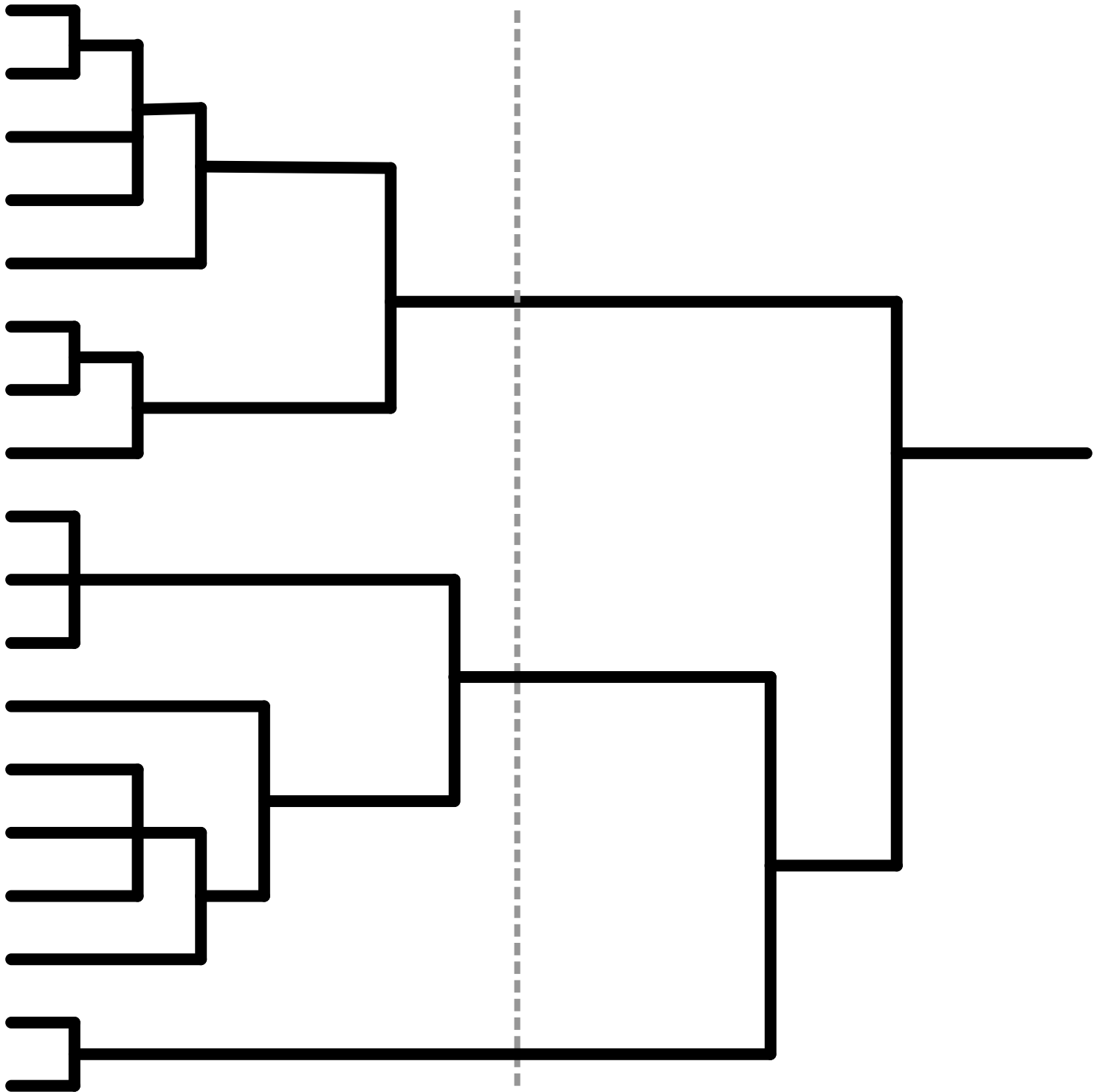
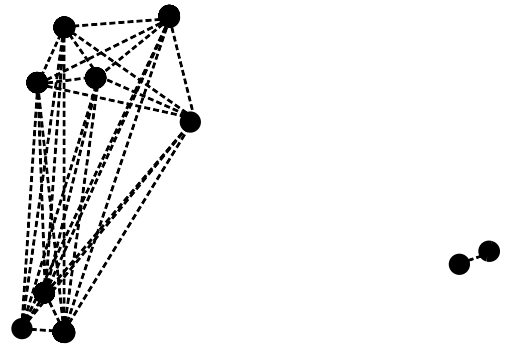
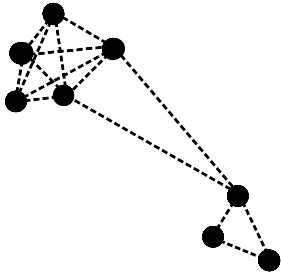
Single-linkage Clustering



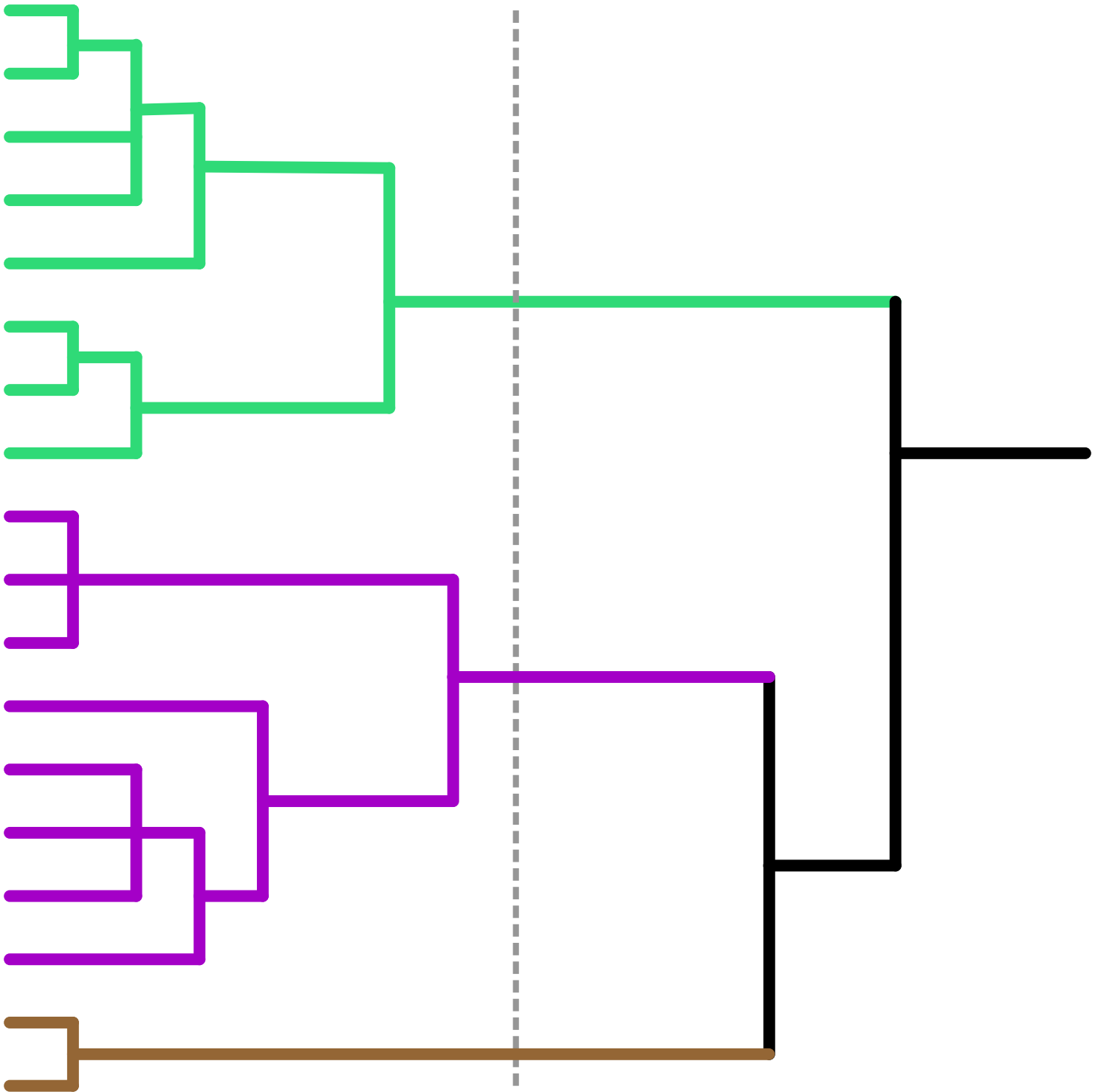
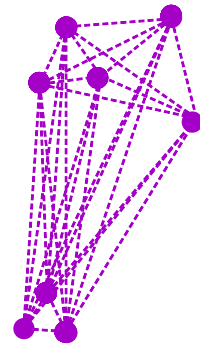
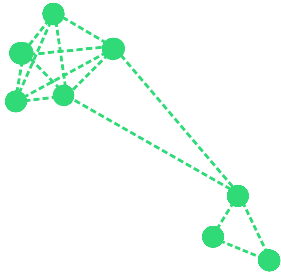
Single-linkage Clustering



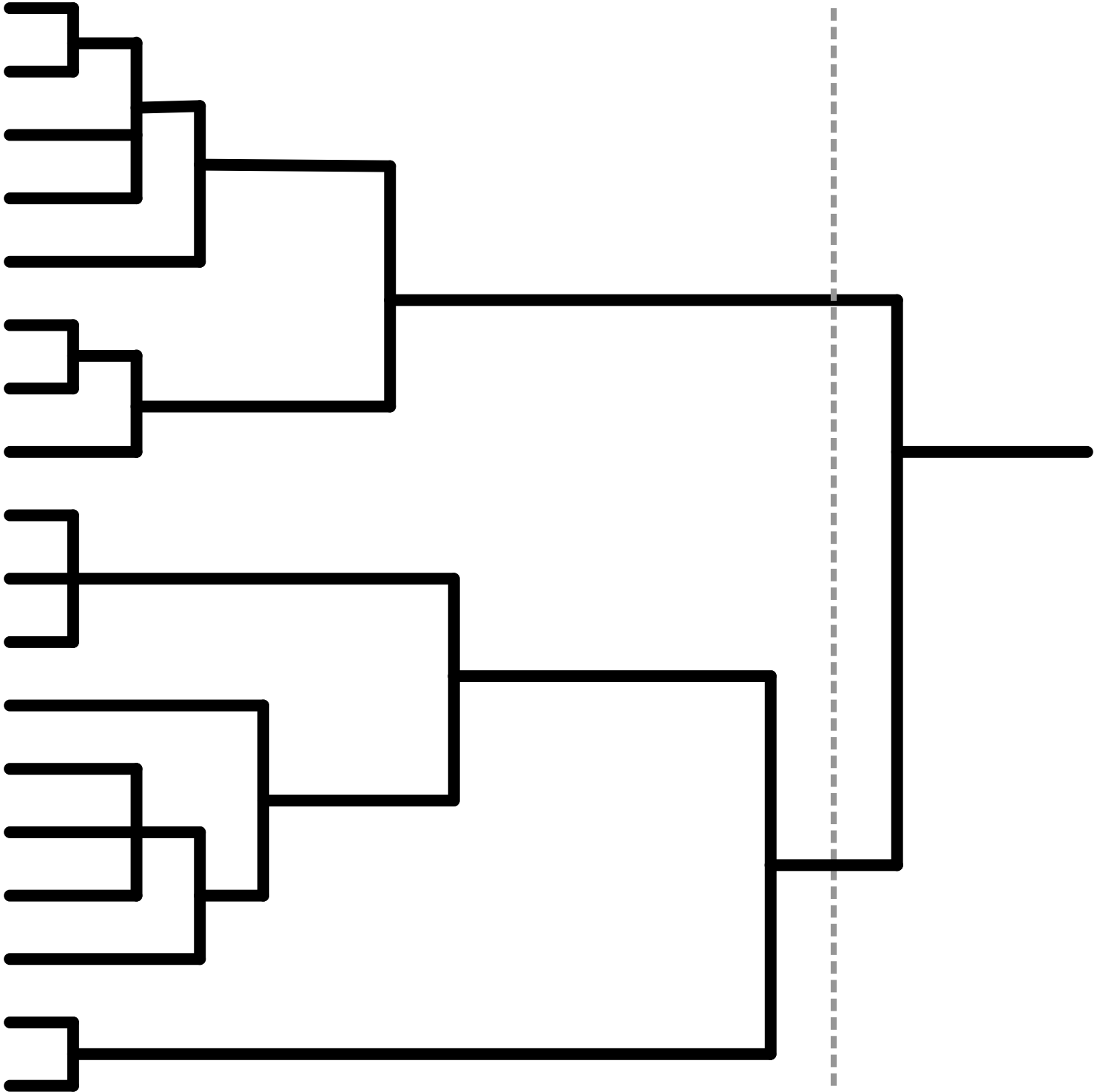
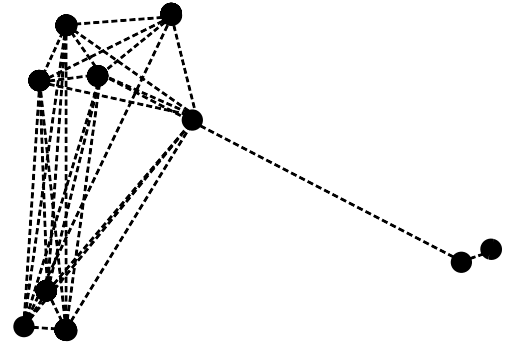
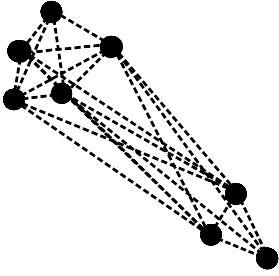
Single-linkage Clustering



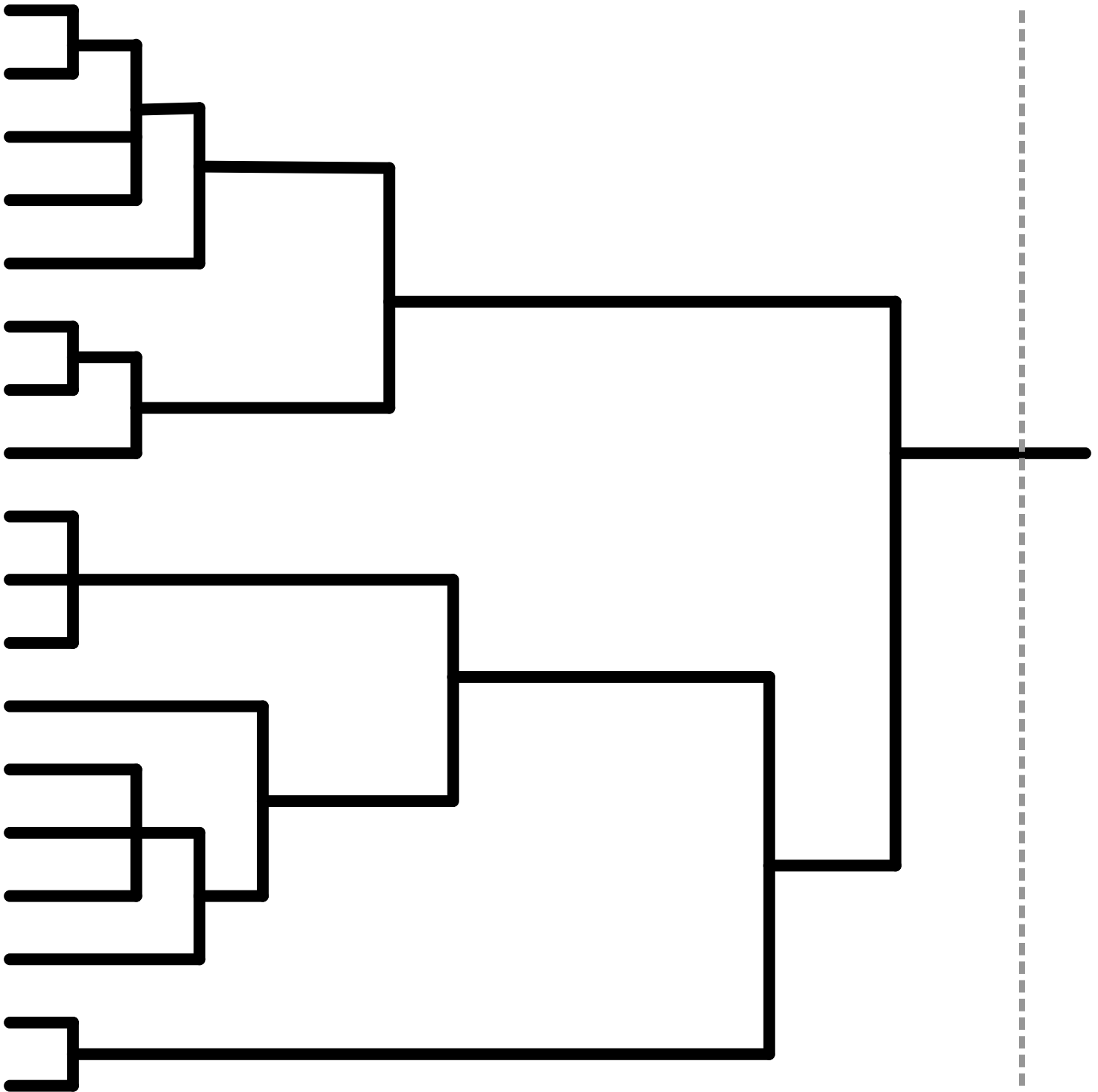
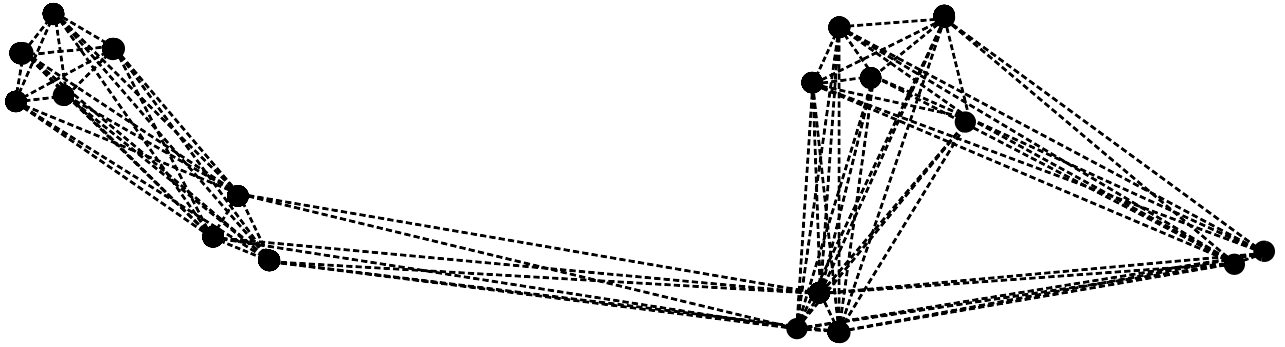
Single-linkage Clustering



Single-linkage Clustering

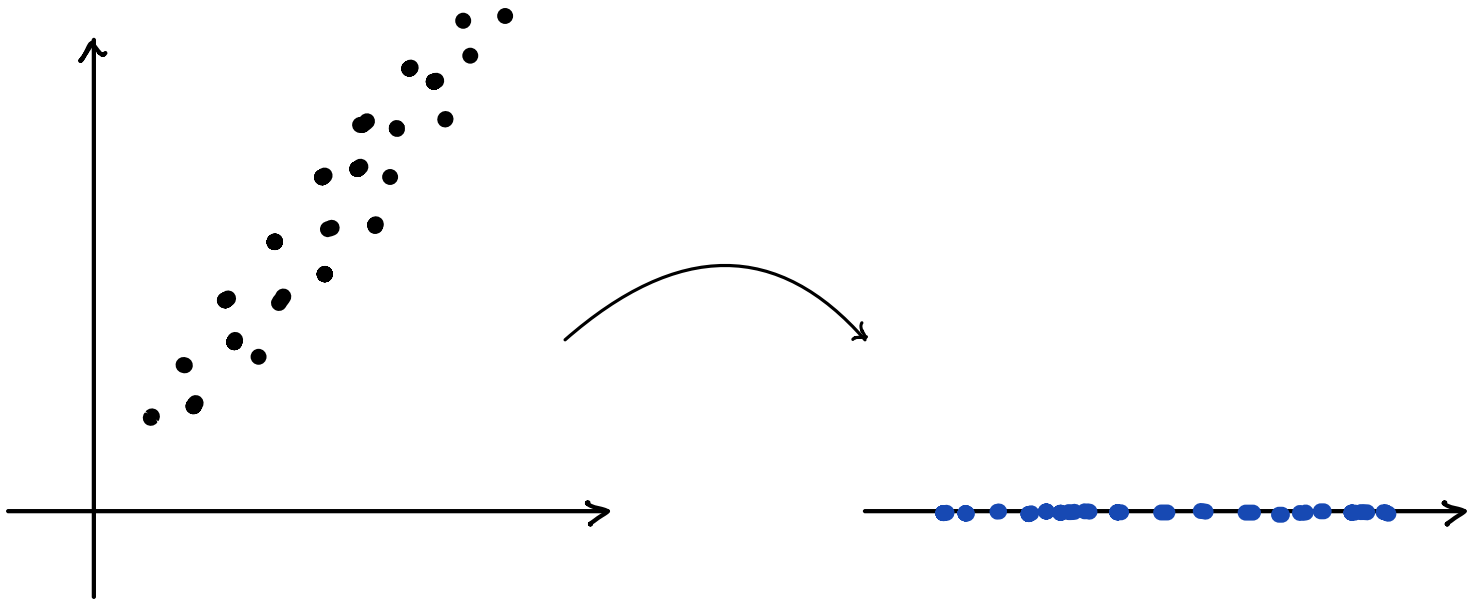


Single-linkage Clustering

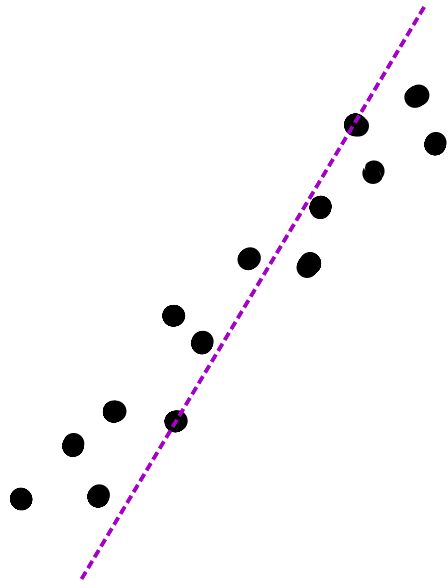


Dimensionality Reduction

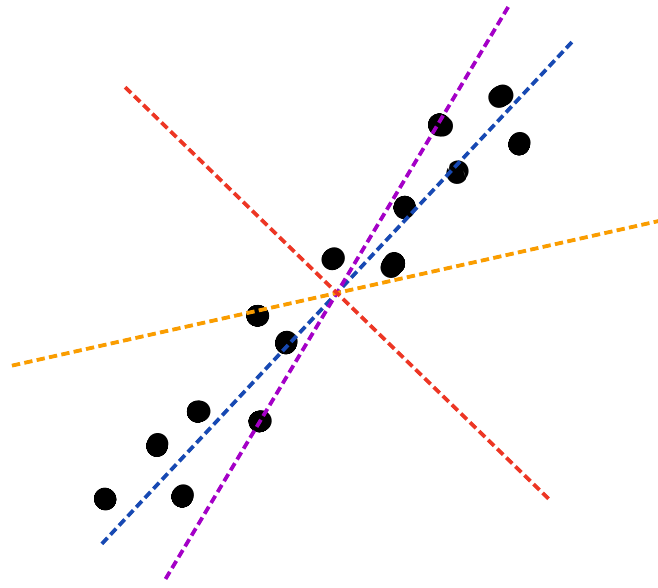
Dimensionality Reduction



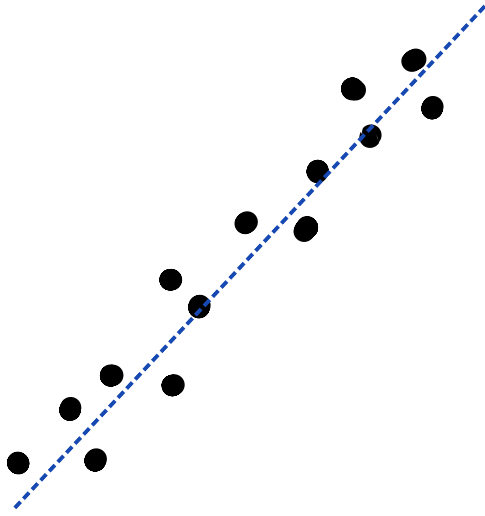
Principal Component Analysis



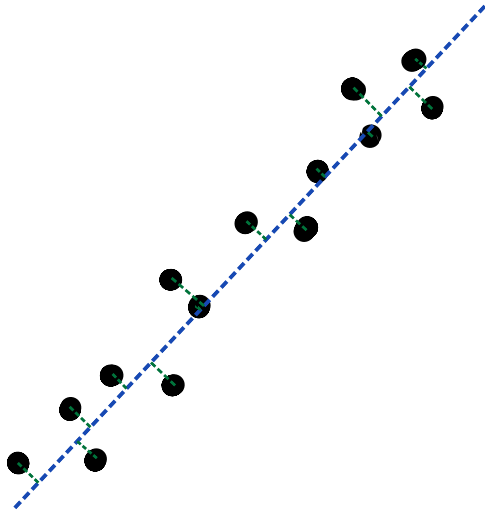
Principal Component Analysis



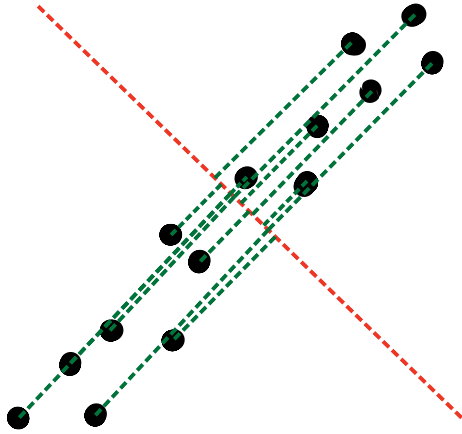
Principal Component Analysis



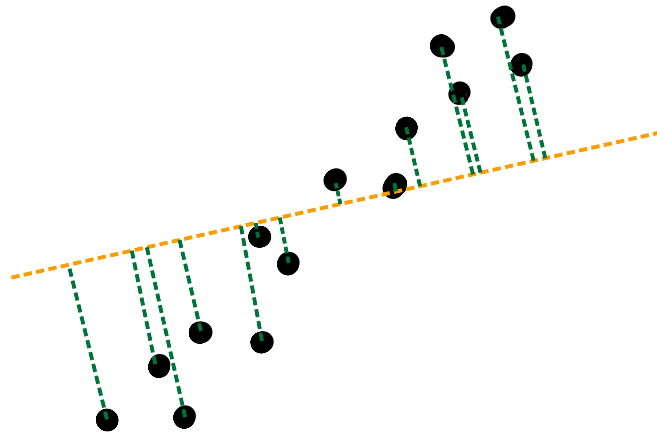
Principal Component Analysis



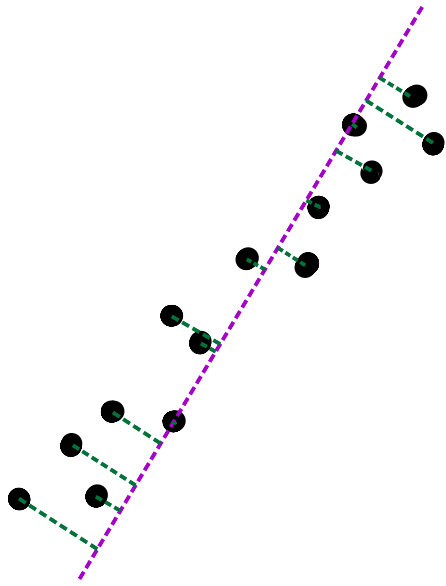
Principal Component Analysis



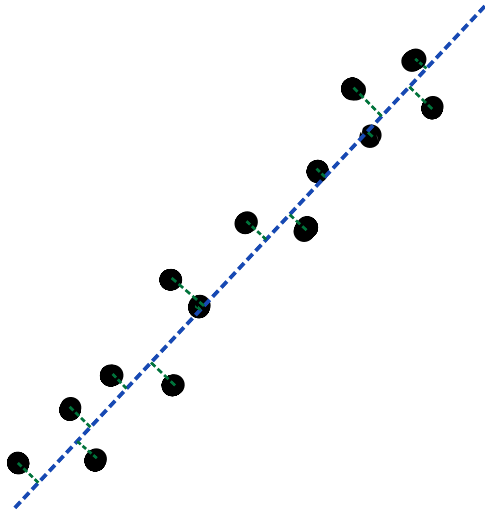
Principal Component Analysis



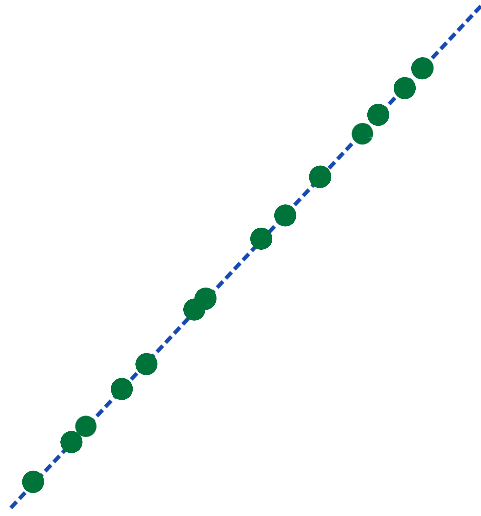
Principal Component Analysis



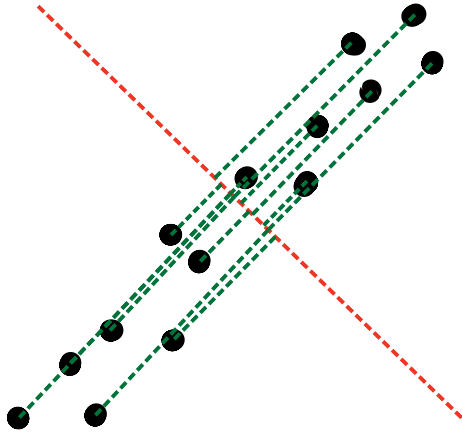
Principal Component Analysis



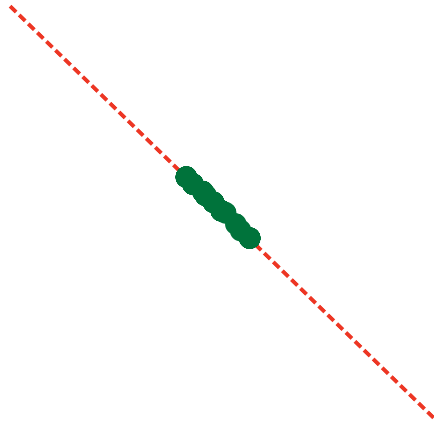
Principal Component Analysis



Principal Component Analysis



Principal Component Analysis



Faces Images Dataset

Actual Image

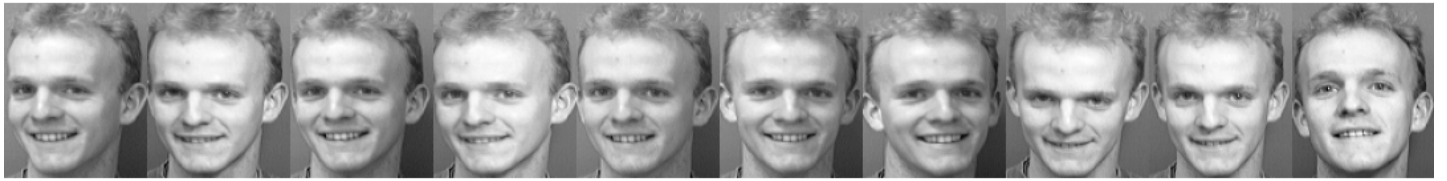


PCA Reconstructed Image



Faces Images Dataset

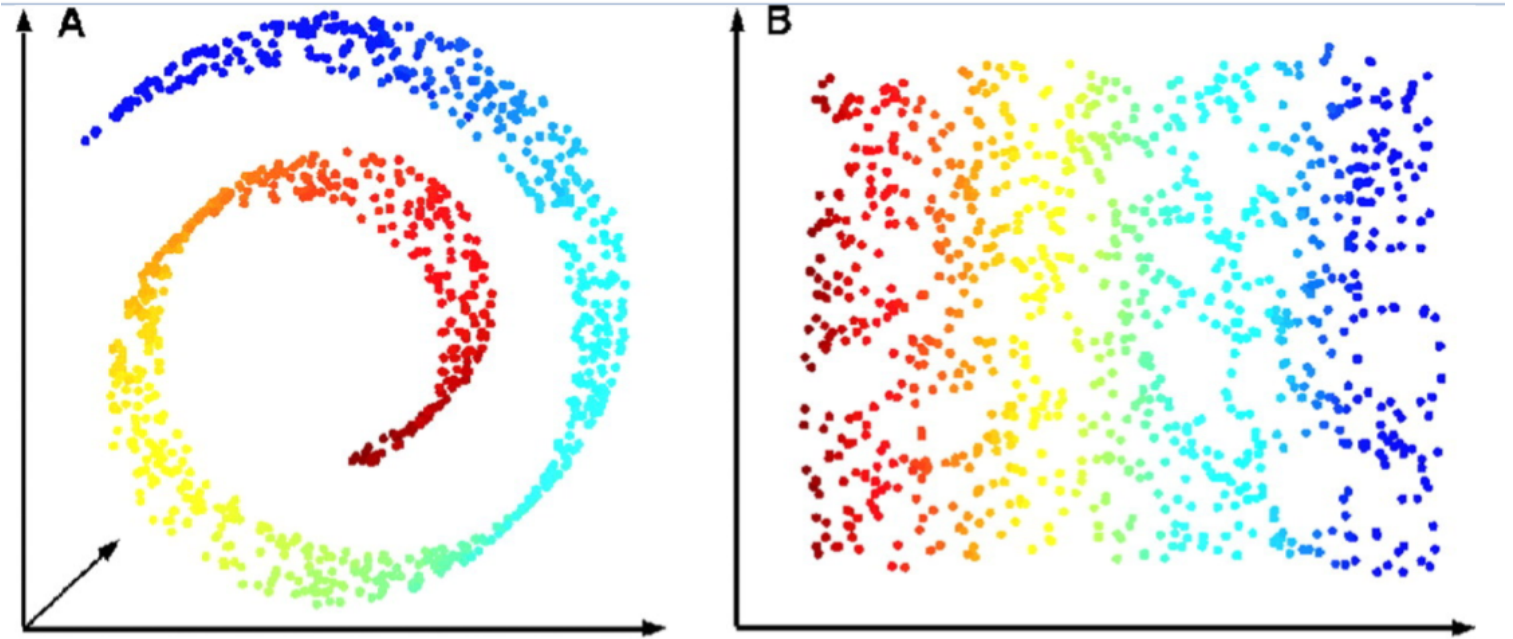
$112 \times 92 = 10304$ dimensions



Reconstructed from 111 dimensions.

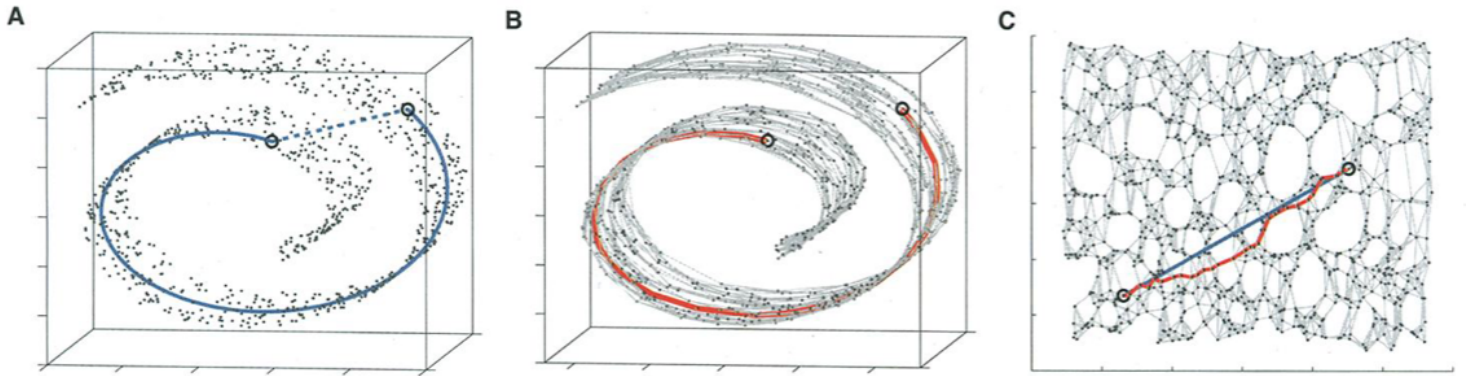


Isomap



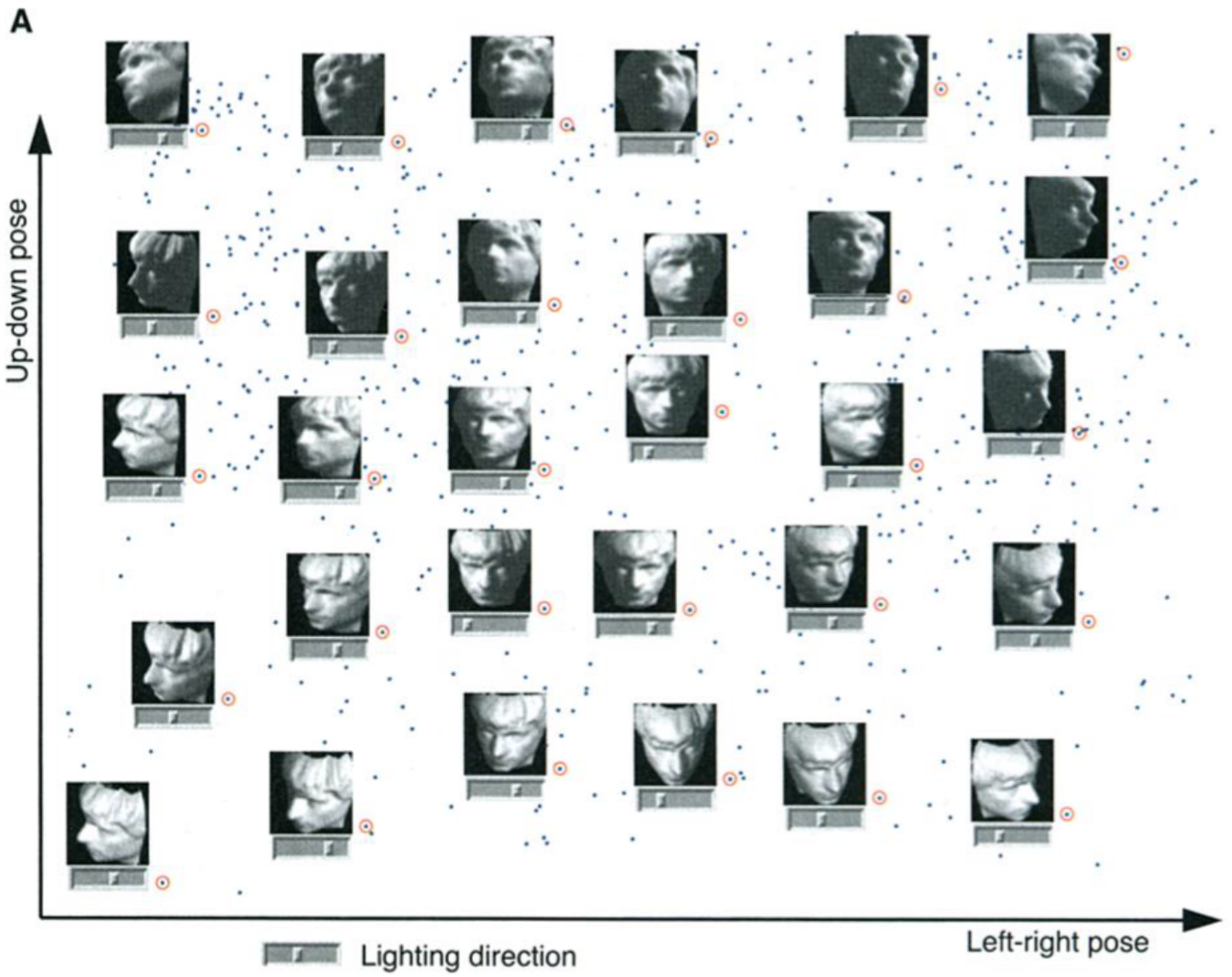
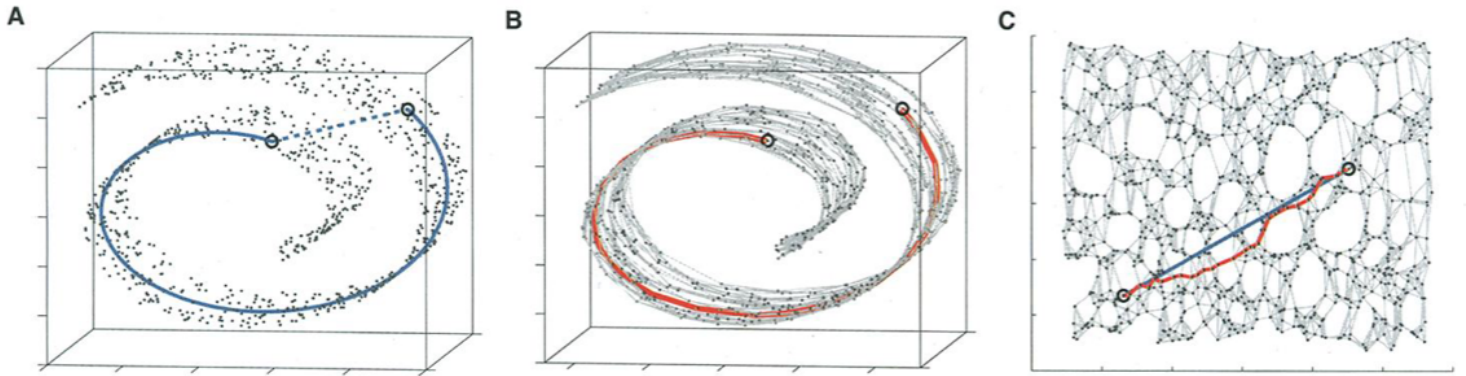
Images by Tenenbaum, de Silva, Langford

Isomap



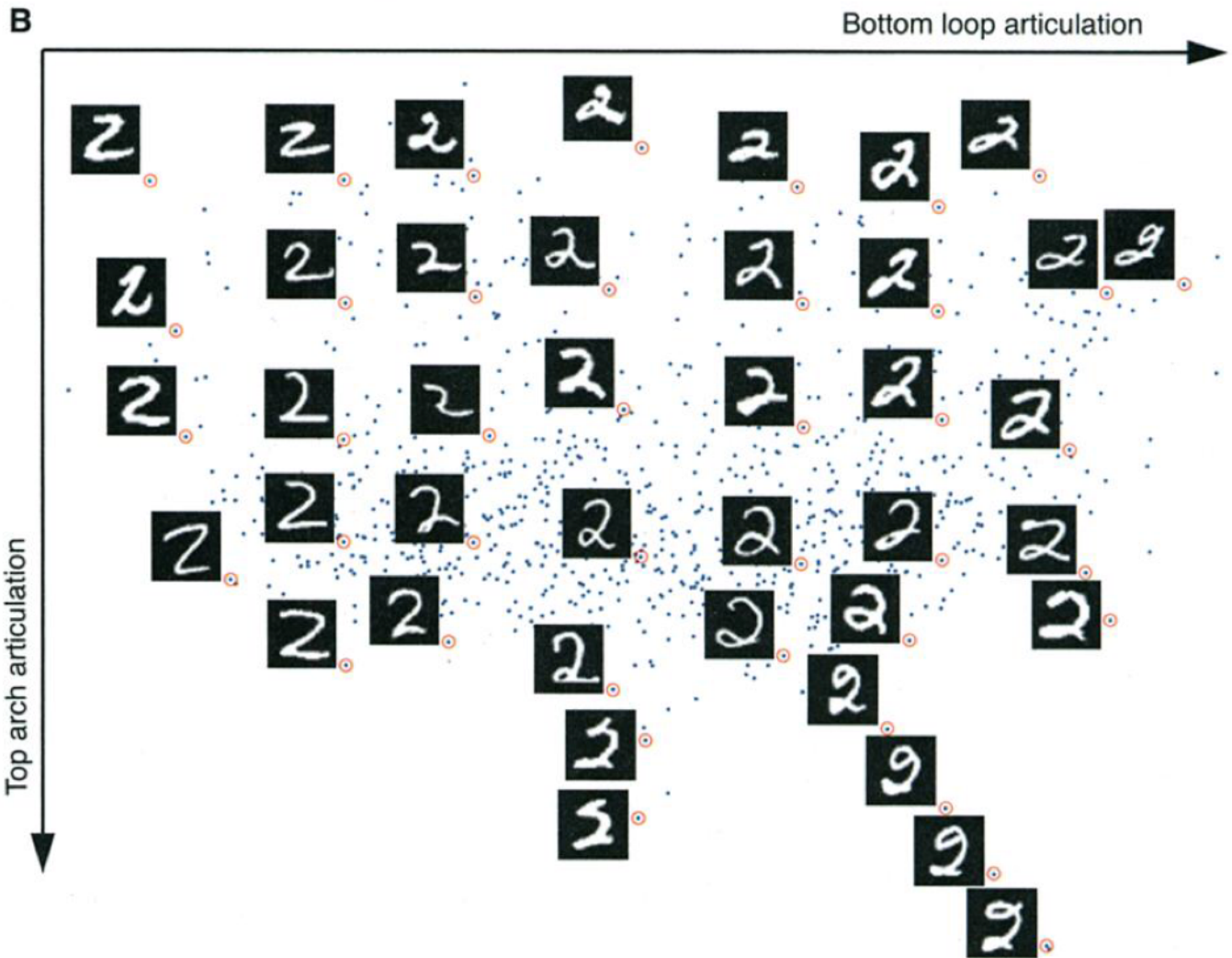
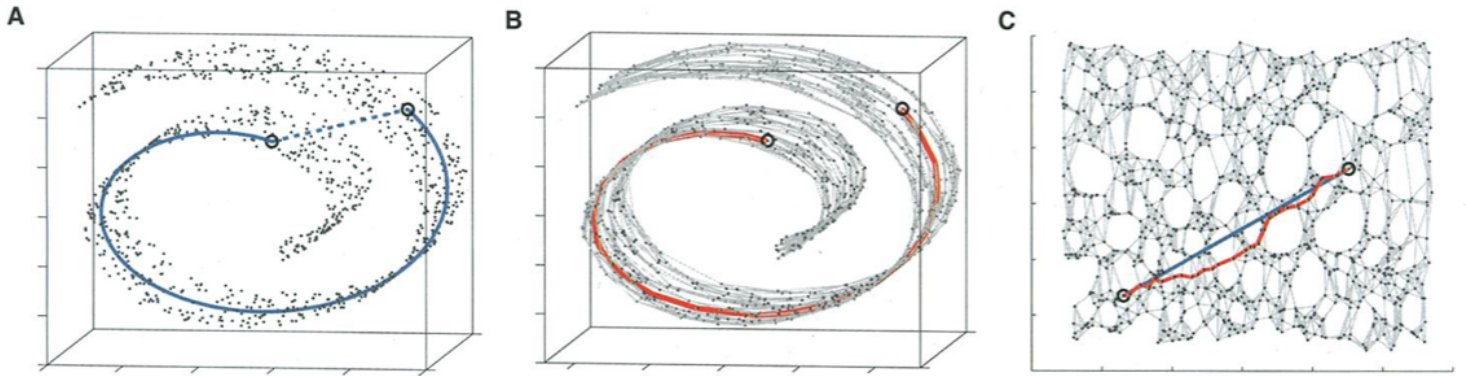
Images by Tenenbaum, de Silva, Langford

Isomap



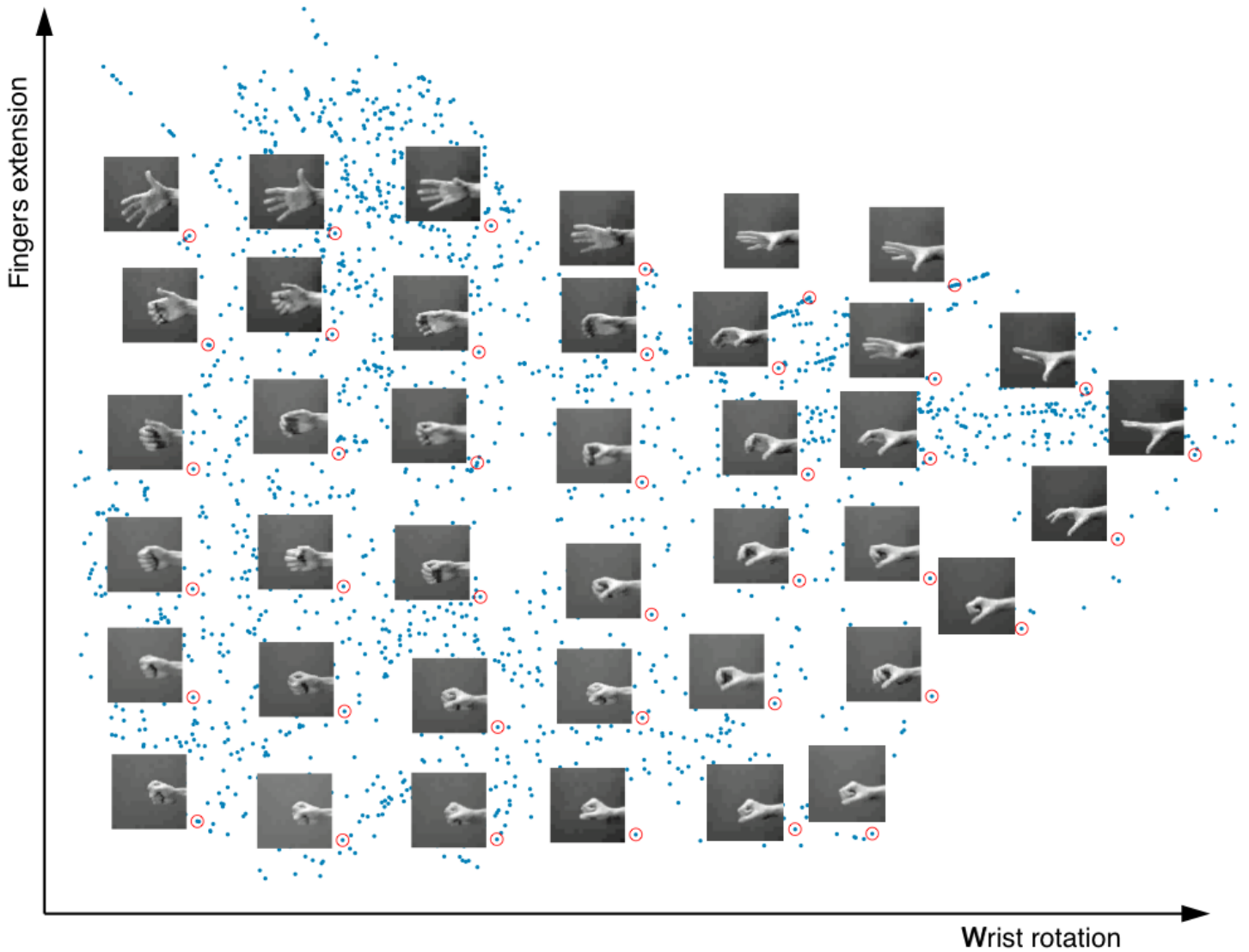
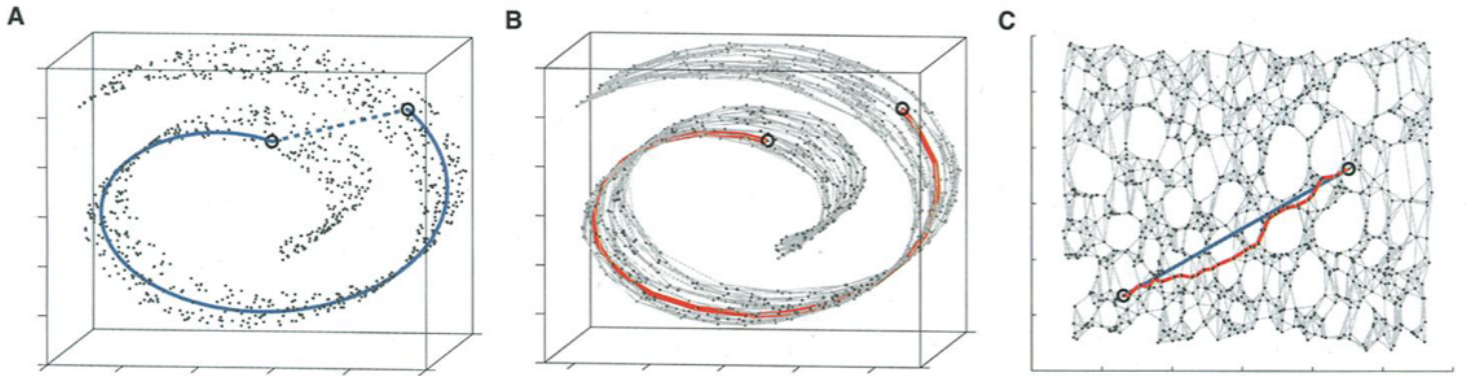
Images by Tenenbaum, de Silva, Langford

Isomap



Images by Tenenbaum, de Silva, Langford

Isomap



Images by Tenenbaum, de Silva, Langford

Topic Modeling

Topic Modeling

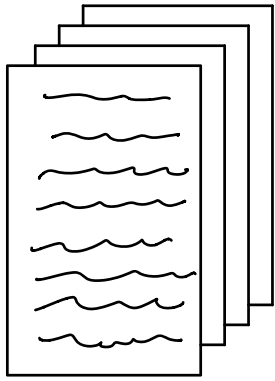
say does believe
like don people just
know god think

launch nasa moon sci
station shuttle orbit earth
space program

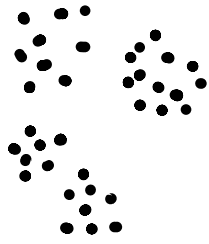
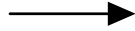
interested sale
drive 00 shipping condition
asking price new offer

team runs
game pitching
year games
hit baseball

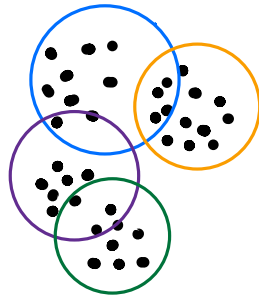
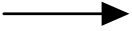
Topic Modeling



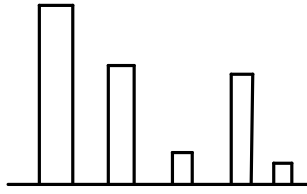
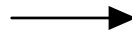
Collection of documents



Word - frequency representation

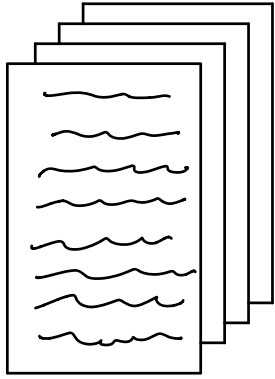


Topic modeling

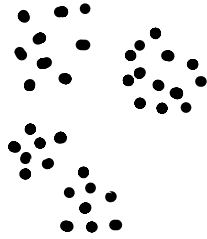
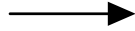


Topic keywords

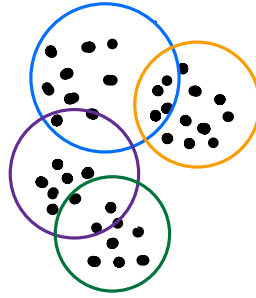
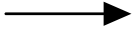
Topic Modeling



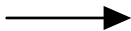
Collection of documents



Word-frequency representation



Topic modeling



Topic keywords (word clouds!)

Faces Images Dataset

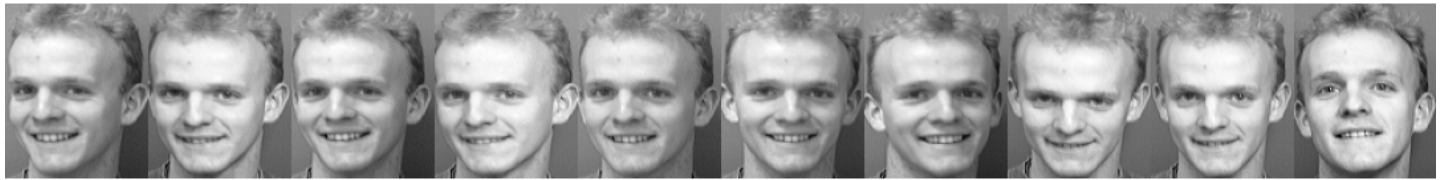
Actual Image

NMF Reconstructed Image



Faces Images Dataset

$112 \times 92 = 10304$ dimensions



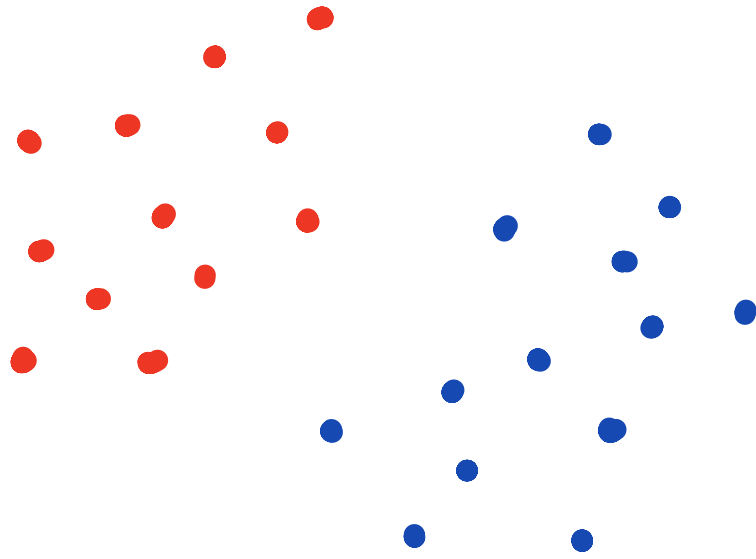
Reconstructed from 111 dimensions.



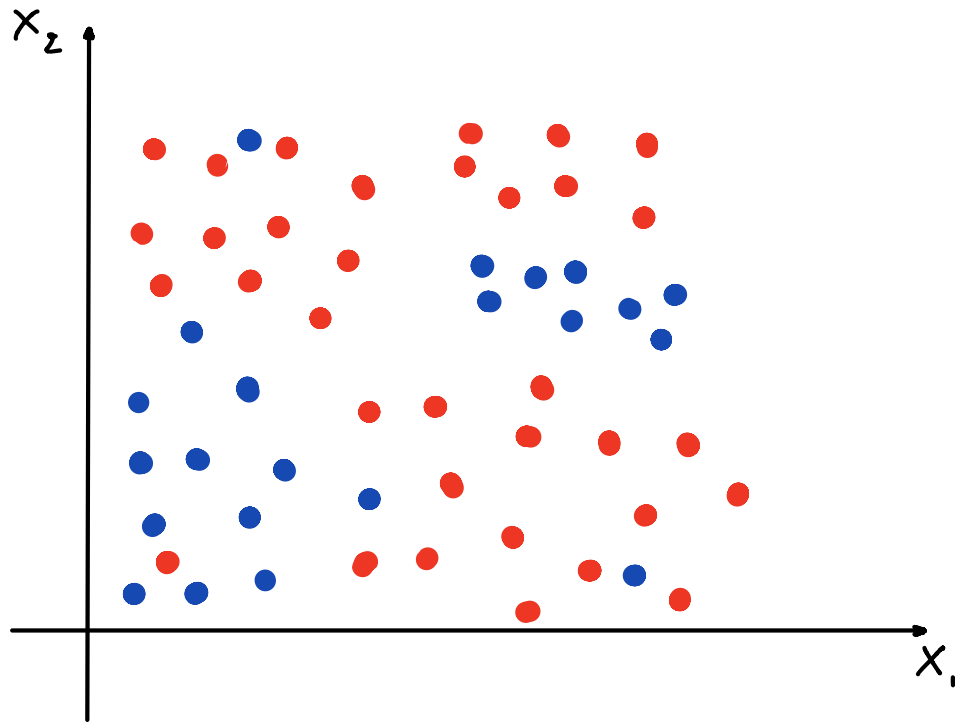
Supervised Learning

Classification

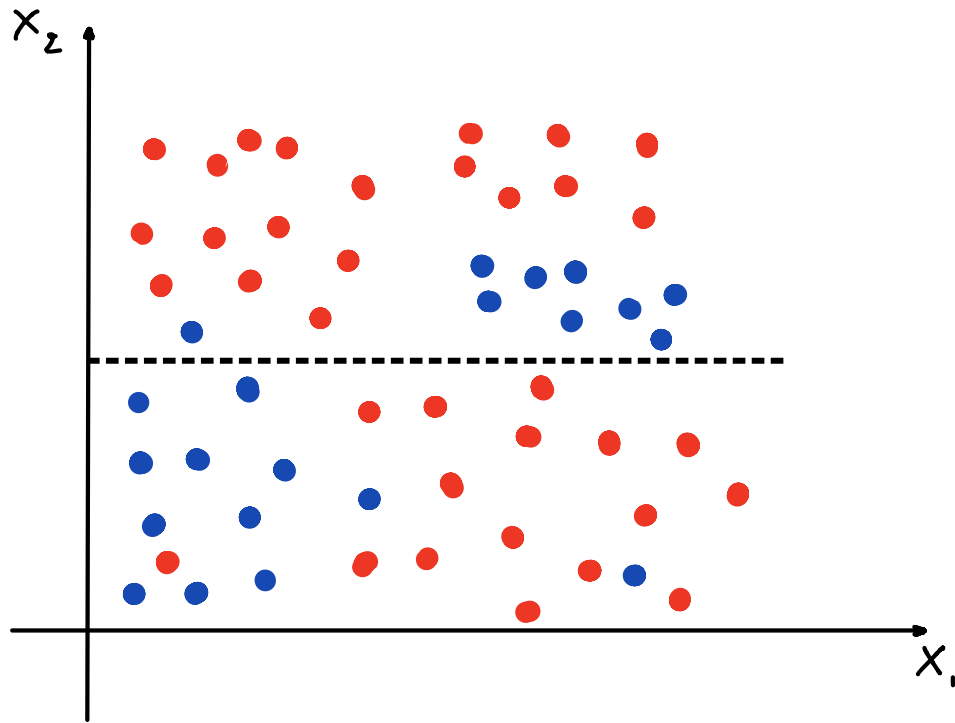
Classification



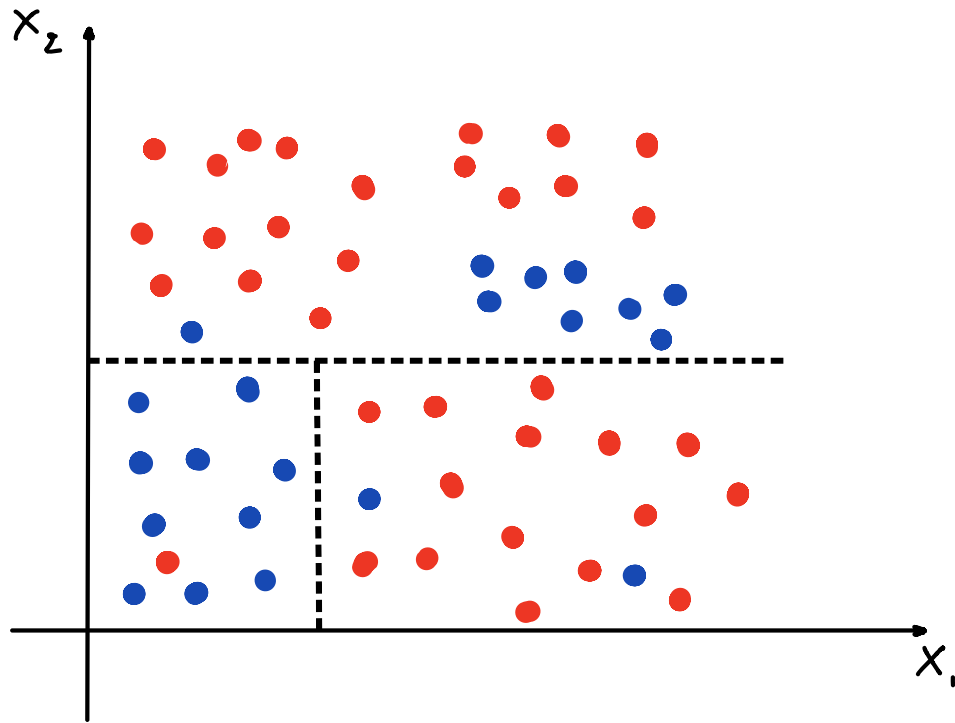
Decision Trees



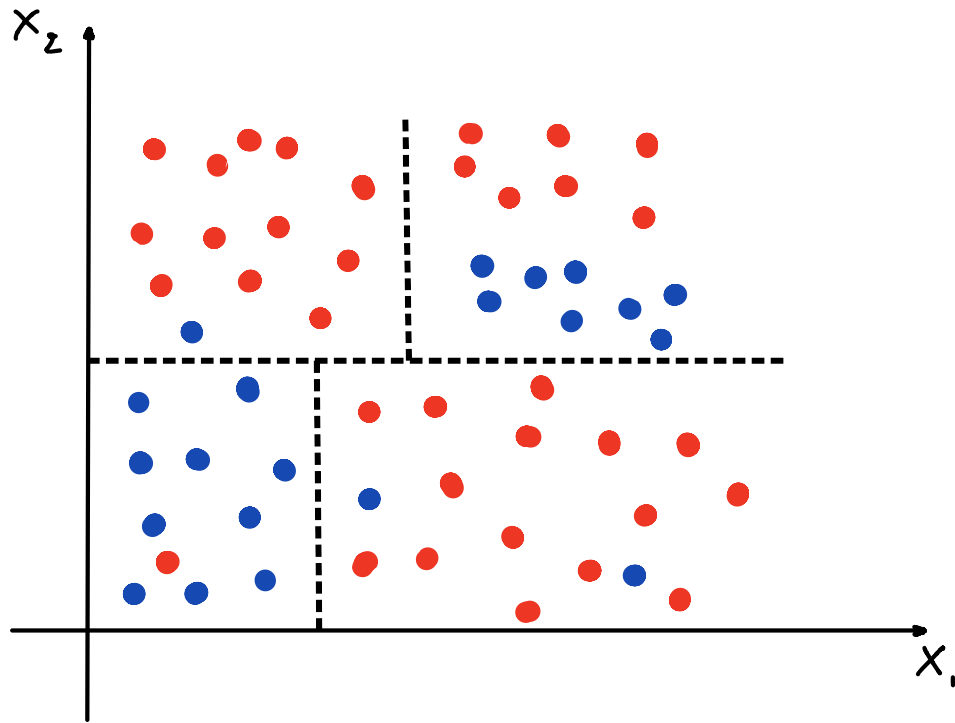
Decision Trees



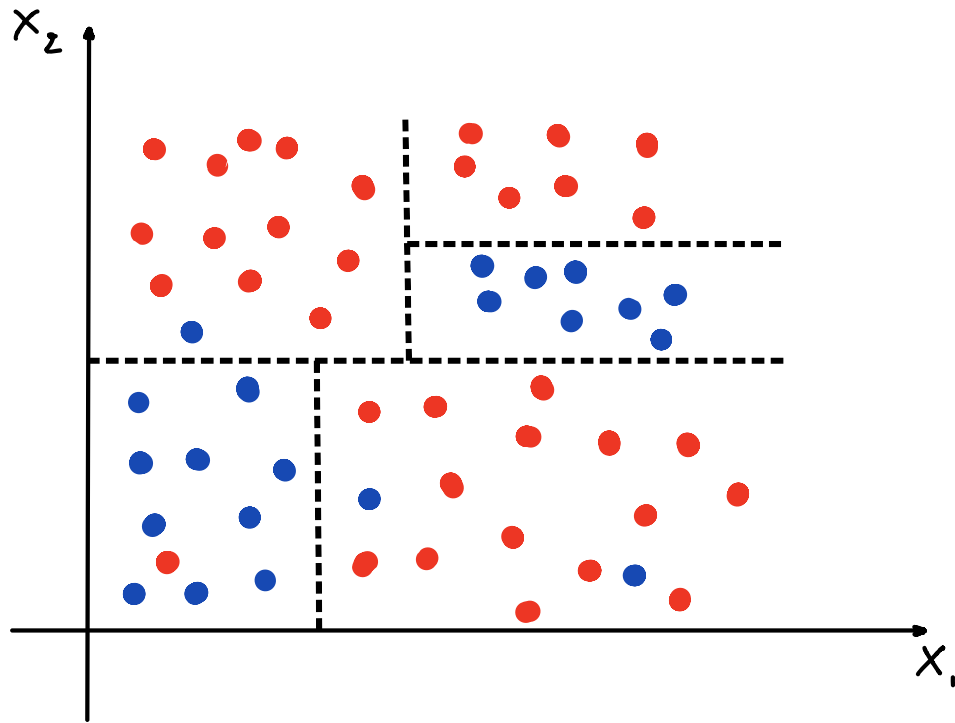
Decision Trees



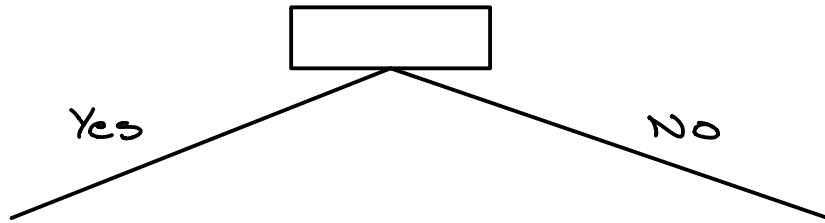
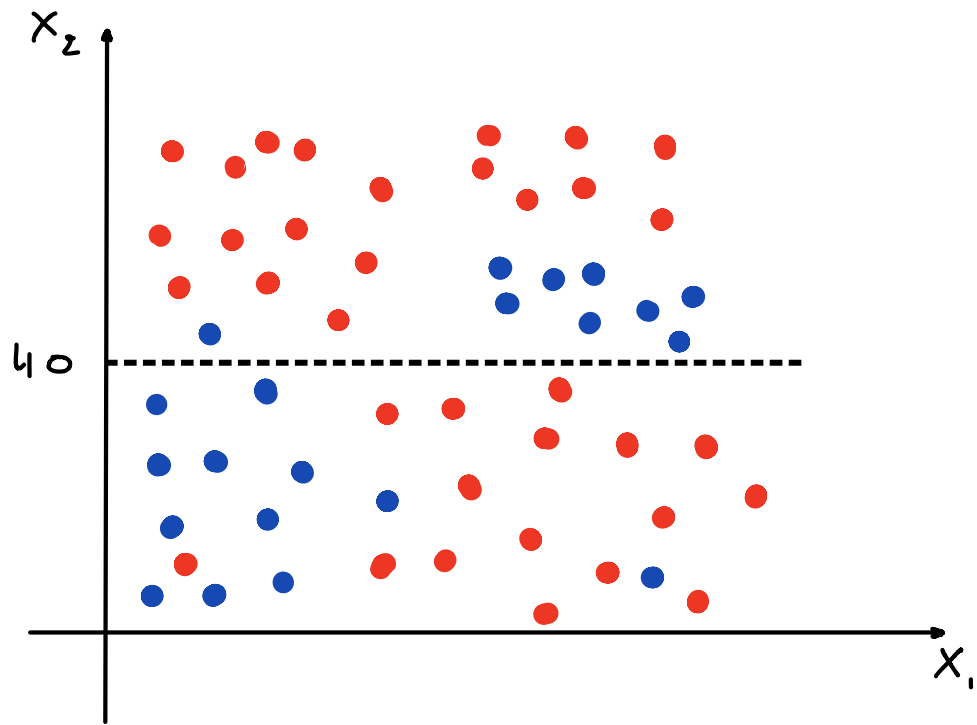
Decision Trees



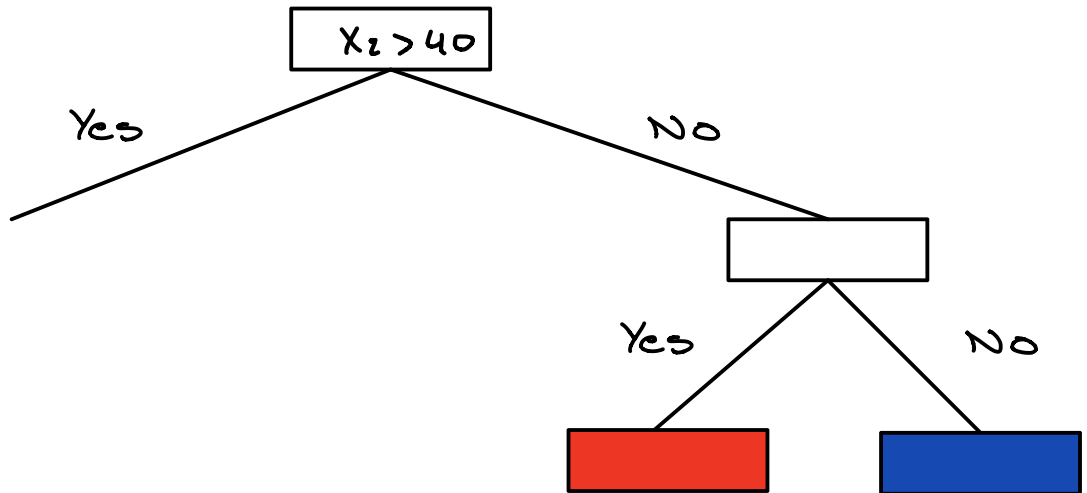
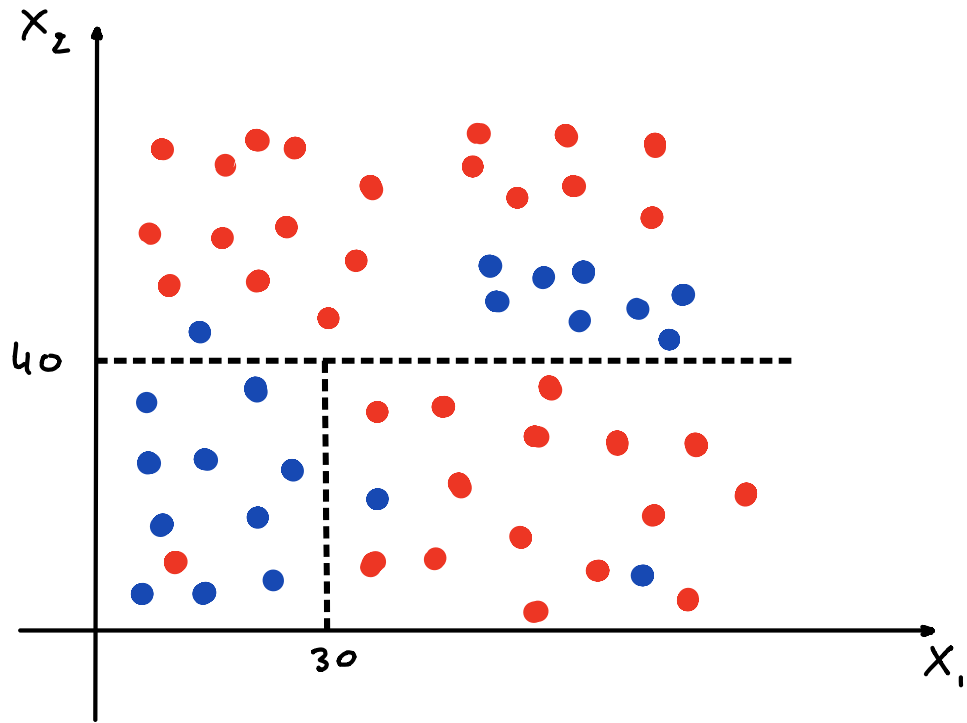
Decision Trees



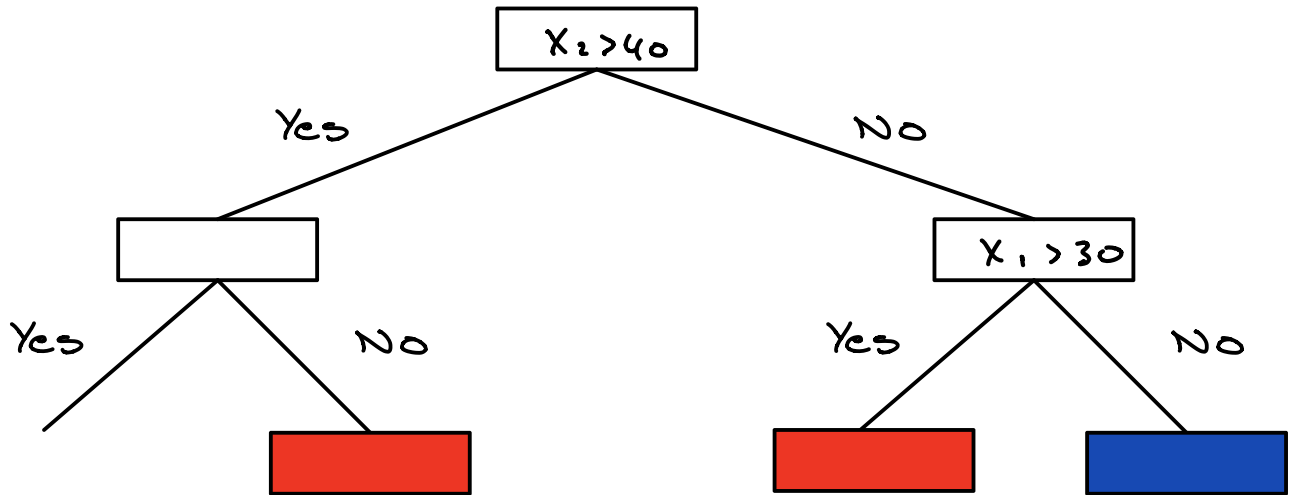
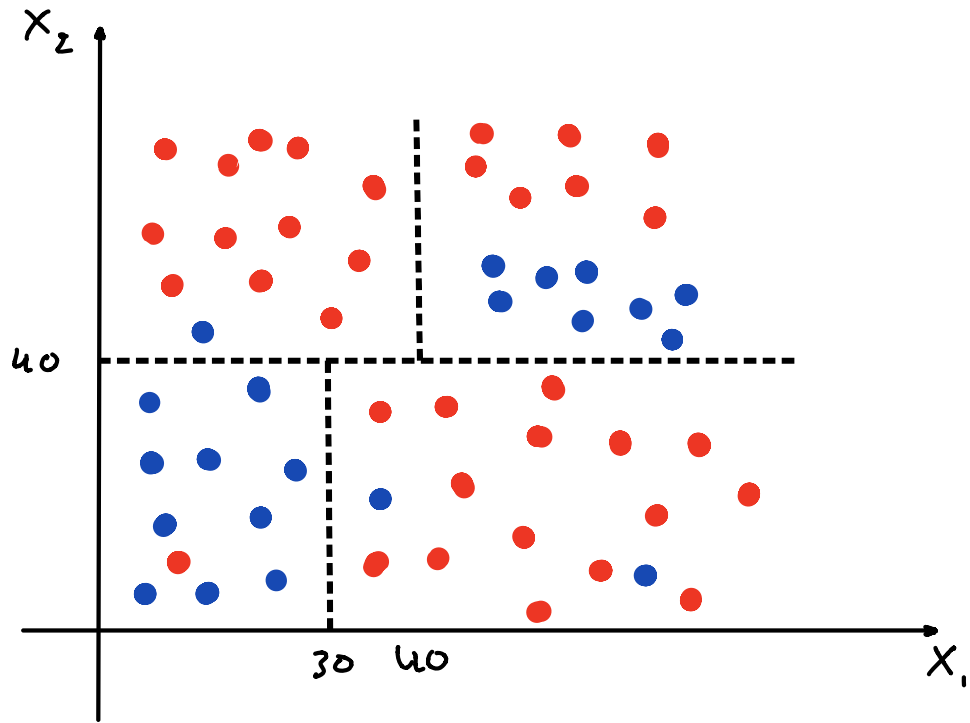
Decision Trees



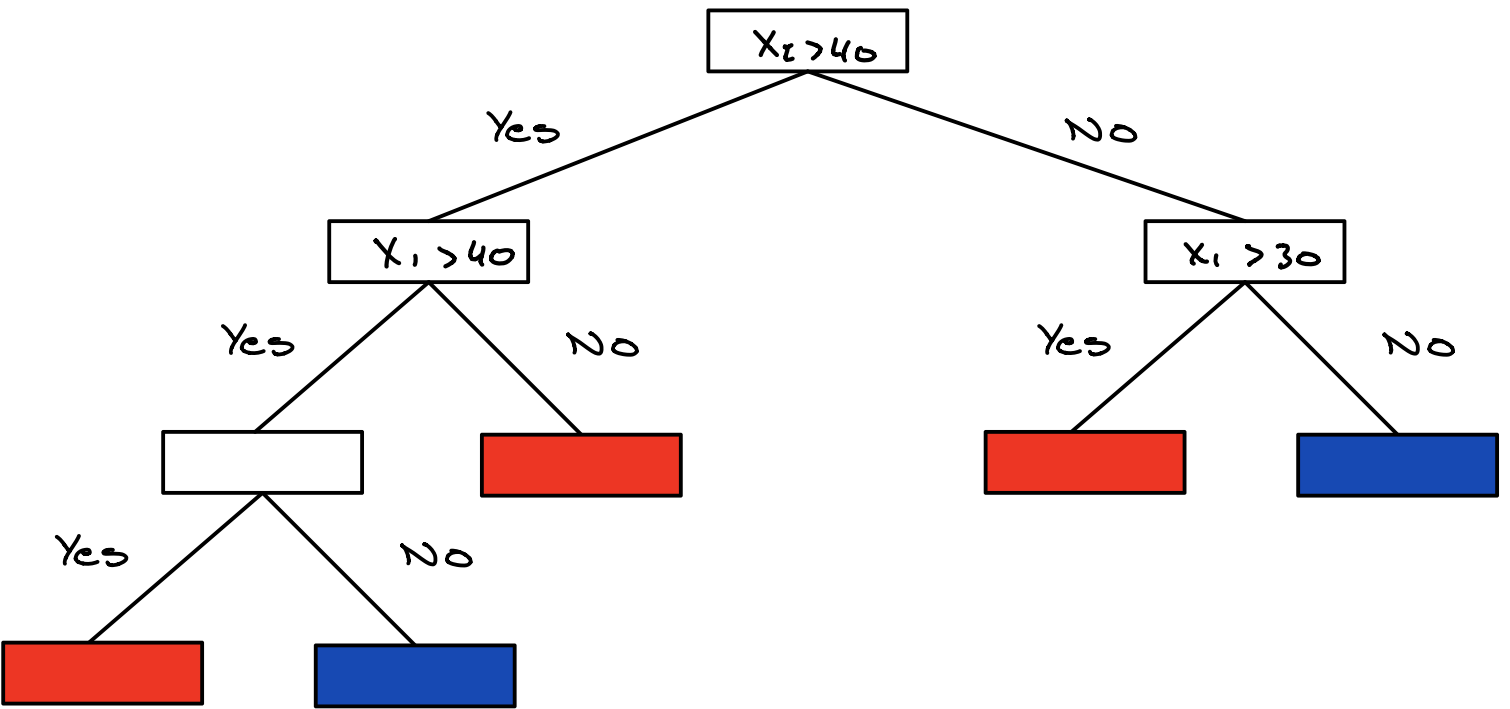
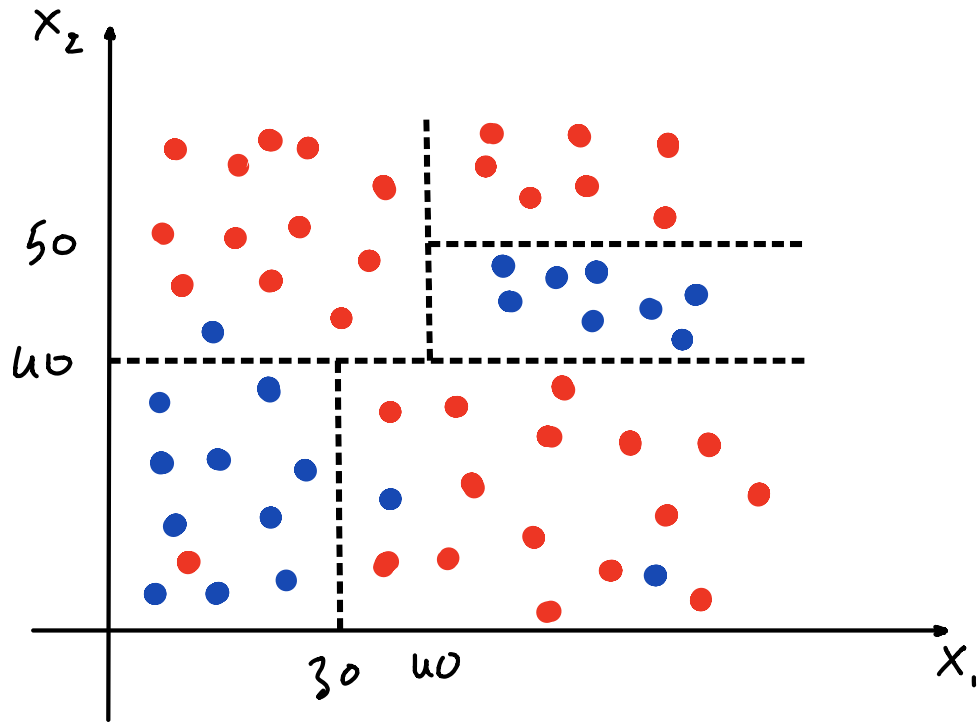
Decision Trees



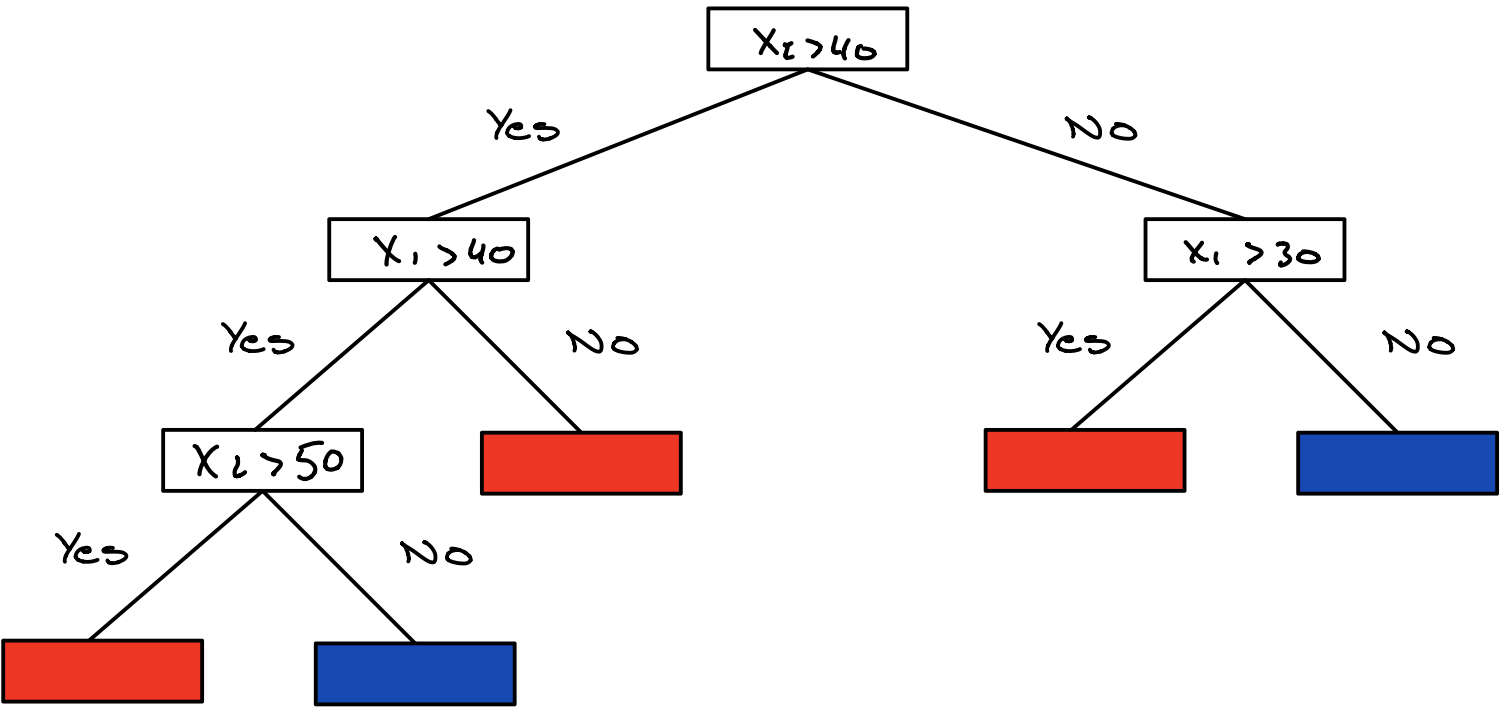
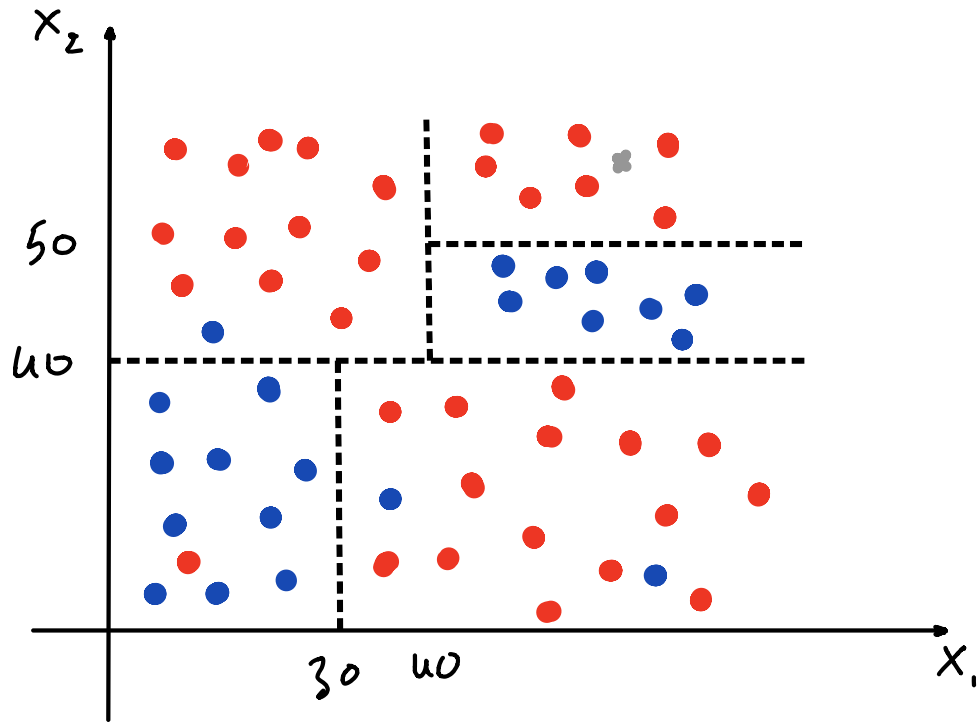
Decision Trees



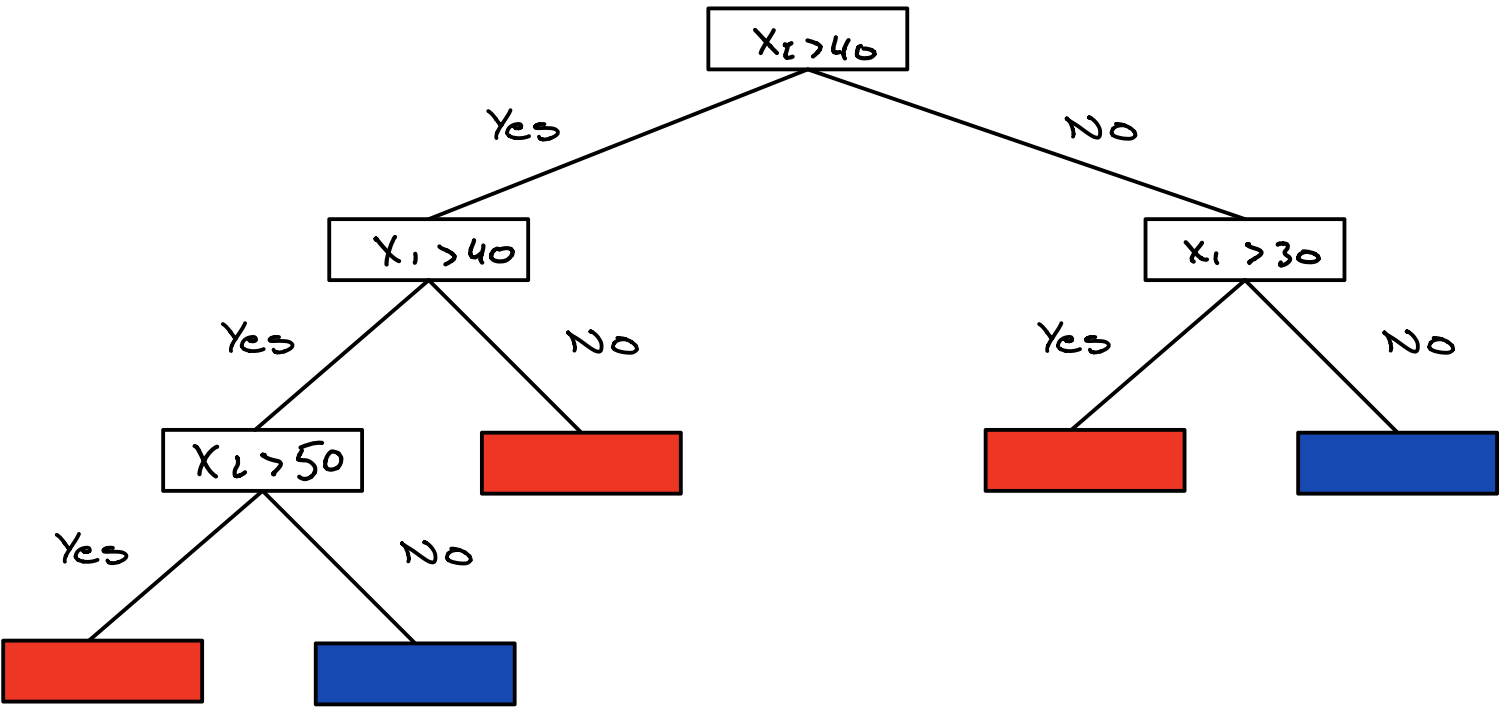
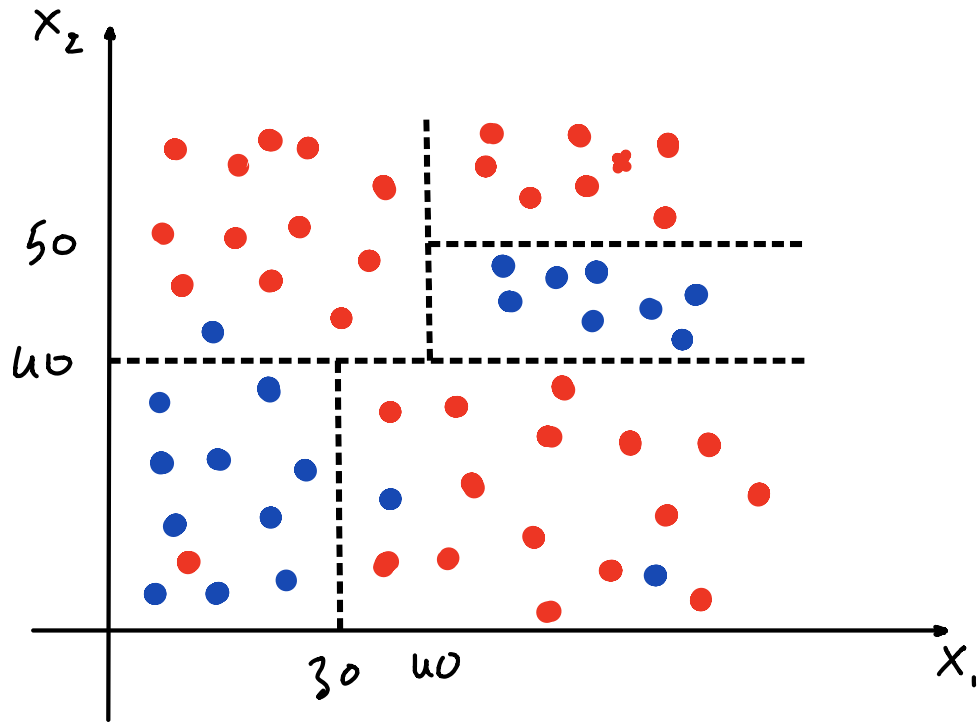
Decision Trees



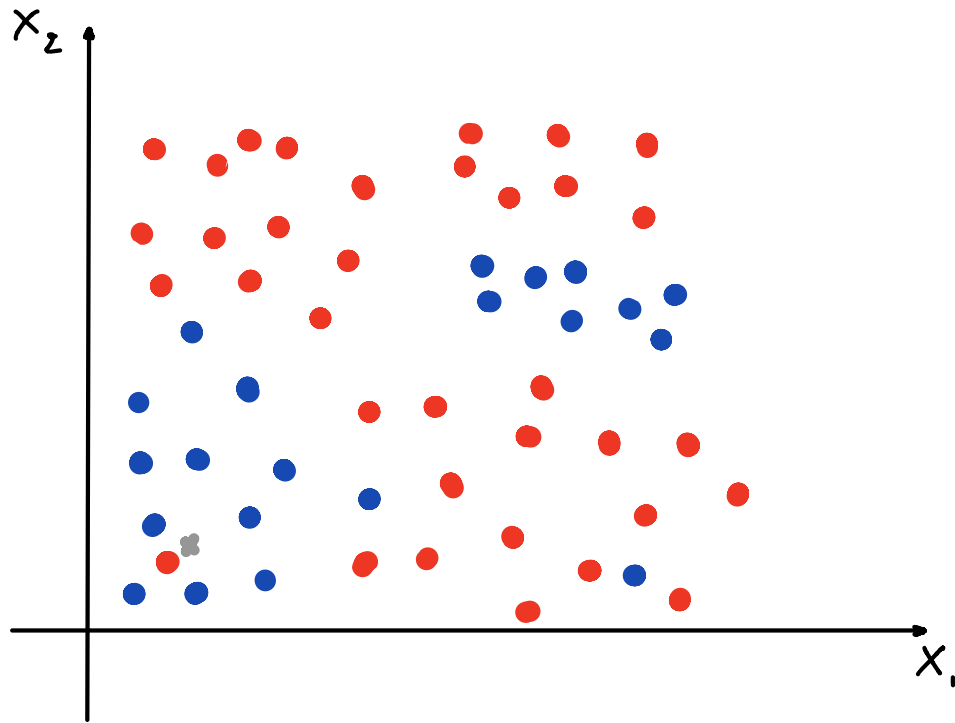
Decision Trees



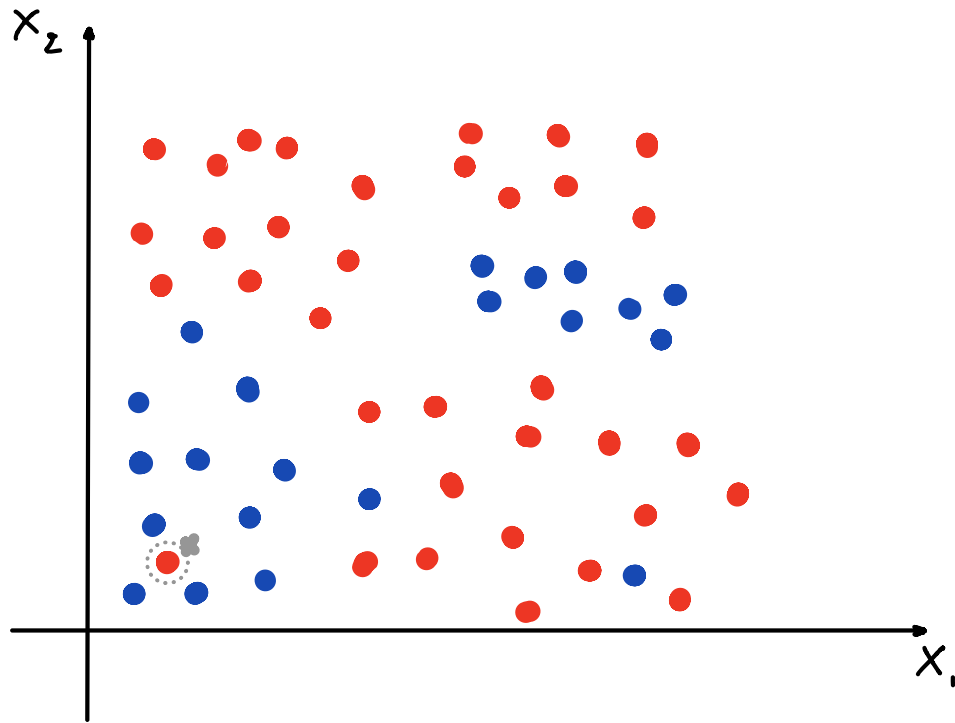
Decision Trees



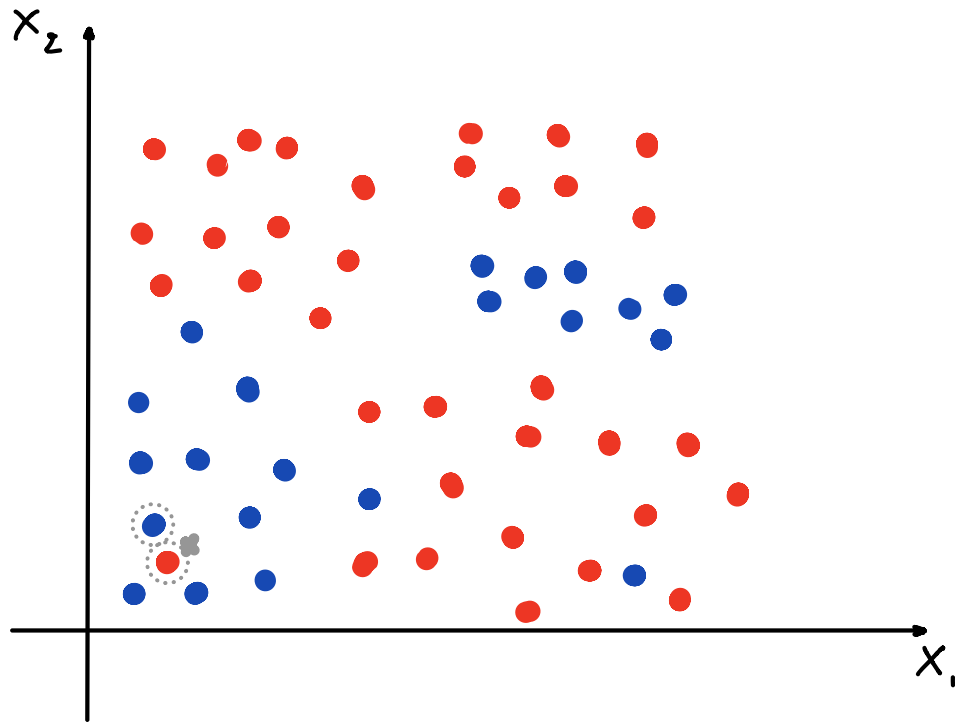
K-nearest Neighbors



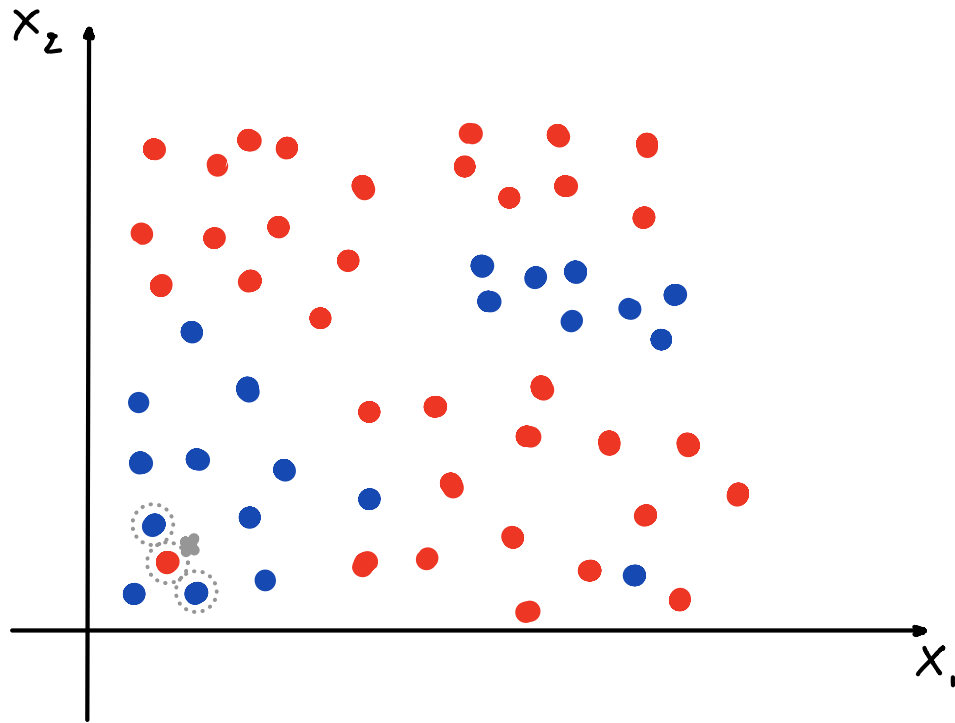
K-nearest Neighbors



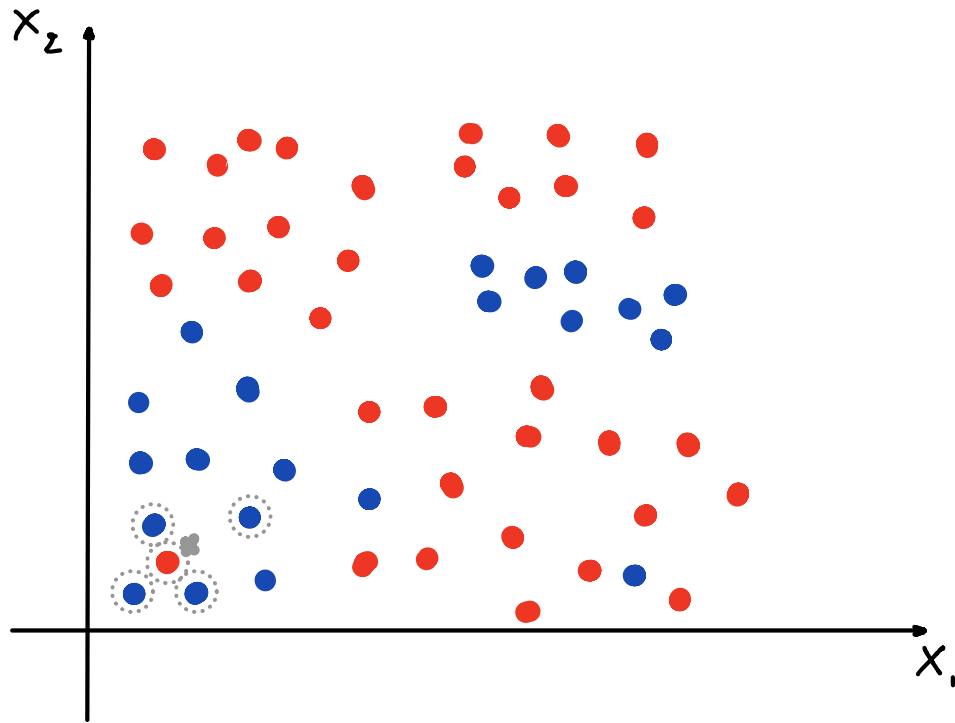
K-nearest Neighbors



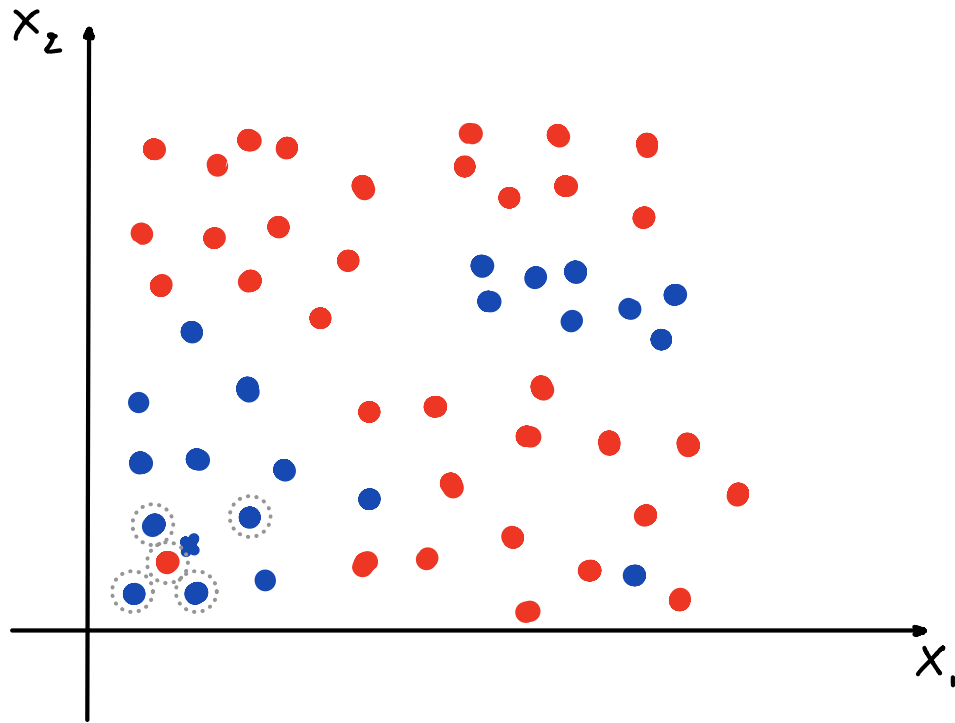
K-nearest Neighbors



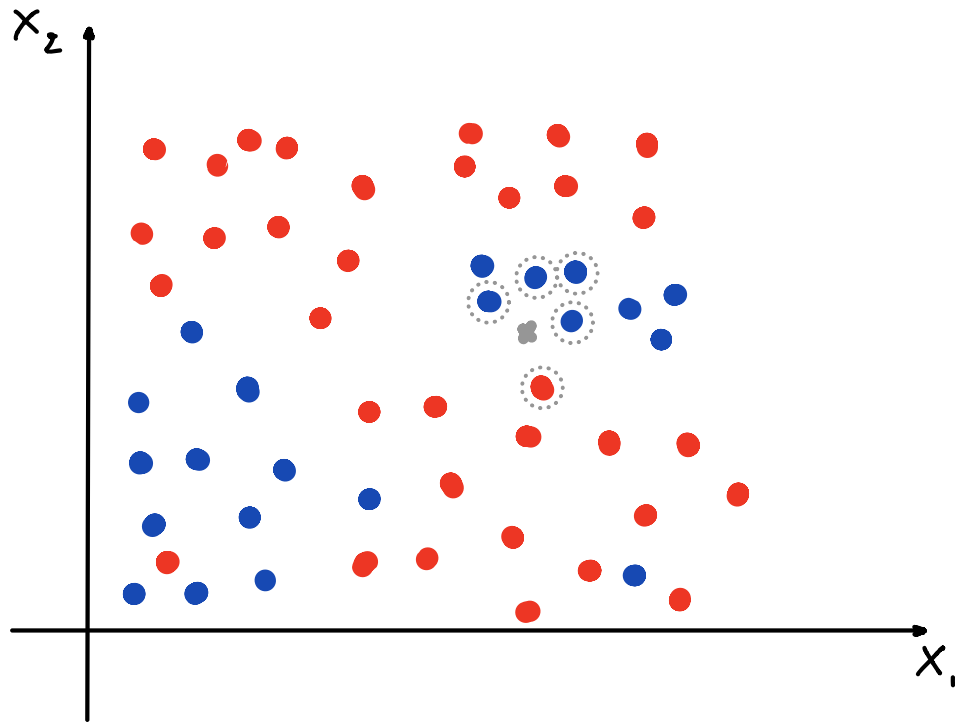
K-nearest Neighbors



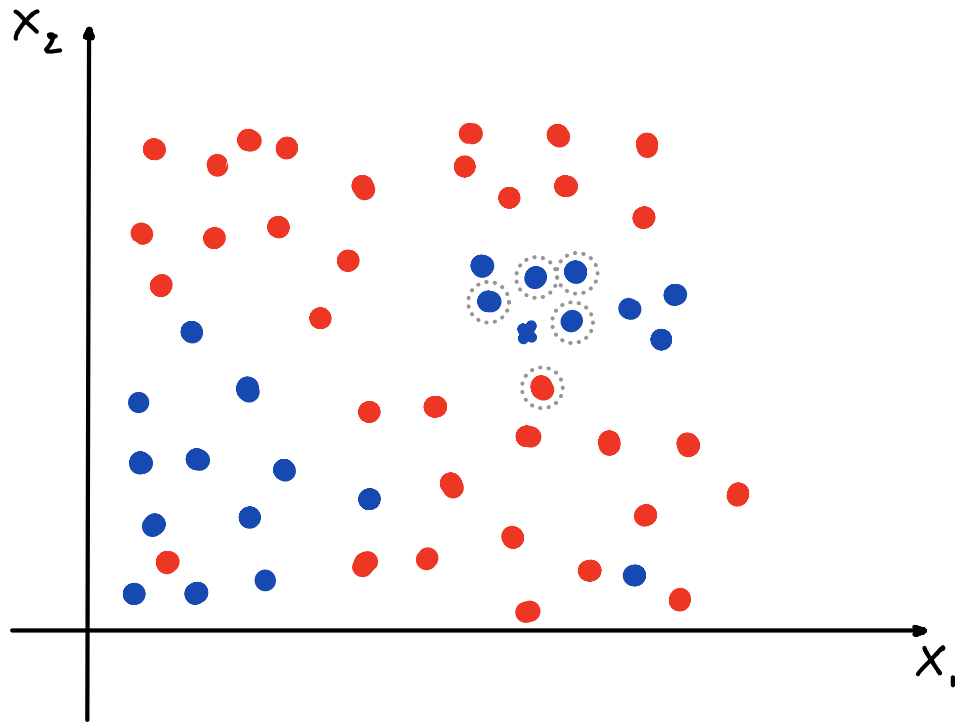
K-nearest Neighbors



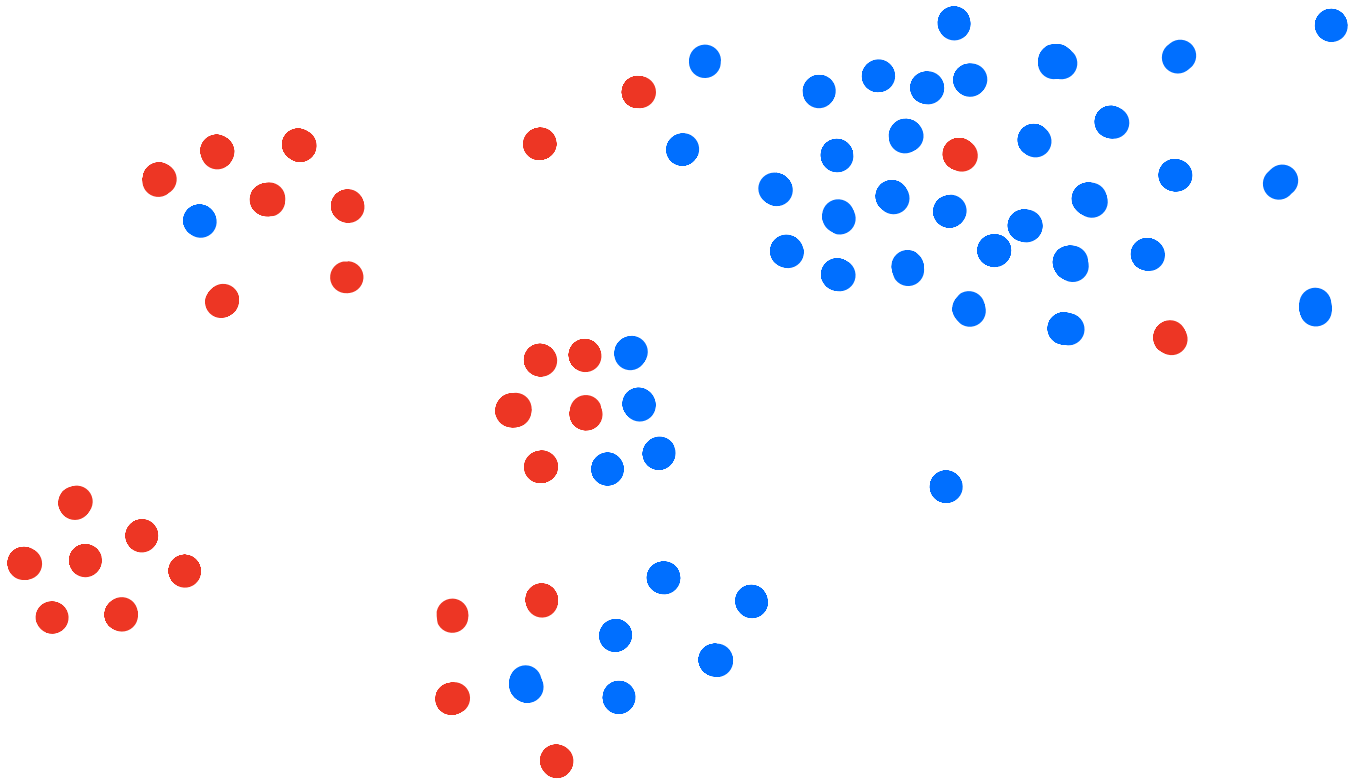
K-nearest Neighbors



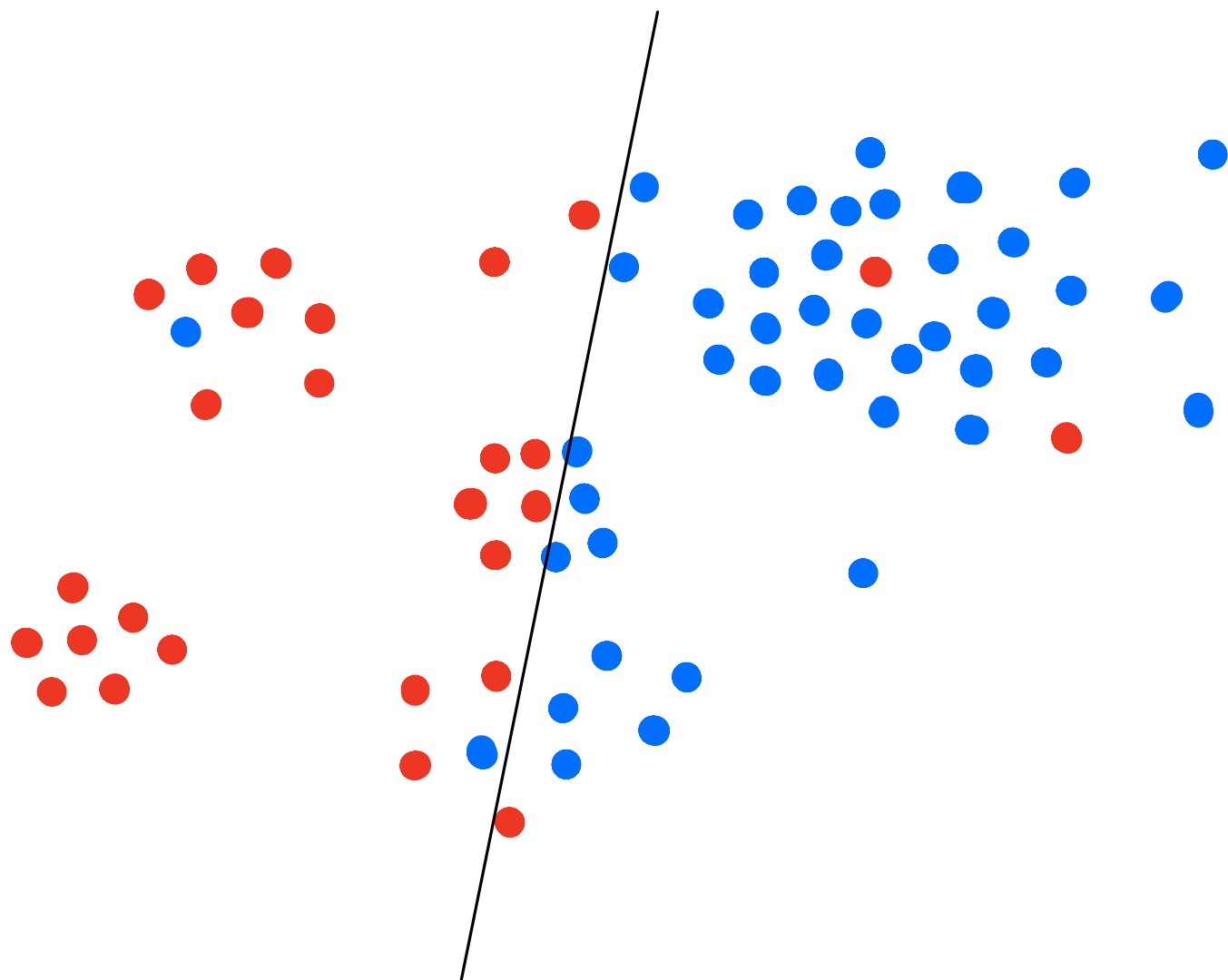
K-nearest Neighbors



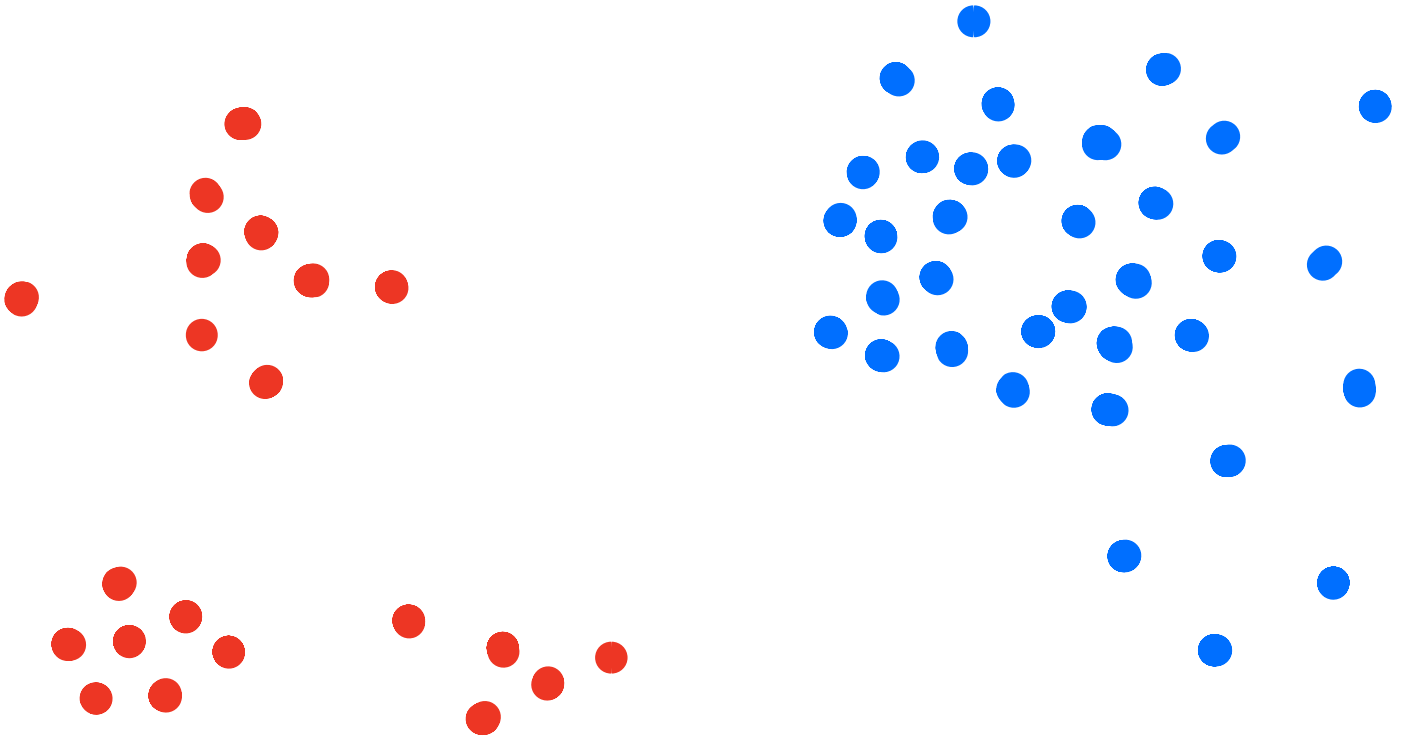
Support Vector Machines (SVM)



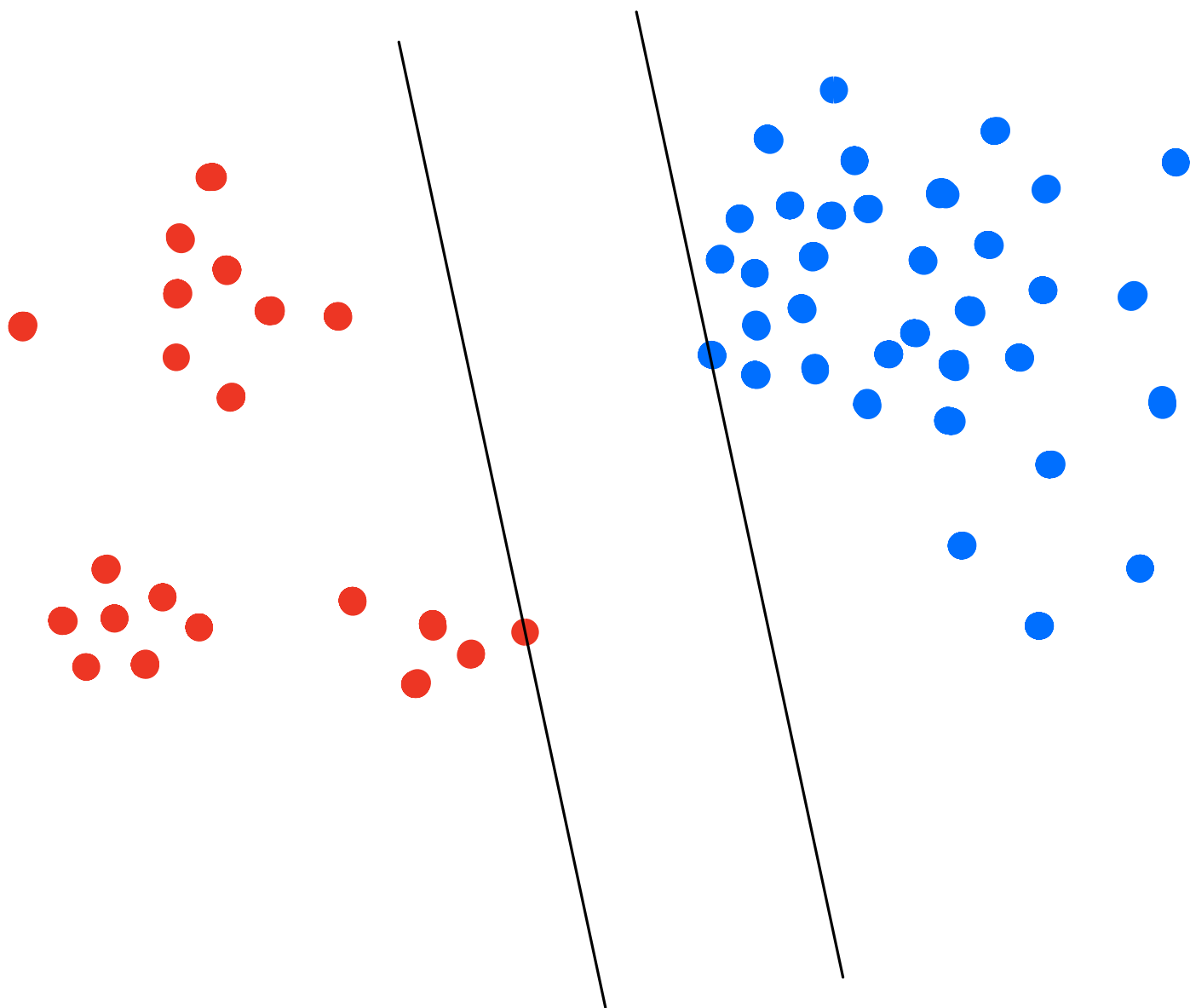
Support Vector Machines (SVM)



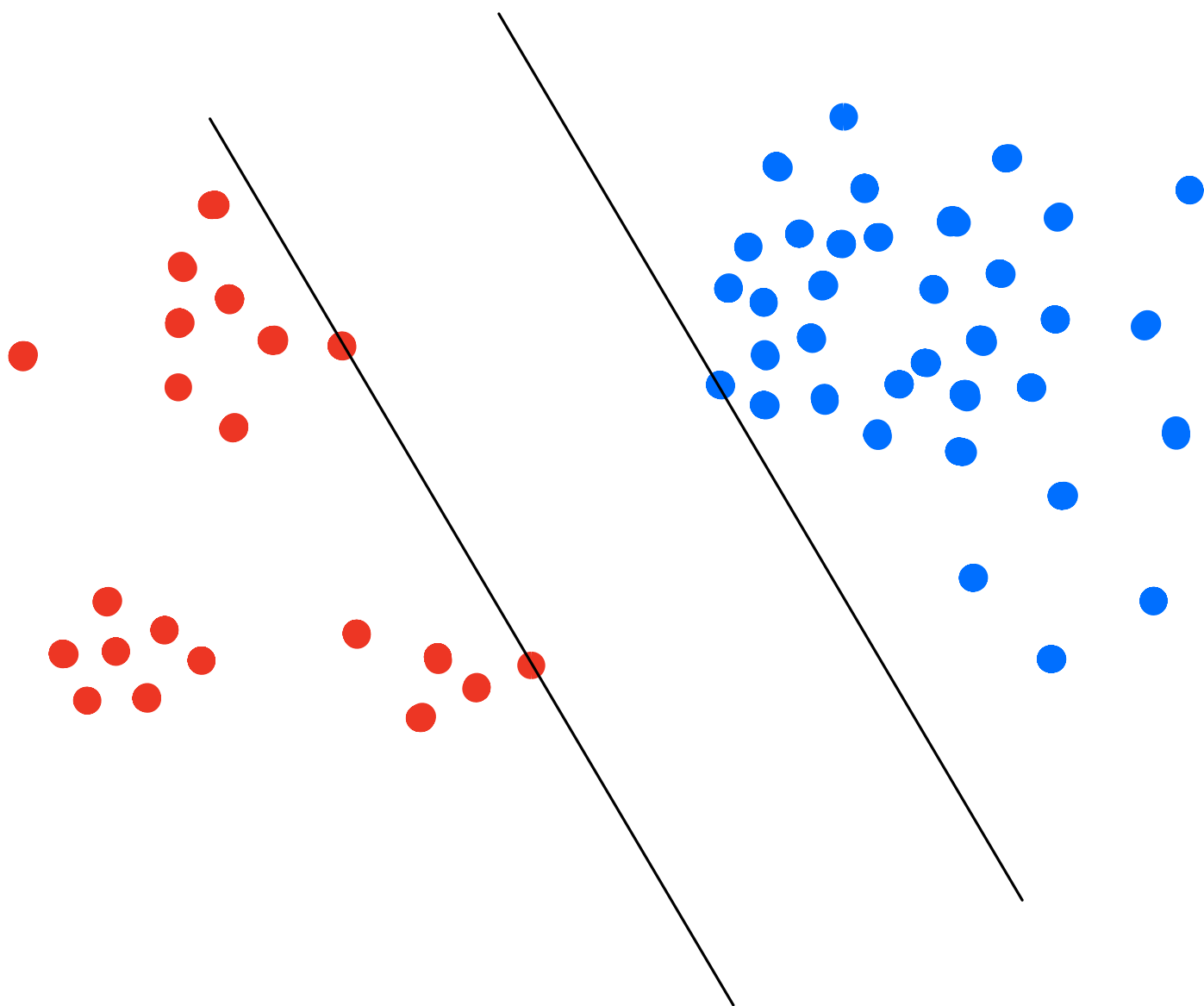
Support Vector Machines (SVM)



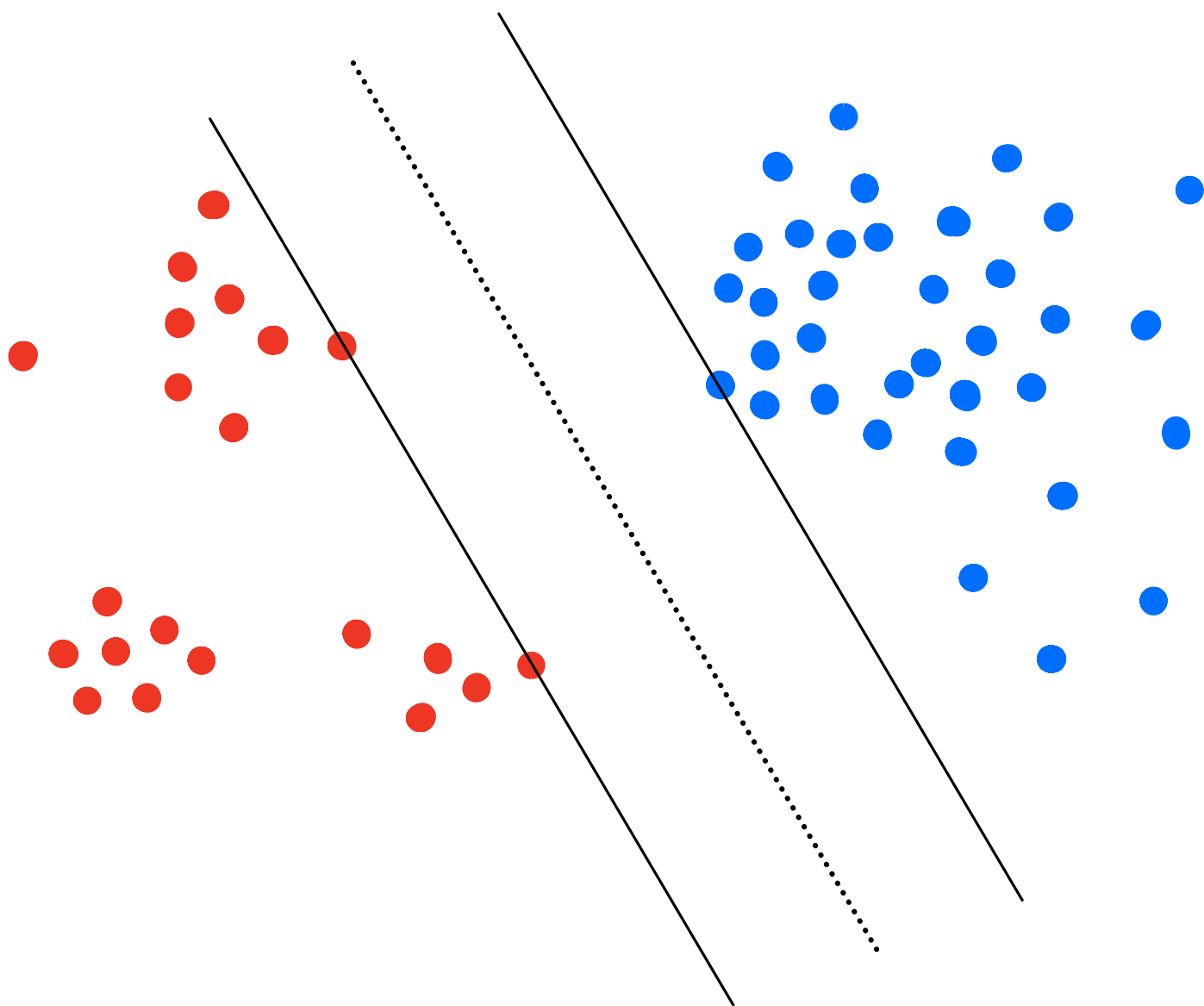
Support Vector Machines (SVM)



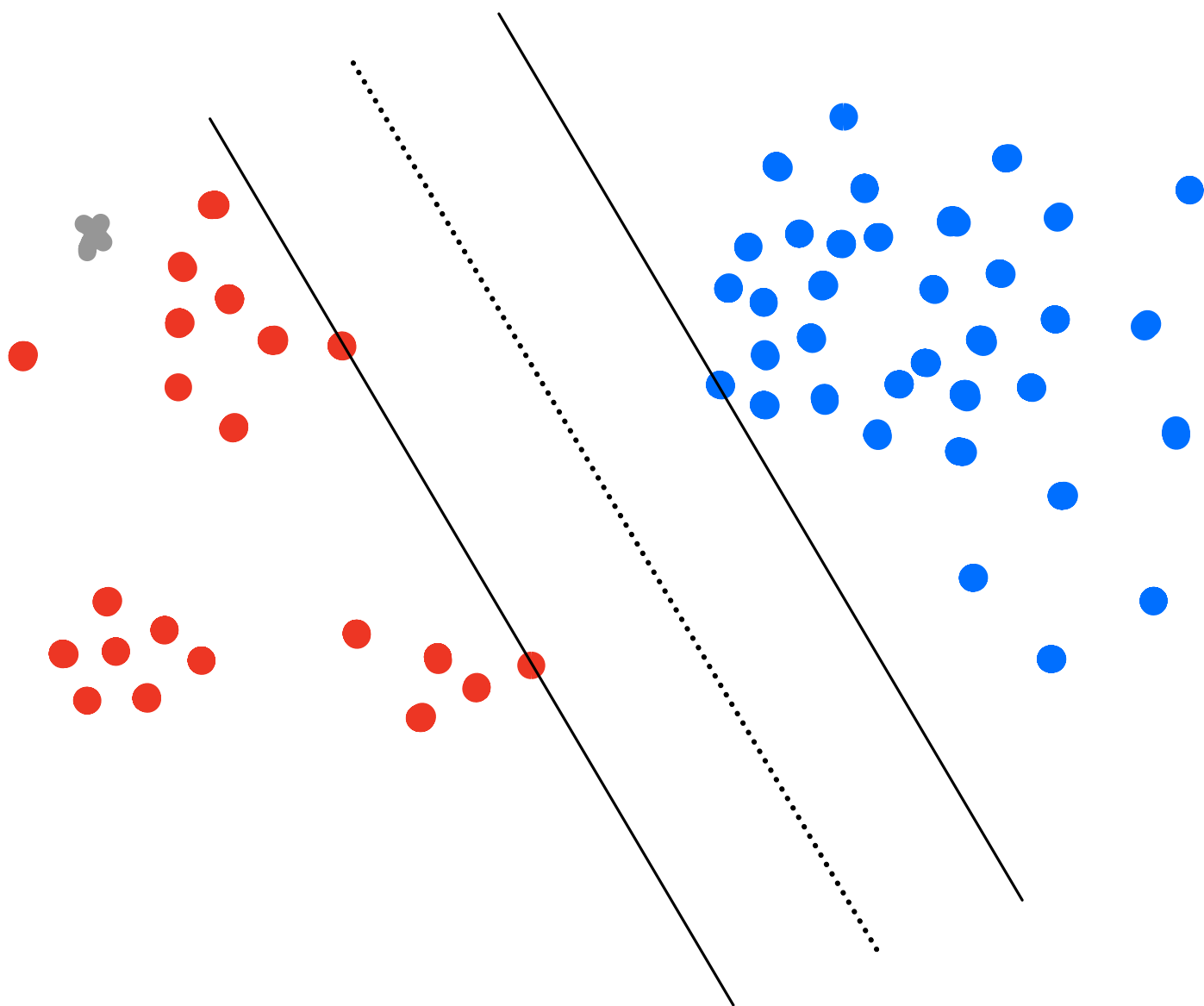
Support Vector Machines (SVM)



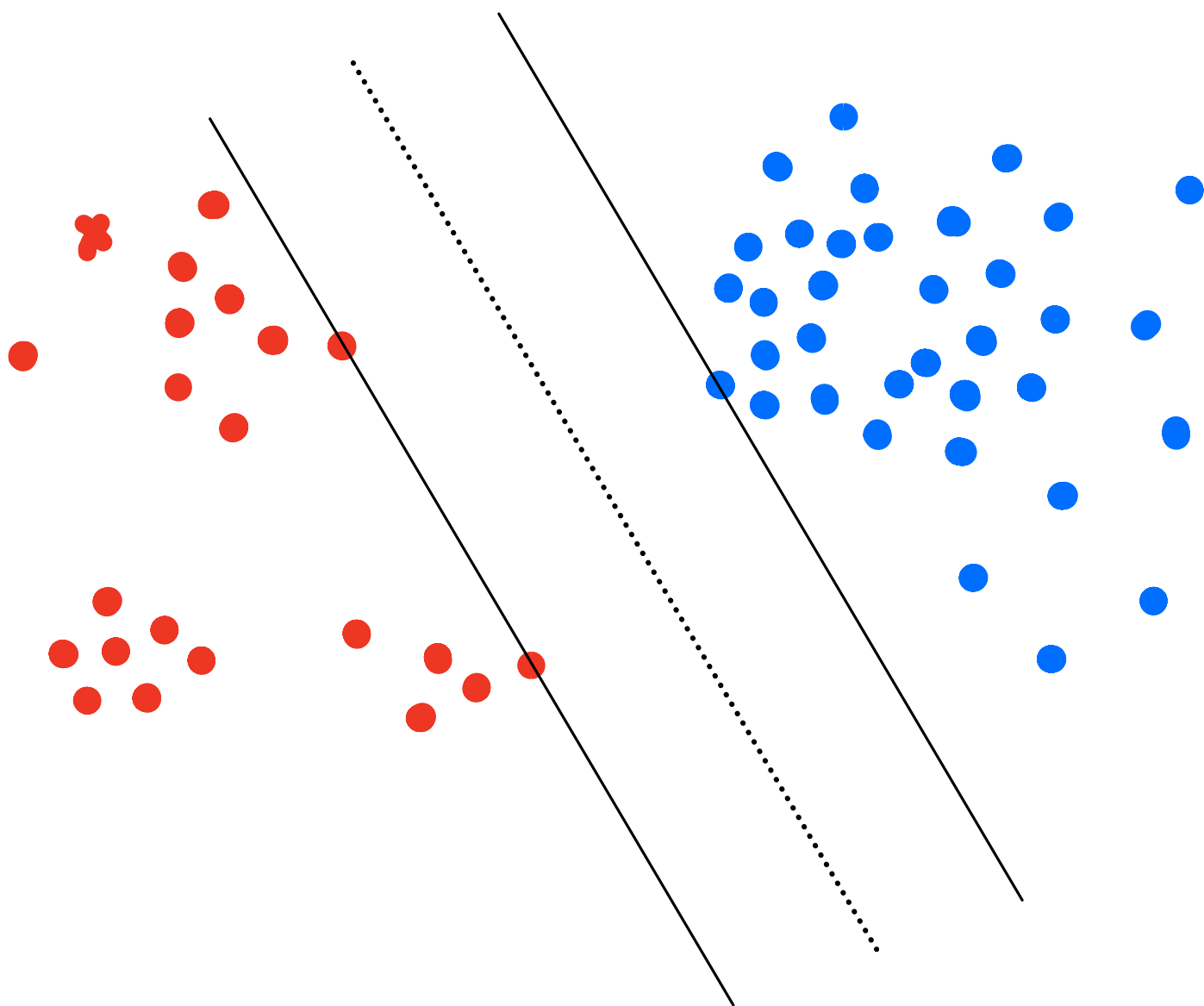
Support Vector Machines (SVM)



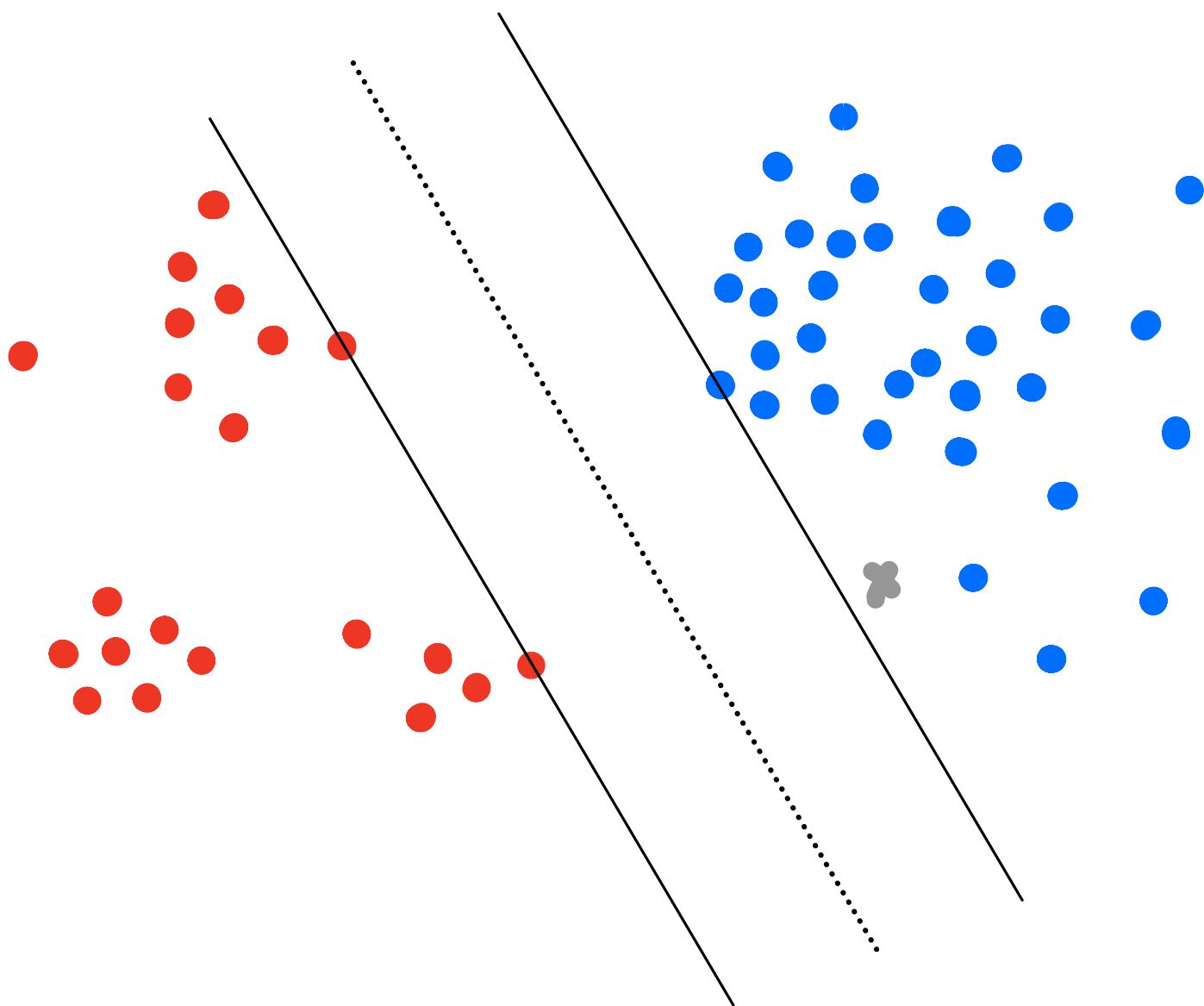
Support Vector Machines (SVM)



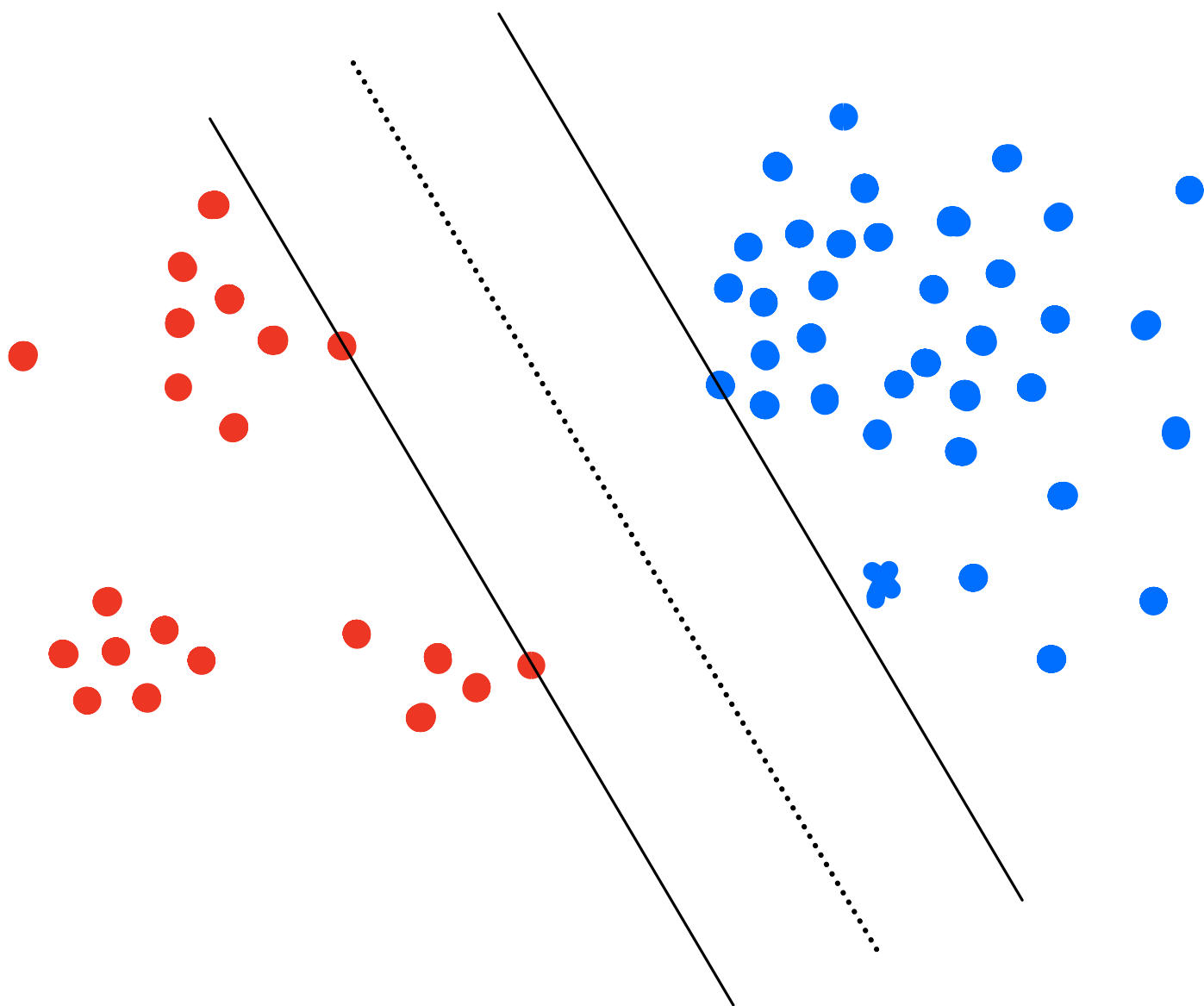
Support Vector Machines (SVM)



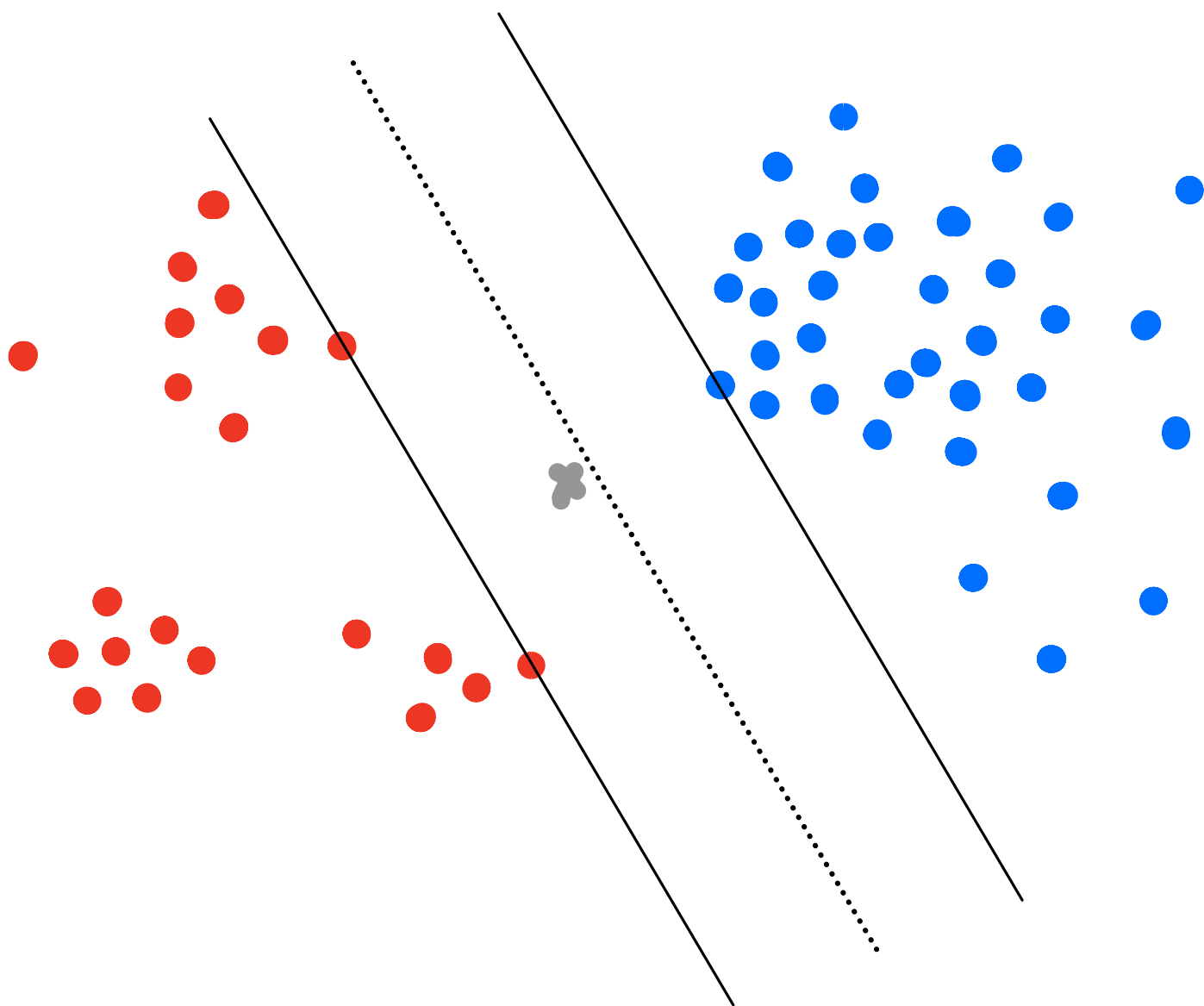
Support Vector Machines (SVM)



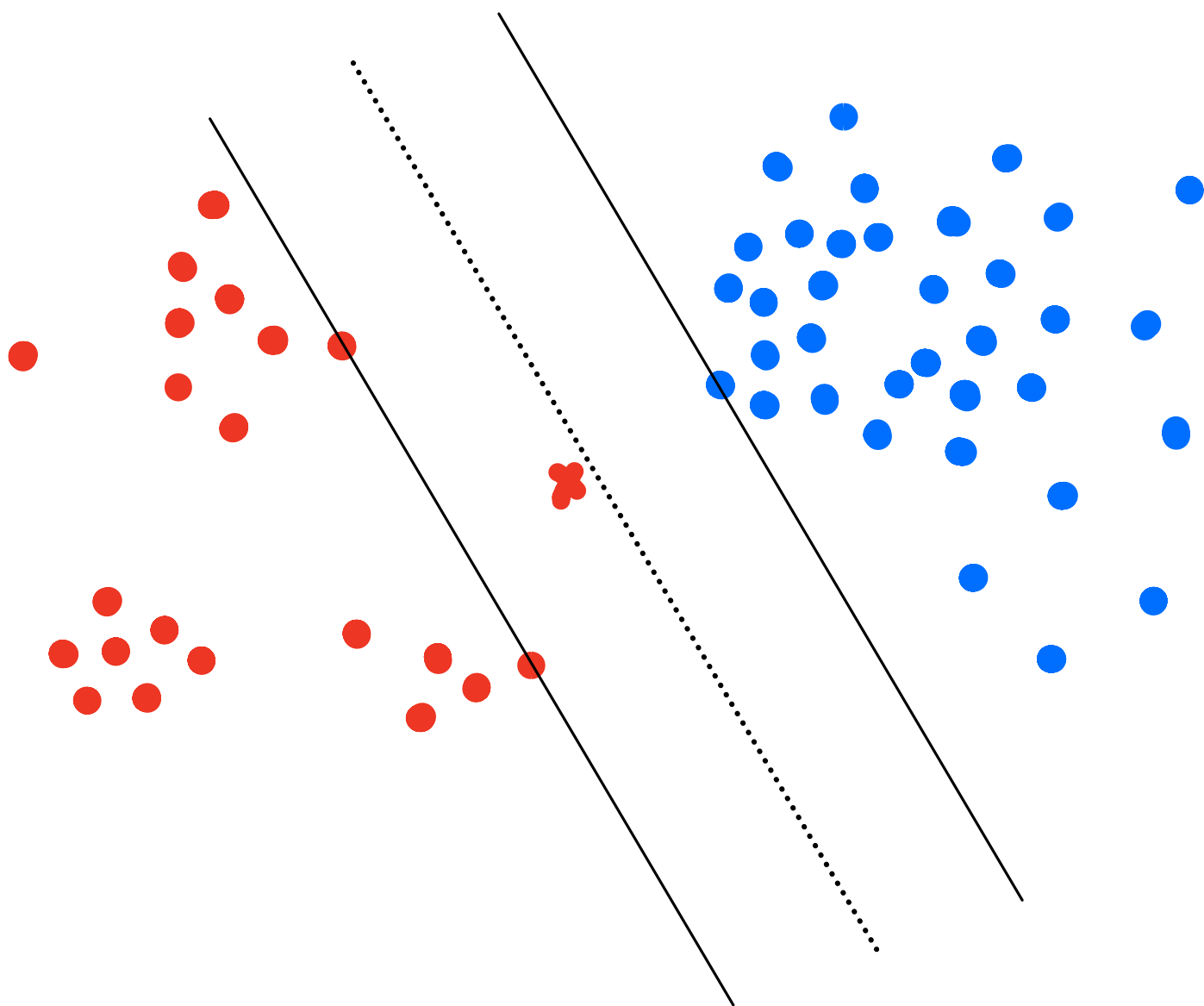
Support Vector Machines (SVM)



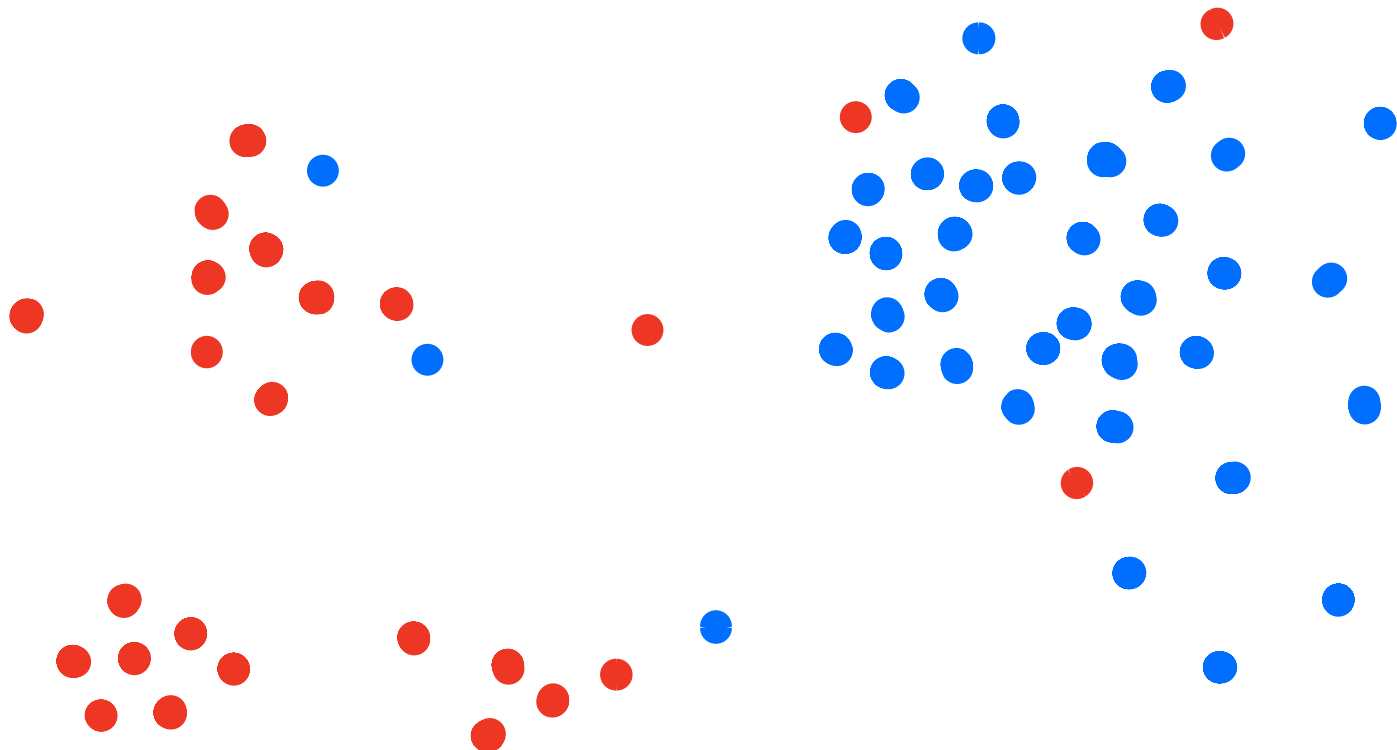
Support Vector Machines (SVM)



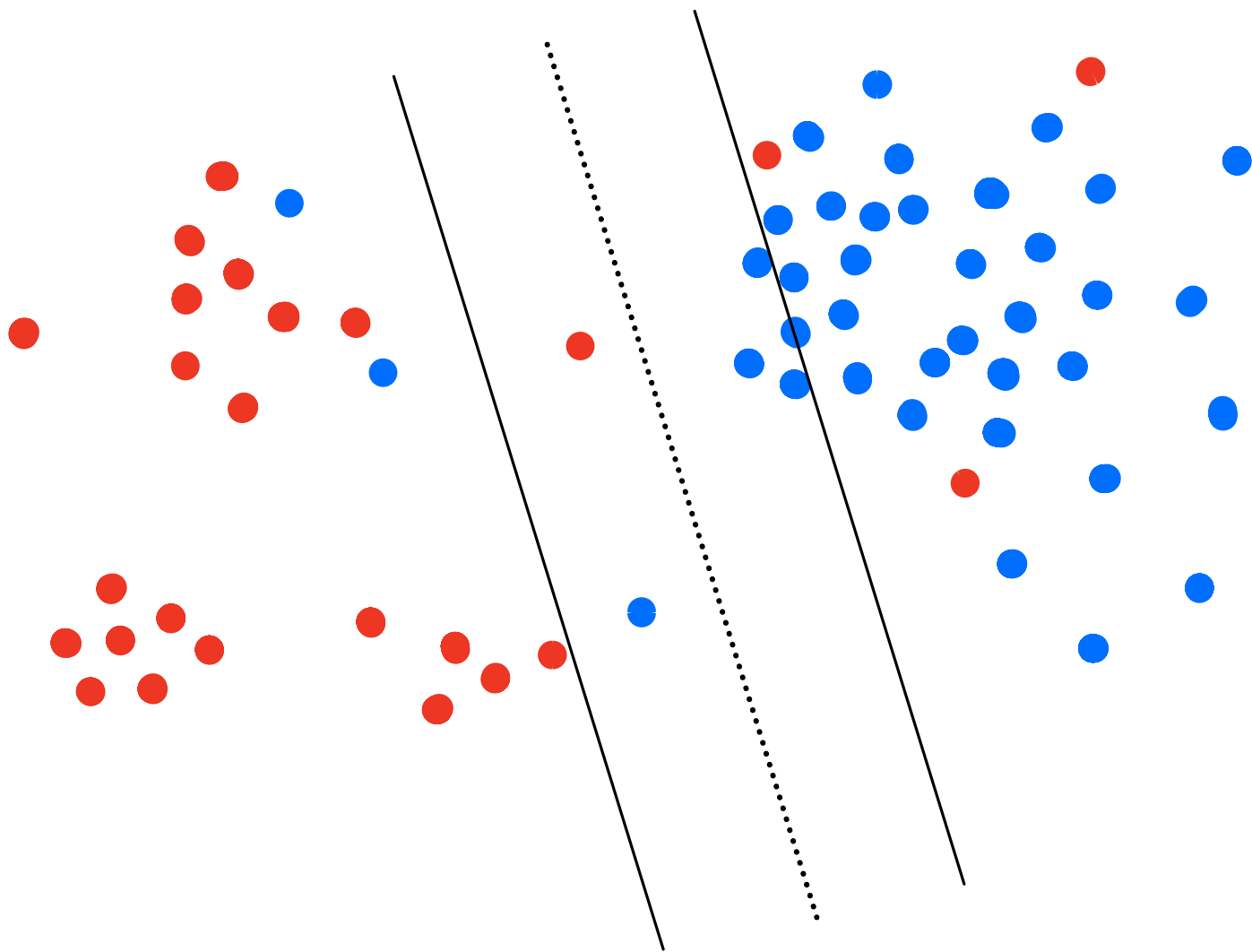
Support Vector Machines (SVM)



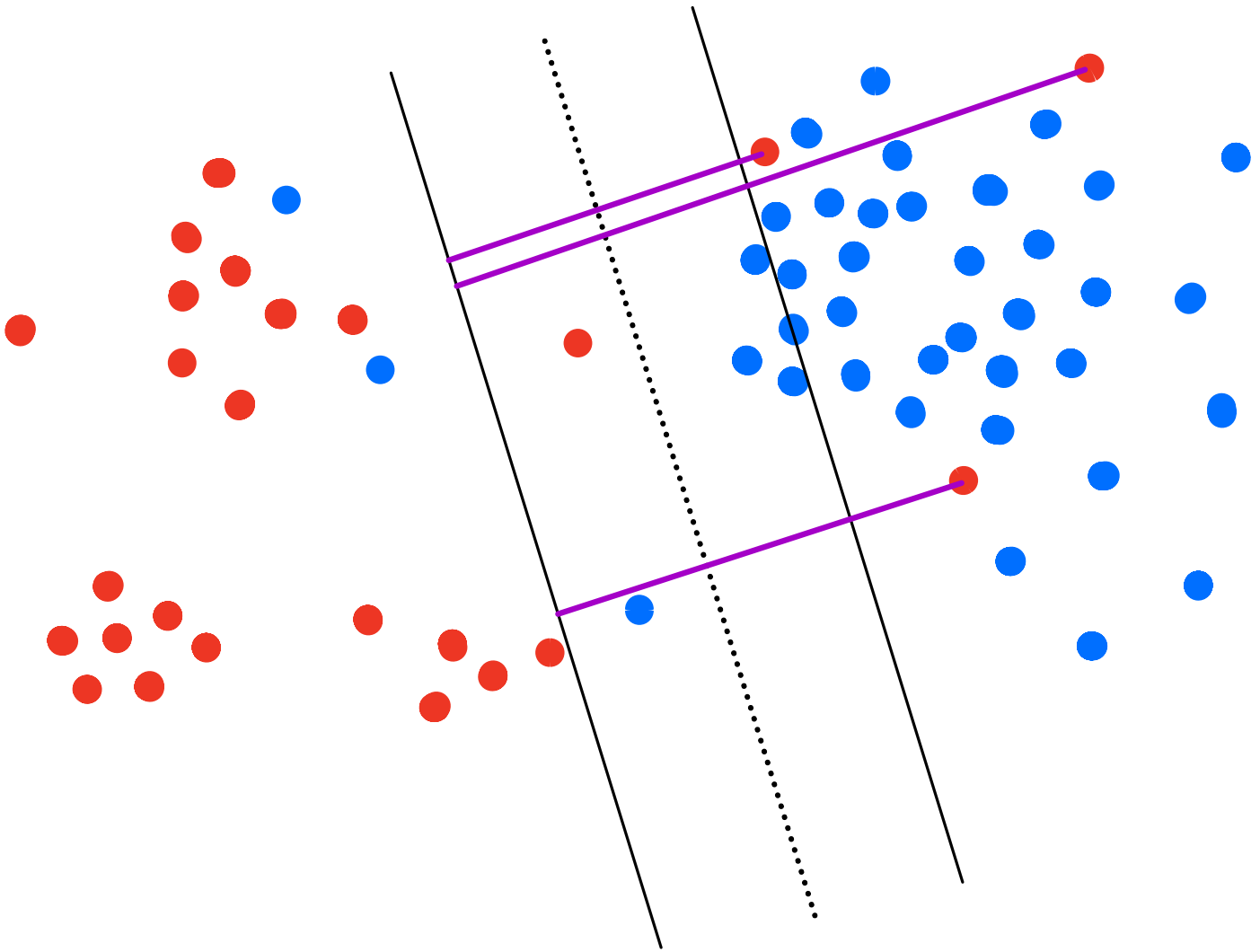
Support Vector Machines (SVM)



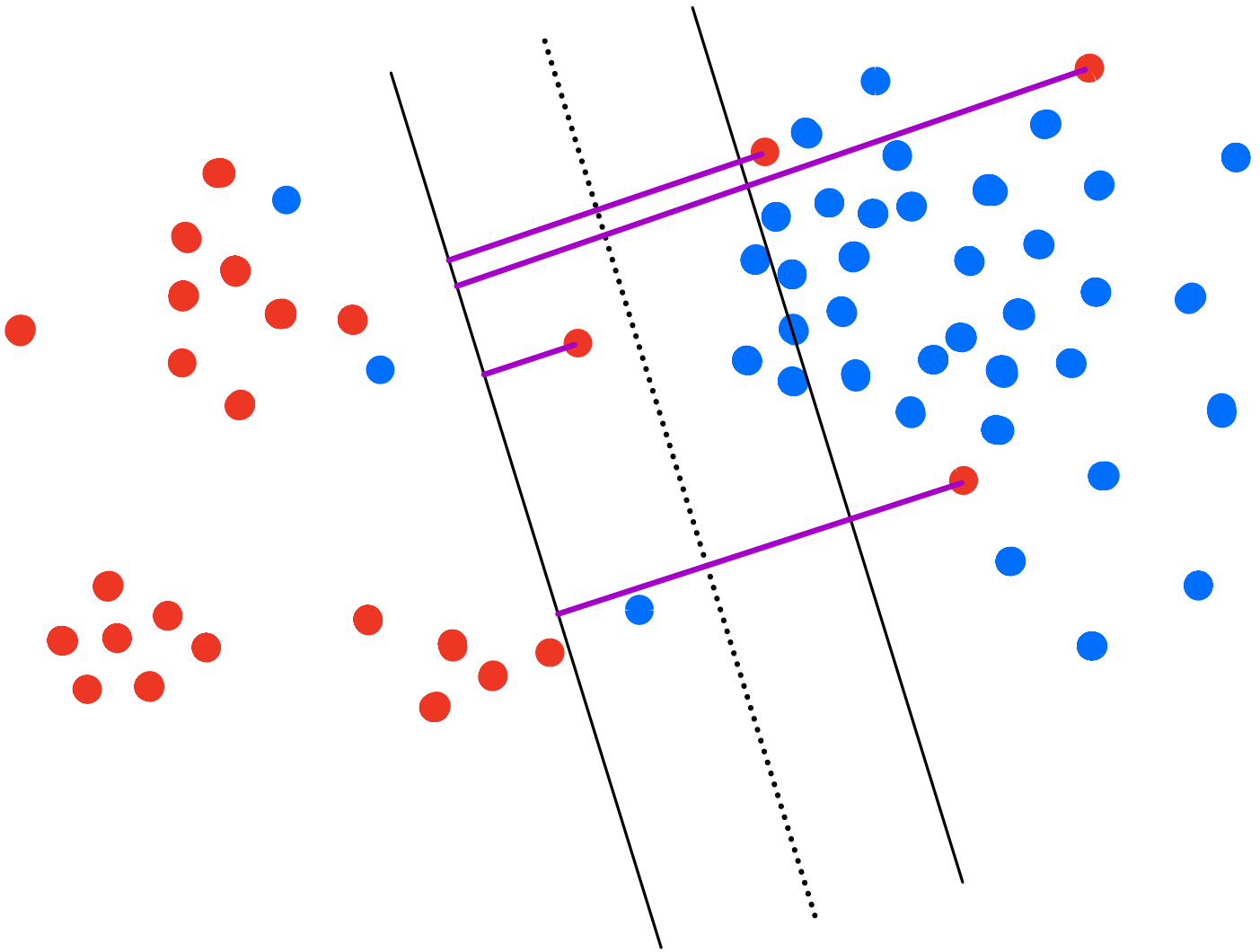
Support Vector Machines (SVM)



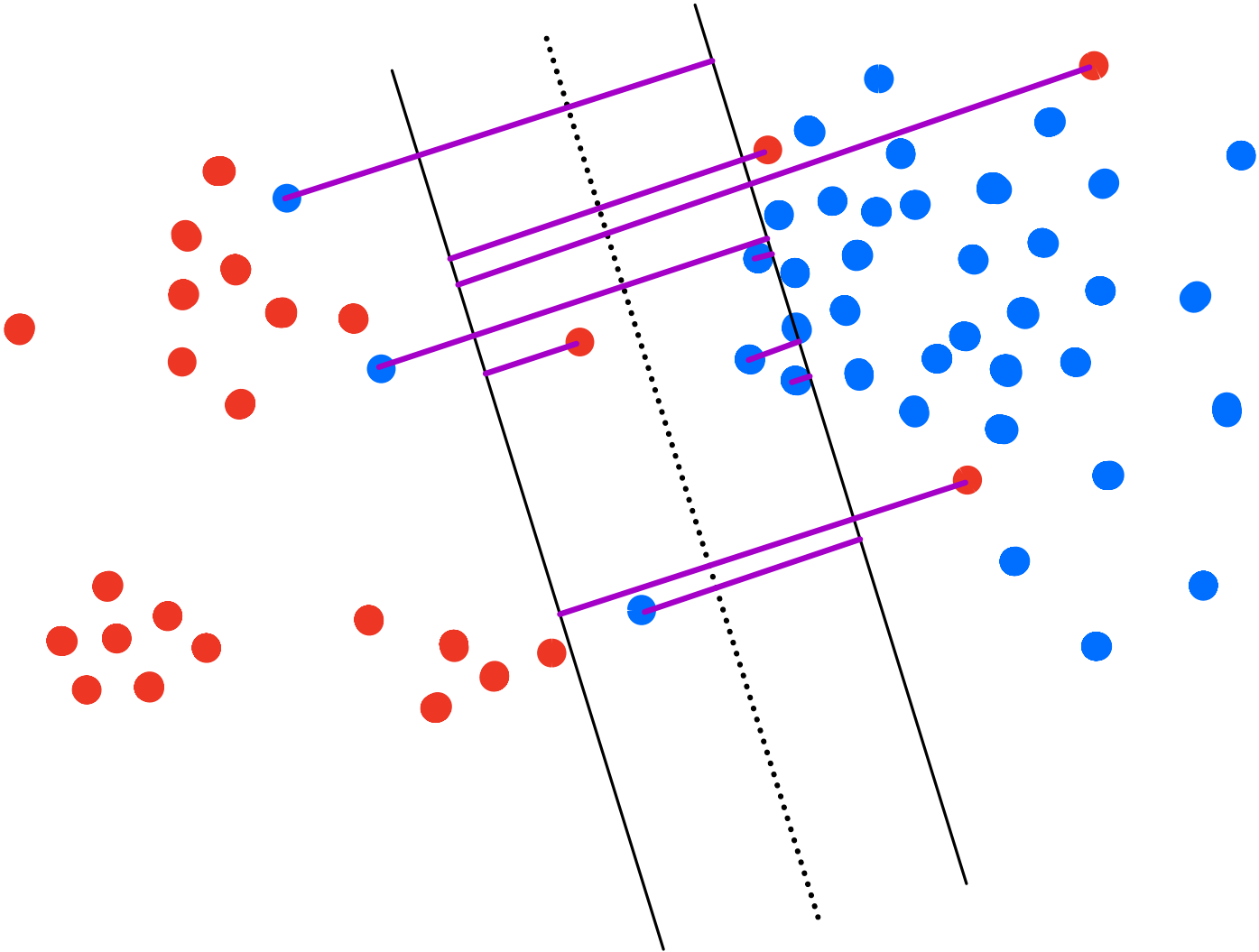
Support Vector Machines (SVM)



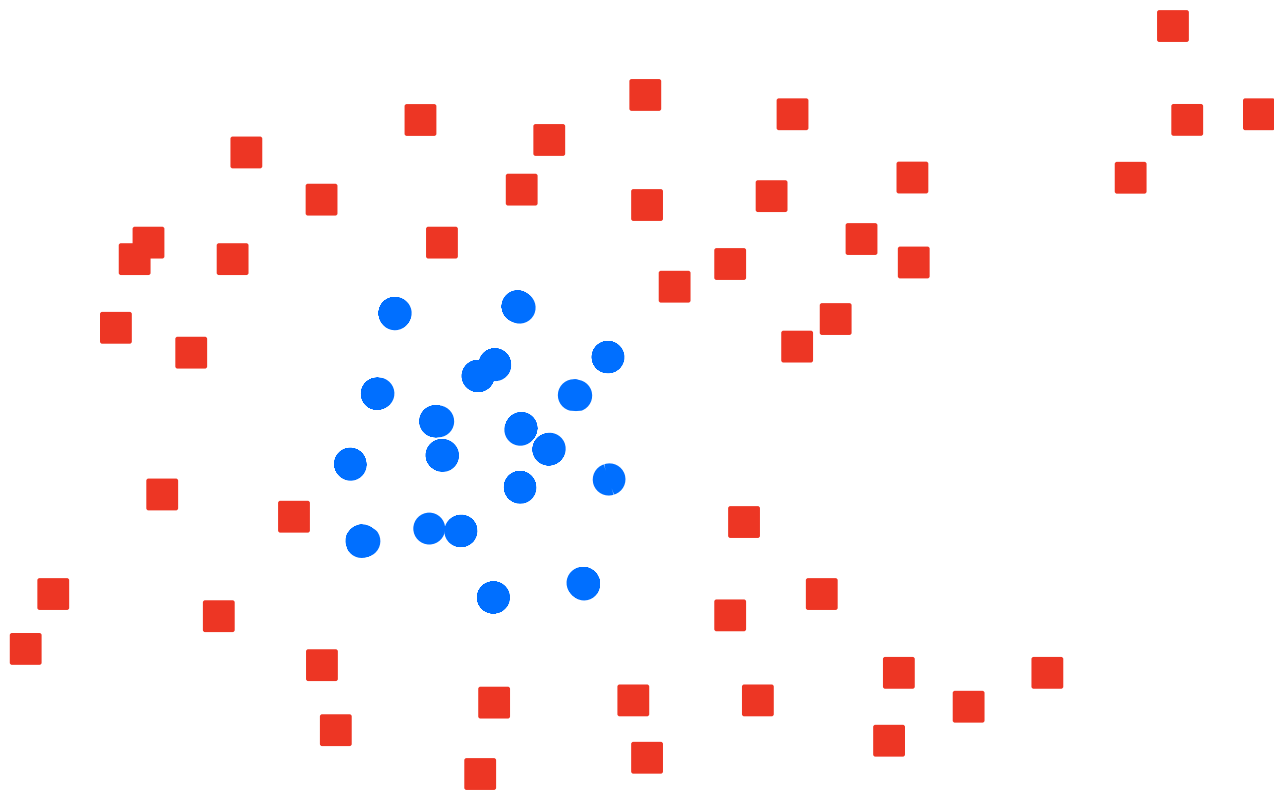
Support Vector Machines (SVM)



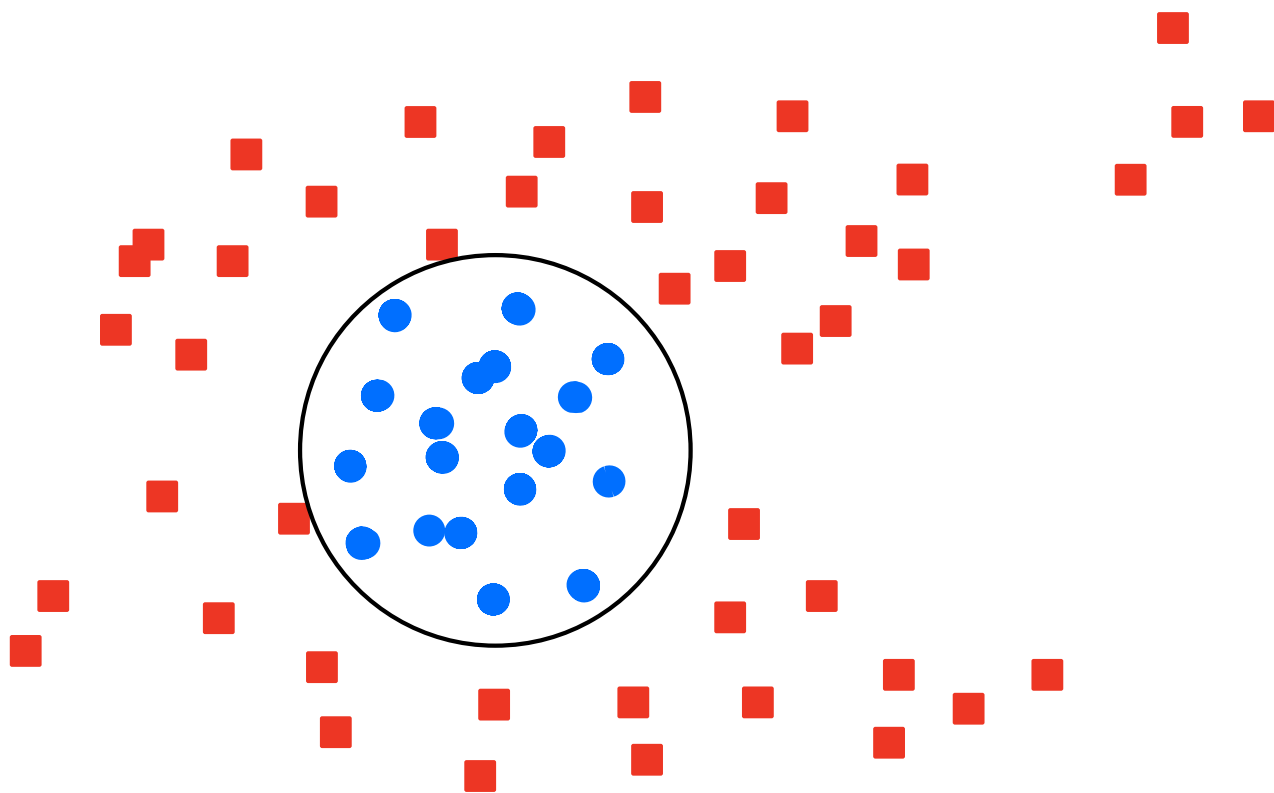
Support Vector Machines (SVM)



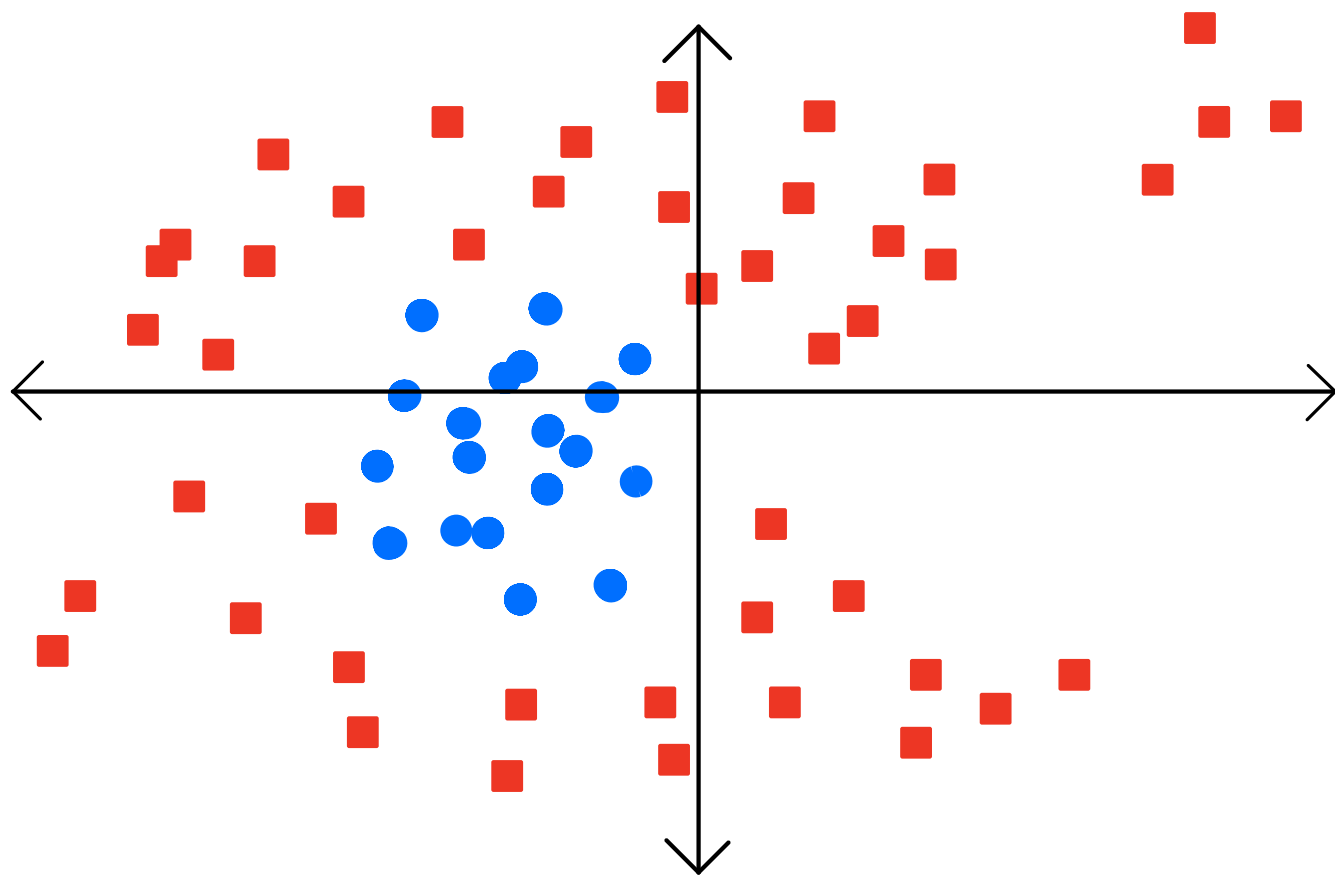
Support Vector Machines (SVM)



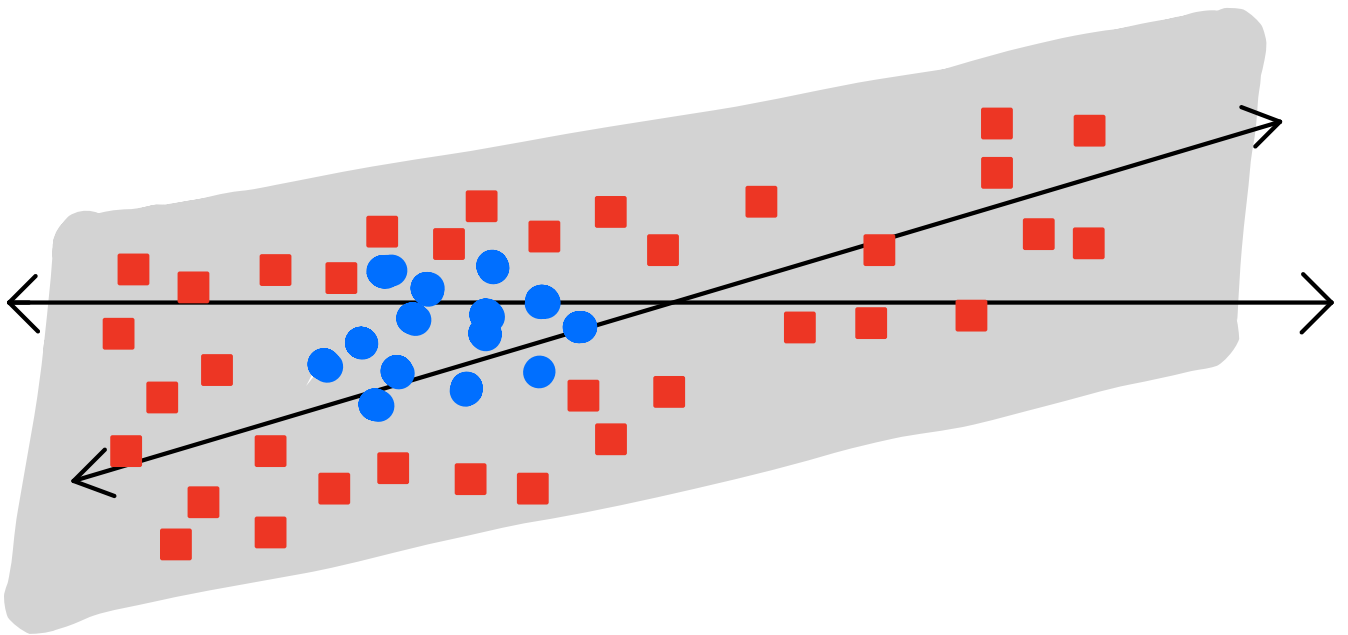
Support Vector Machines (SVM)



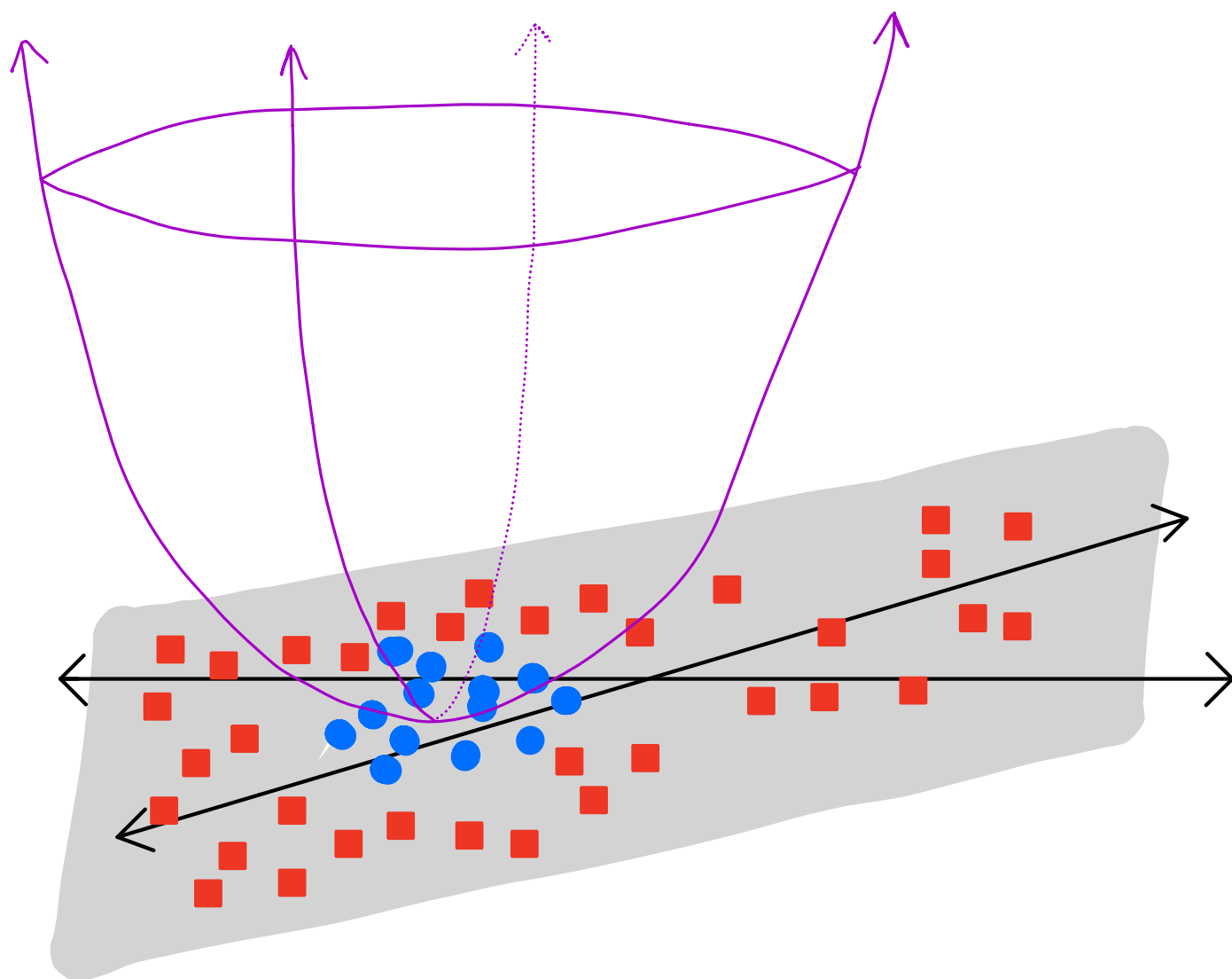
Support Vector Machines (SVM)



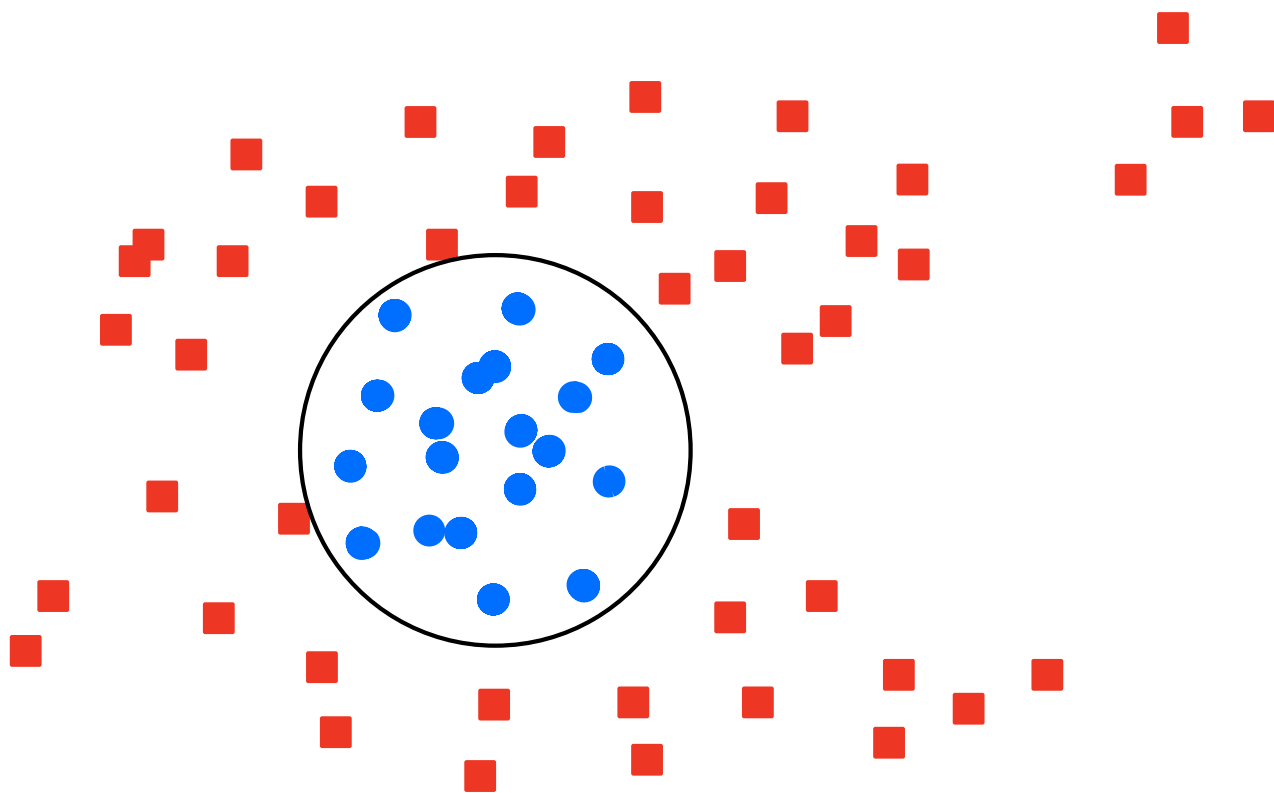
Support Vector Machines (SVM)



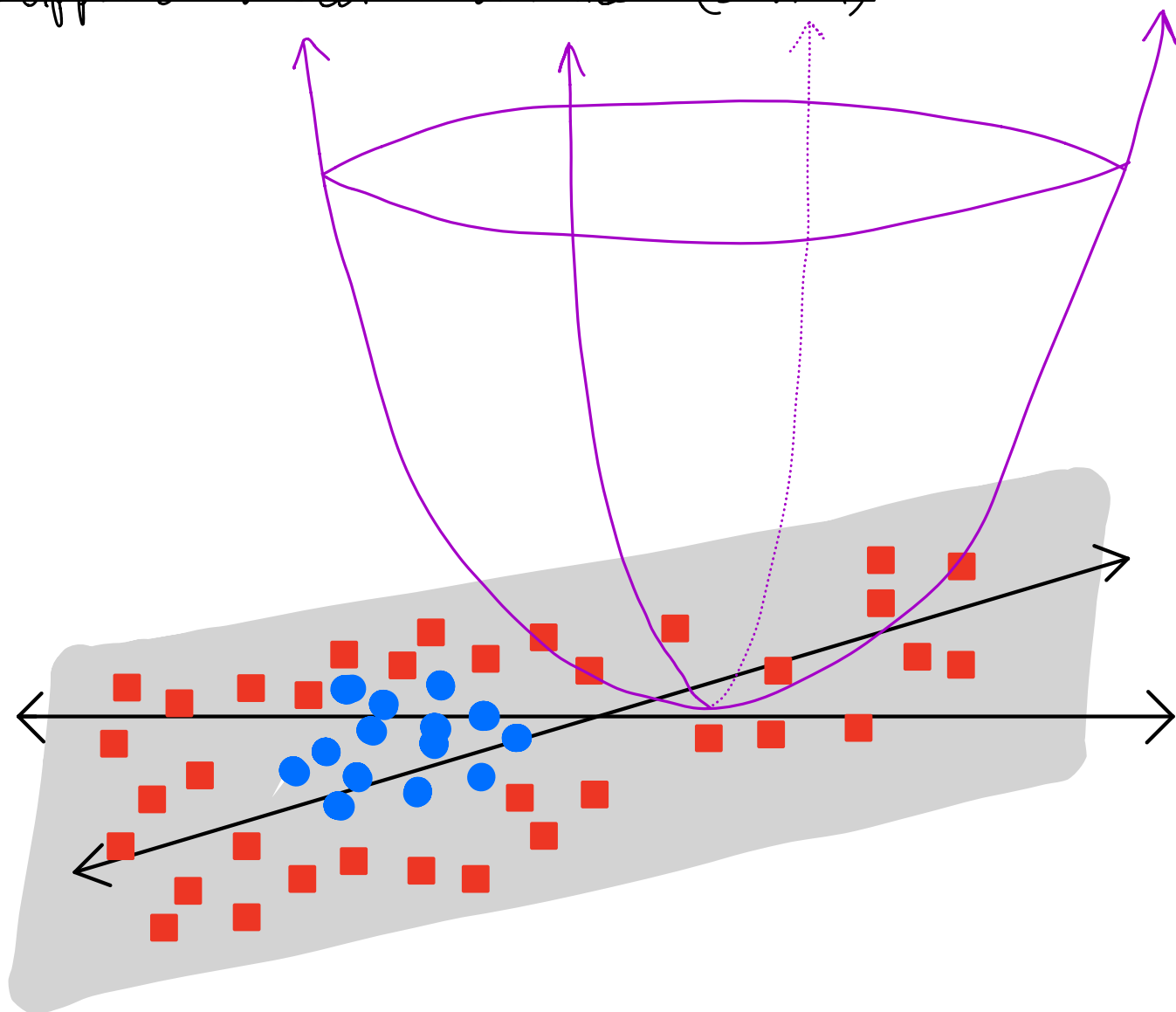
Support Vector Machines (SVM)



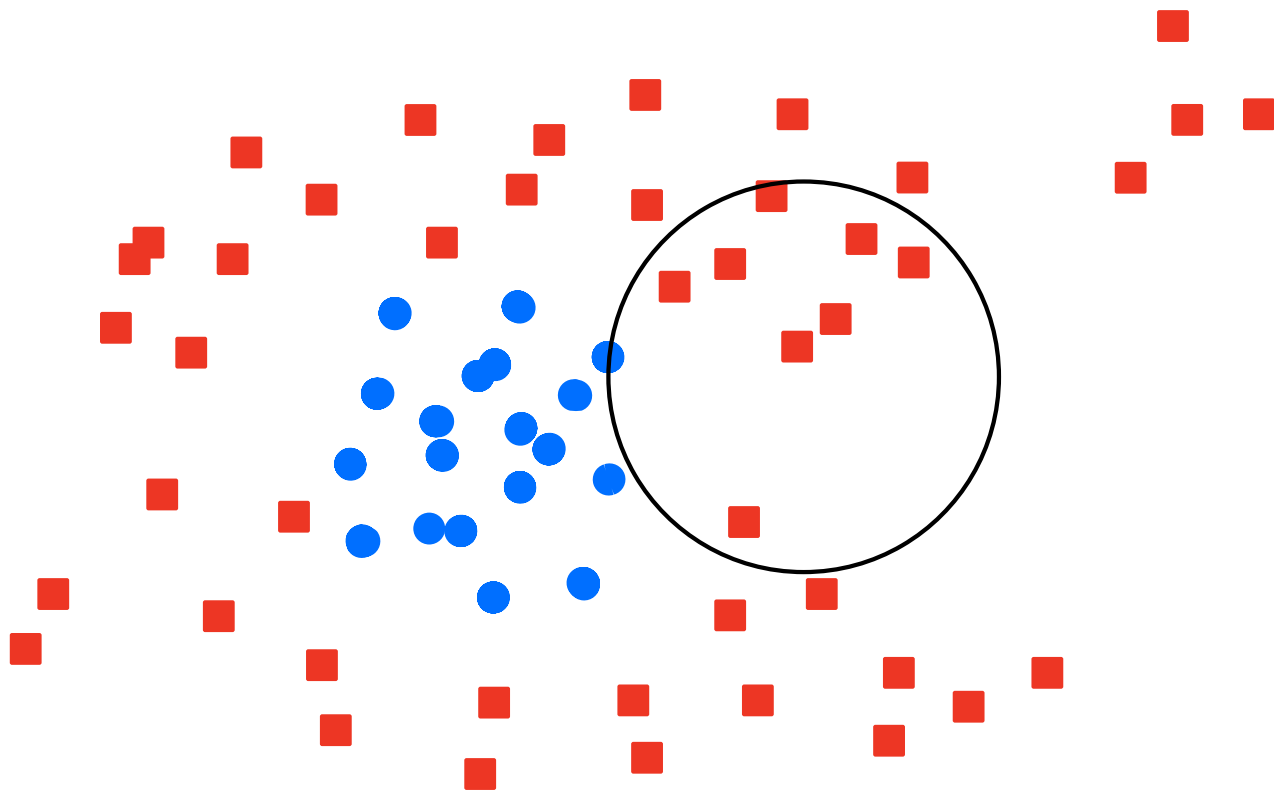
Support Vector Machines (SVM)



Support Vector Machines (SVM)



Support Vector Machines (SVM)



AI and Art

Style Transfer (Generative Adversarial Networks)



<https://softologyblog.wordpress.com/2019/03/31/style-transfer-gans-generative-adversarial-networks/>

<https://github.com/cysmith/neural-style-tf>

<https://deepart.io/>

Thank you for attending!