5 ALGORITHMS YOU MUST BE AWARE OF BEFORE GOING TO DEEP LEARNING

FOR A BETTER FUTURE ...

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Some common challenges

- Classification (KNN, Decision Trees, Neural Nets, SVM)
- Clustering (K-Means, Hierarchical, Fuzzy C Means)
- Density Estimation (Gaussian Mixture Models)
- Regression (Linear or Logistic Regression)
- Dimensionality Reduction (PCA, LDA, SVD)

and many more

K-Nearest Neighbor (KNN)

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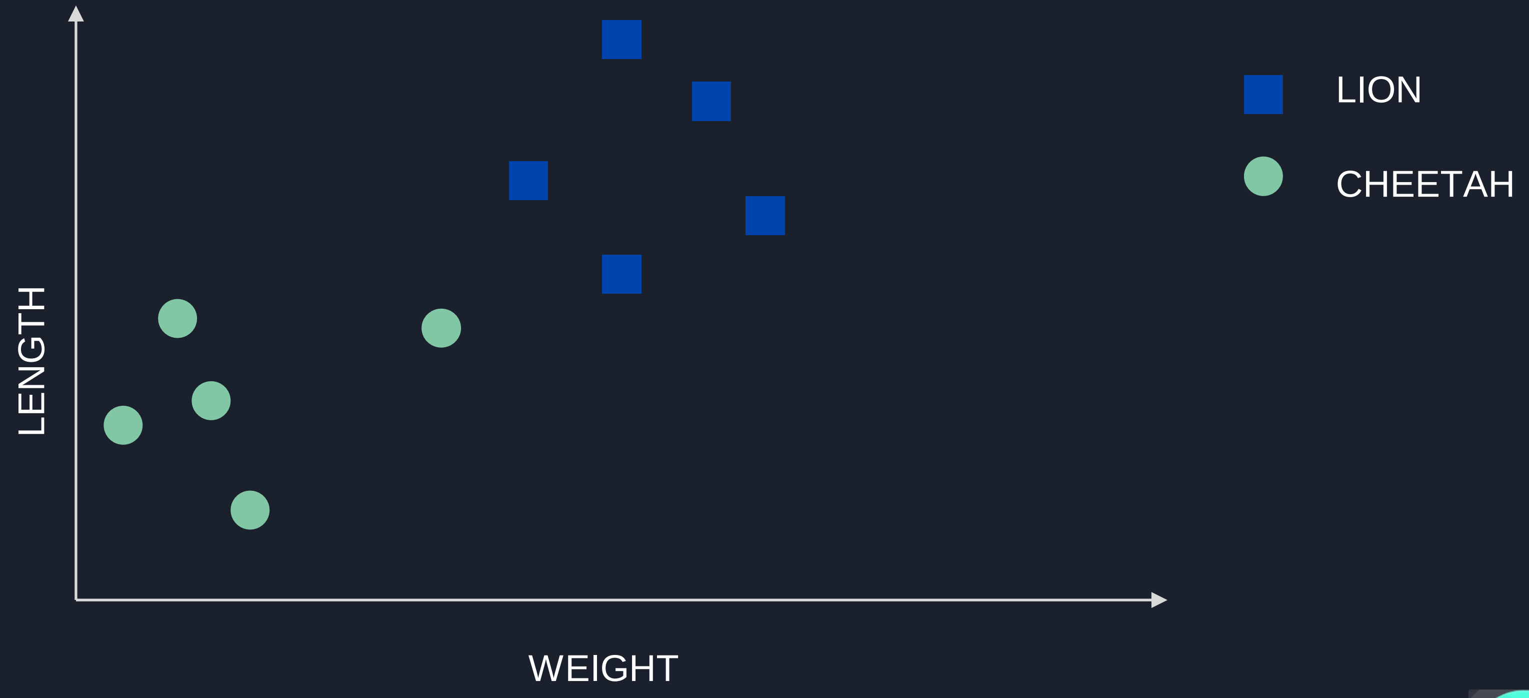
The simplest idea is often the best idea



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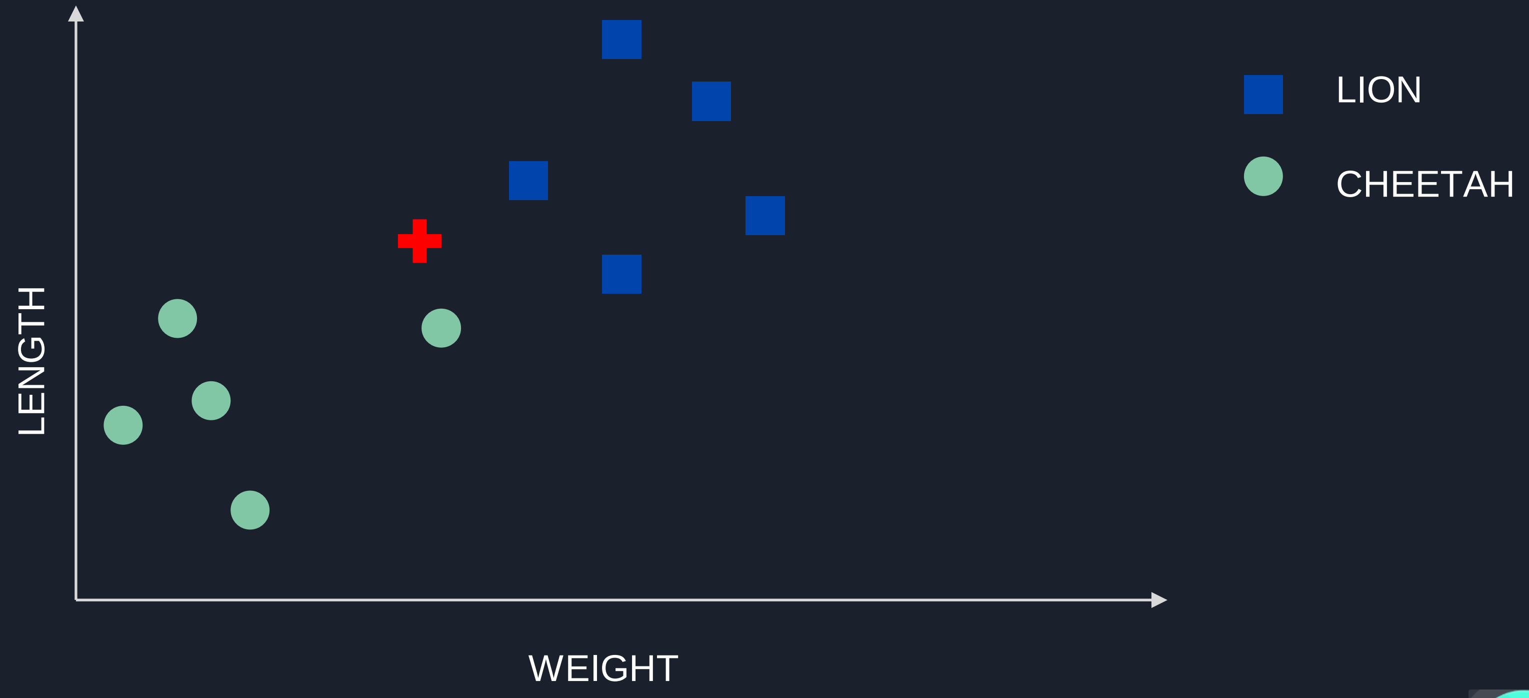
The simplest idea is often the best idea



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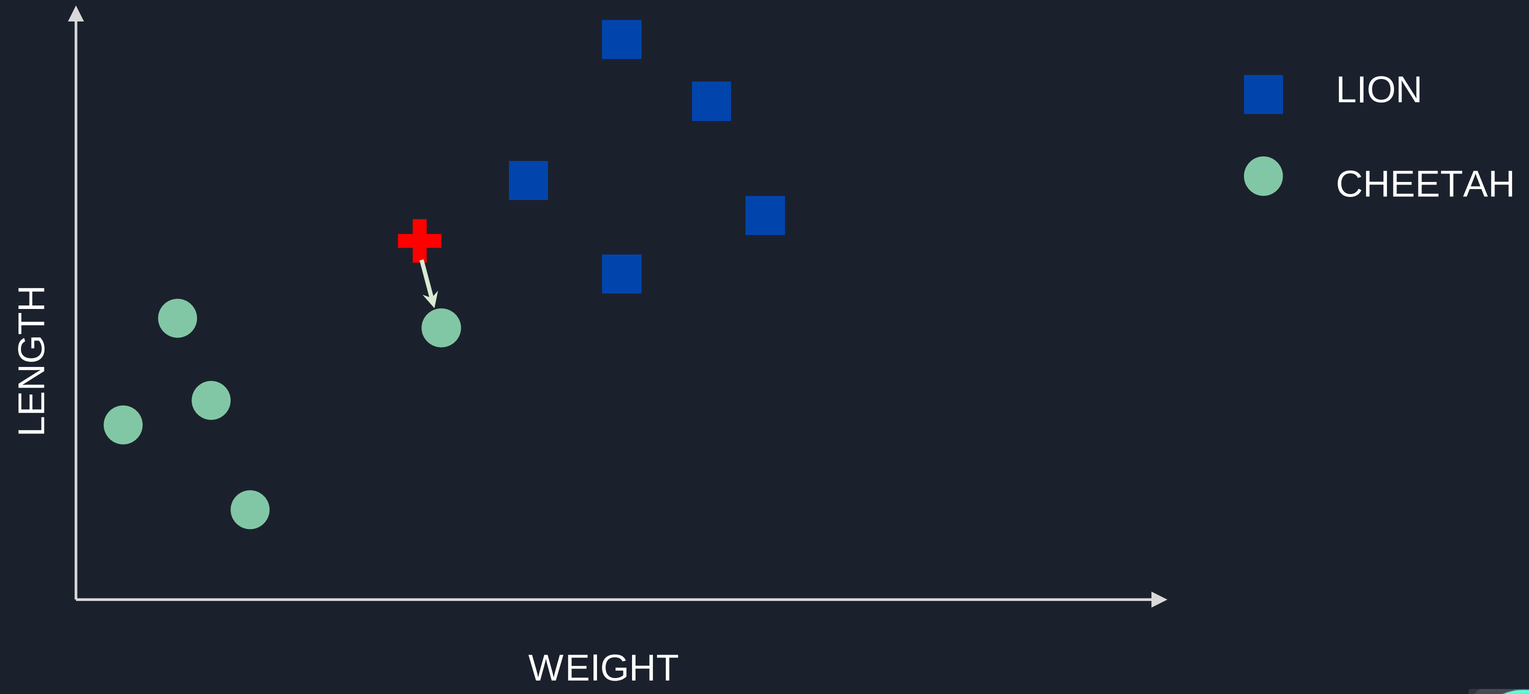
The simplest idea



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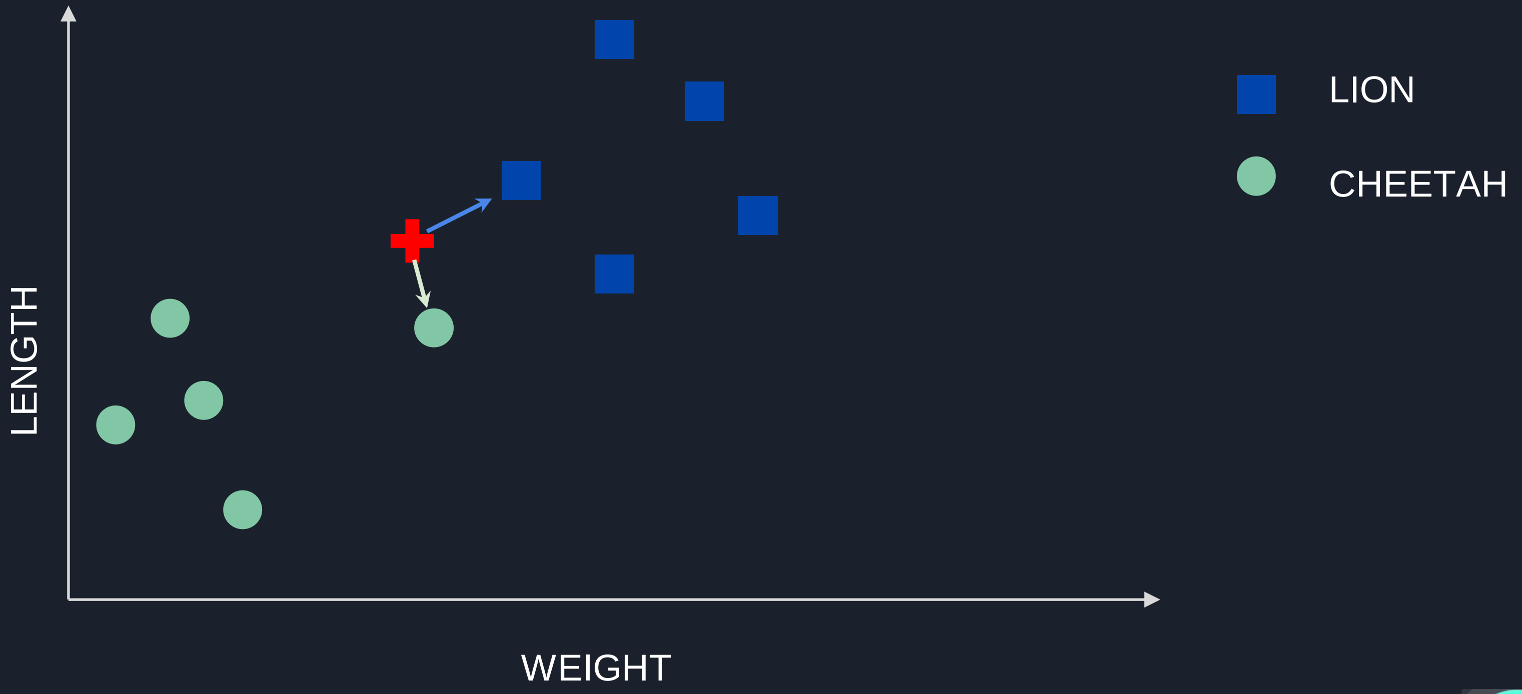
Ambiguity



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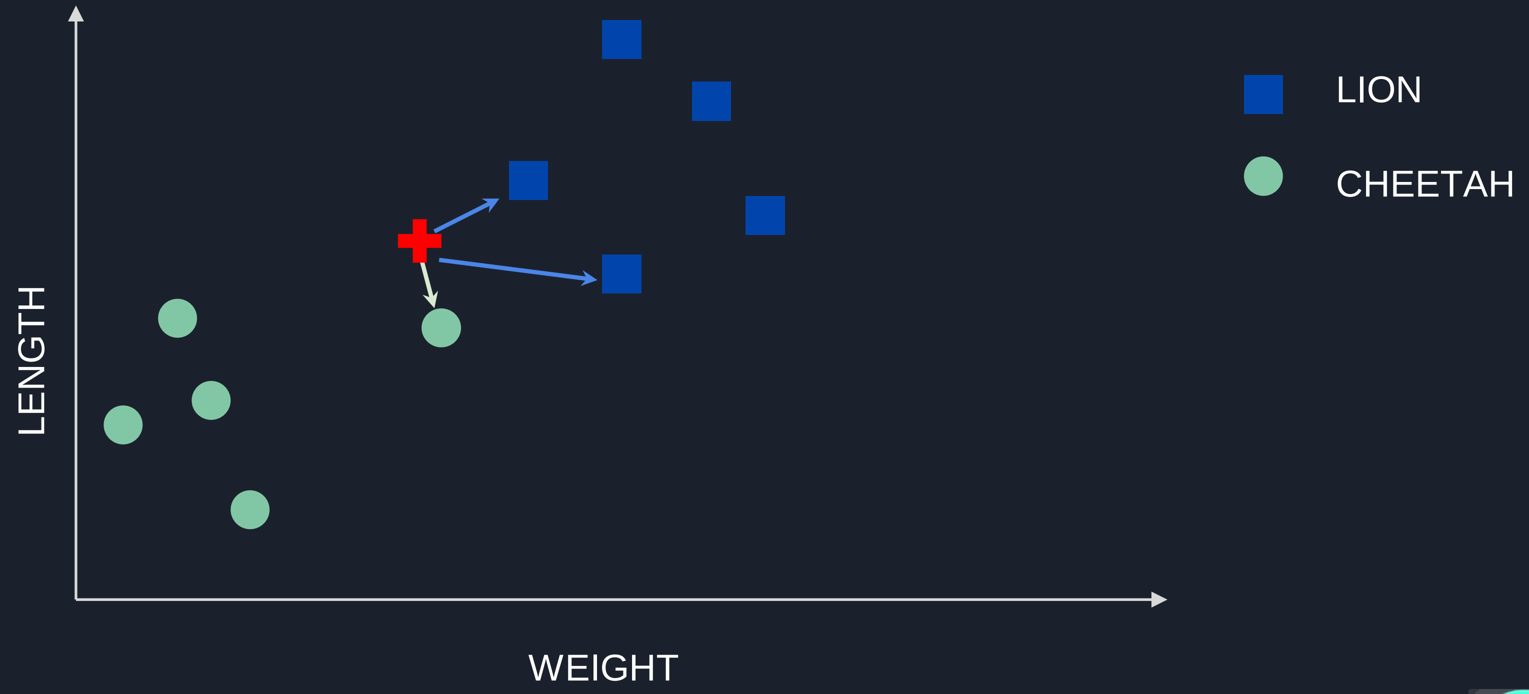
More neighbours... Better predictions



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Further References

- Wikipedia - k-nearest neighbors algorithm - Wikipedia
- Blogs :
  - Introduction to KNN, K-Nearest Neighbors : Simplified - Analytics Vidhya
  - A Quick Introduction to K-Nearest Neighbors Algorithm - Medium
  - K-Nearest Neighbours - GeeksforGeeks
- Demo :
  - http://vision.stanford.edu/teaching/cs231n-demos/knn/
- API
  - sklearn.neighbors.KNeighborsClassifier — scikit-learn 0.19.2
  - k-nearest neighbor classification - MATLAB
  - Weka 3 - Data Mining with Open Source Machine Learning Software
- Books :
  - Machine Learning – T. Mitchell
  - Pattern Recognition and Machine Learning – C.M. Bishop
- Related Papers
  - **K-nearest neighbour**
  - A fuzzy **k-nearest neighbor** algorithm
  - The distance-weighted **k-nearest-neighbor** rule
  - When is “**nearest neighbor**” meaningful?

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K-Means Clustering

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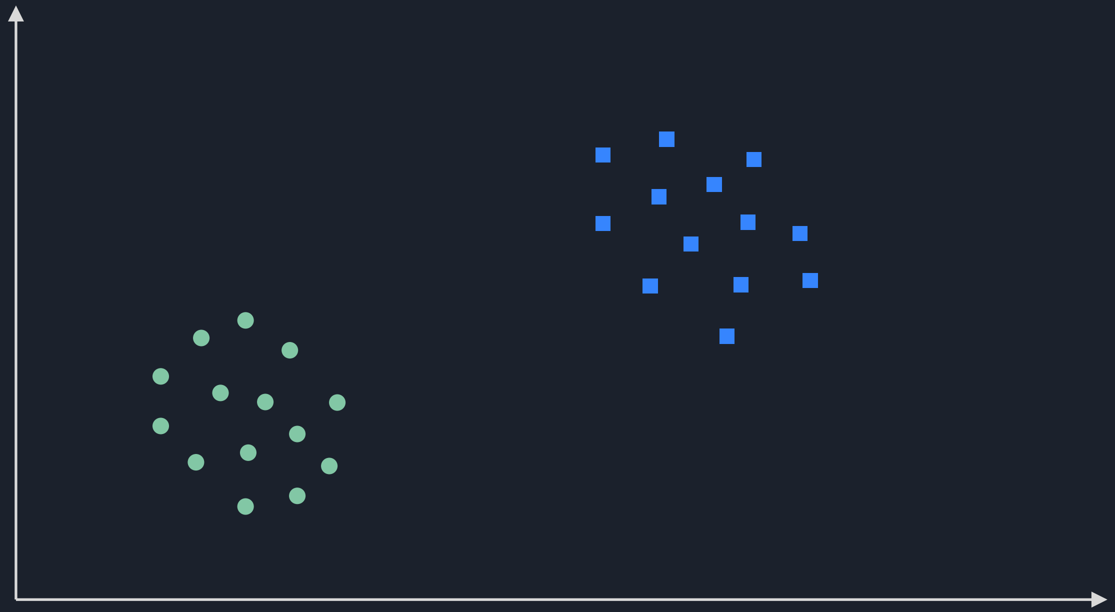
Clustering : Dividing samples into groups



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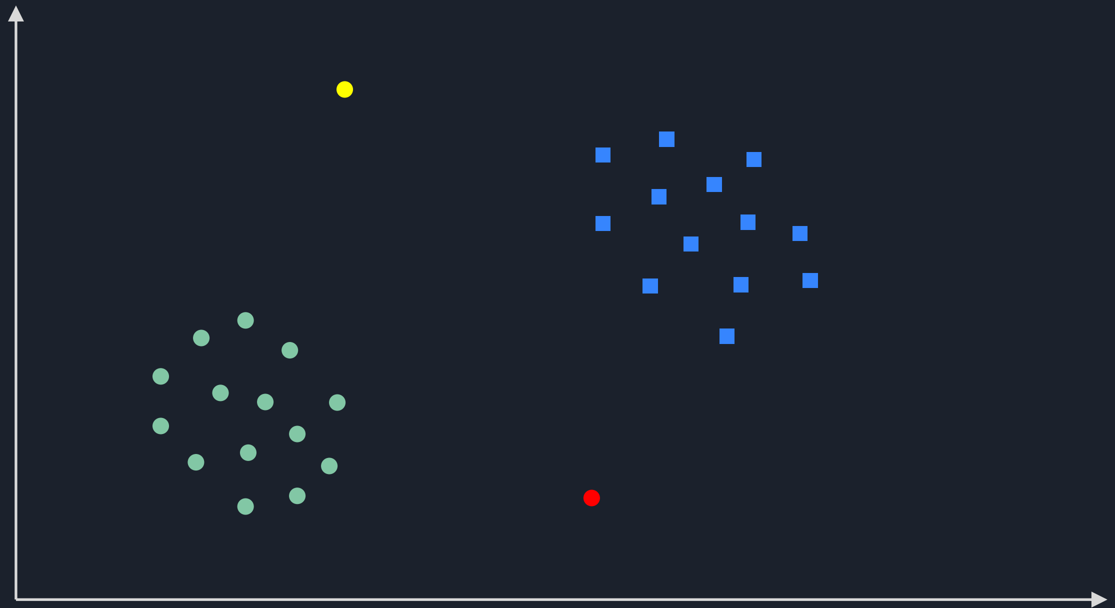
2 classes 2 means



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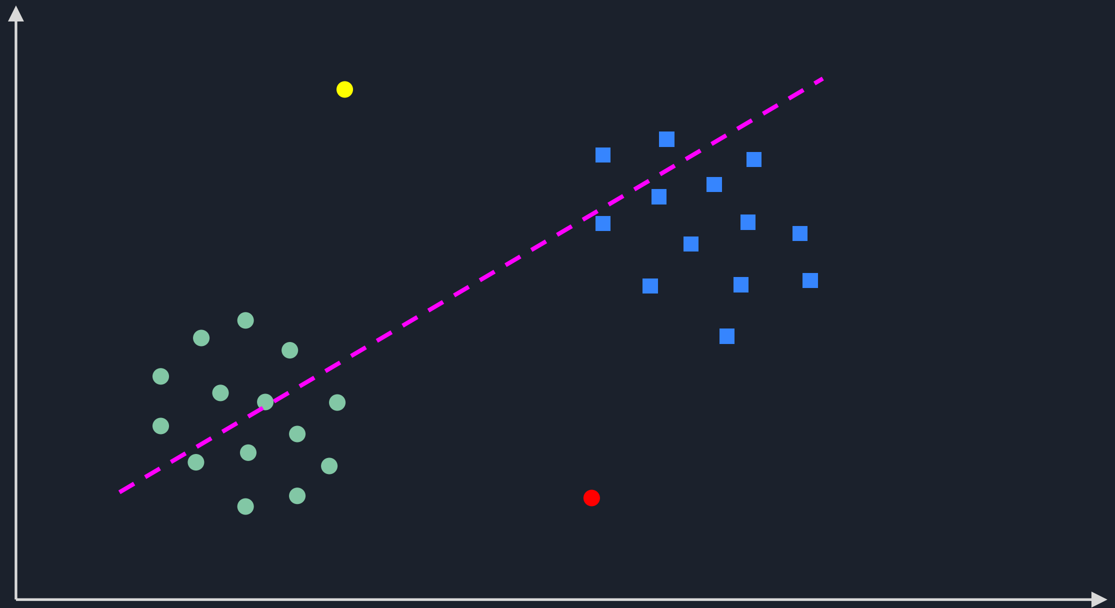
Who belongs to whom



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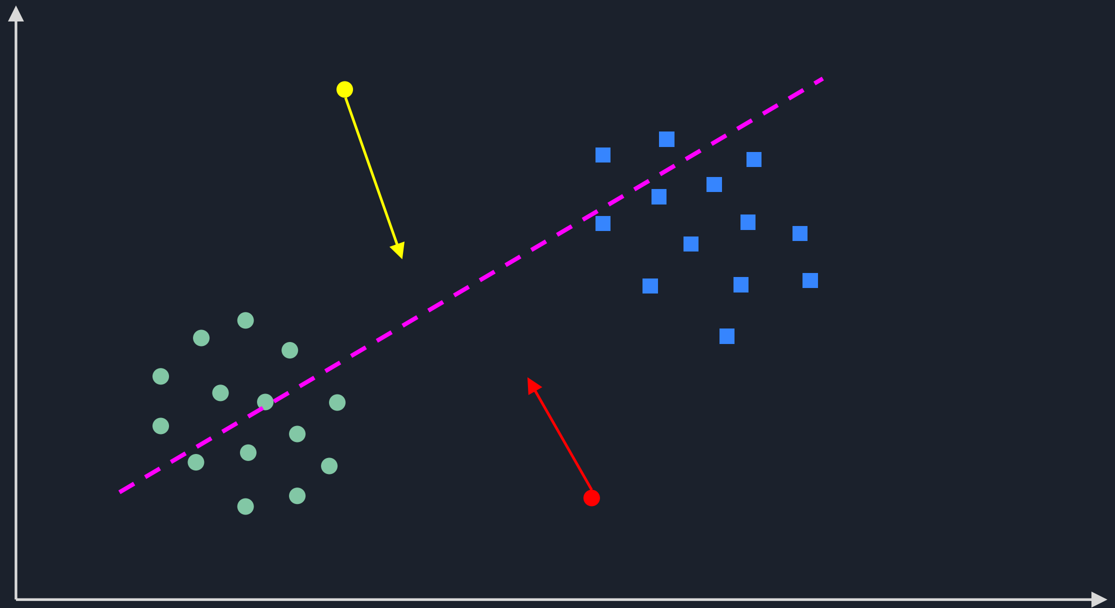
Means need to move to the centre of their members



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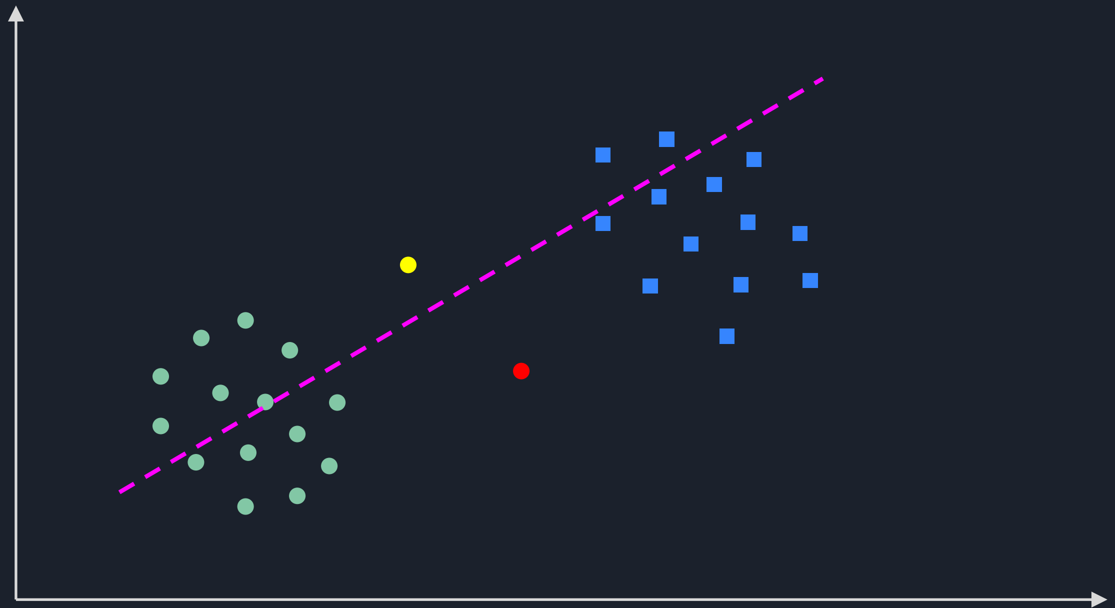
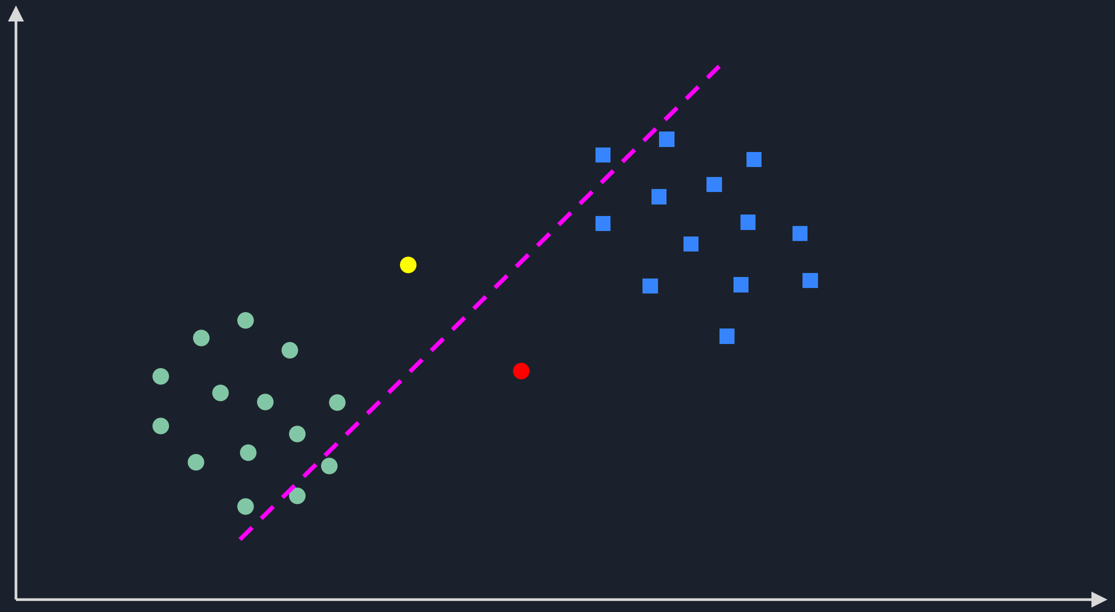
Means have moved and samples need to decide again



Switching sides



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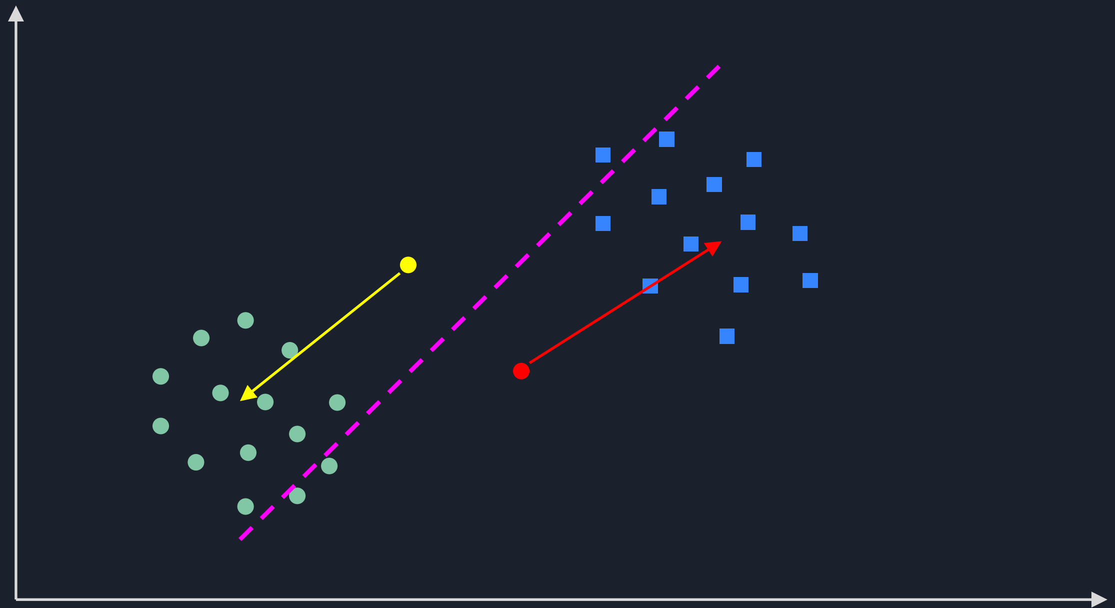
Mean needs to move again



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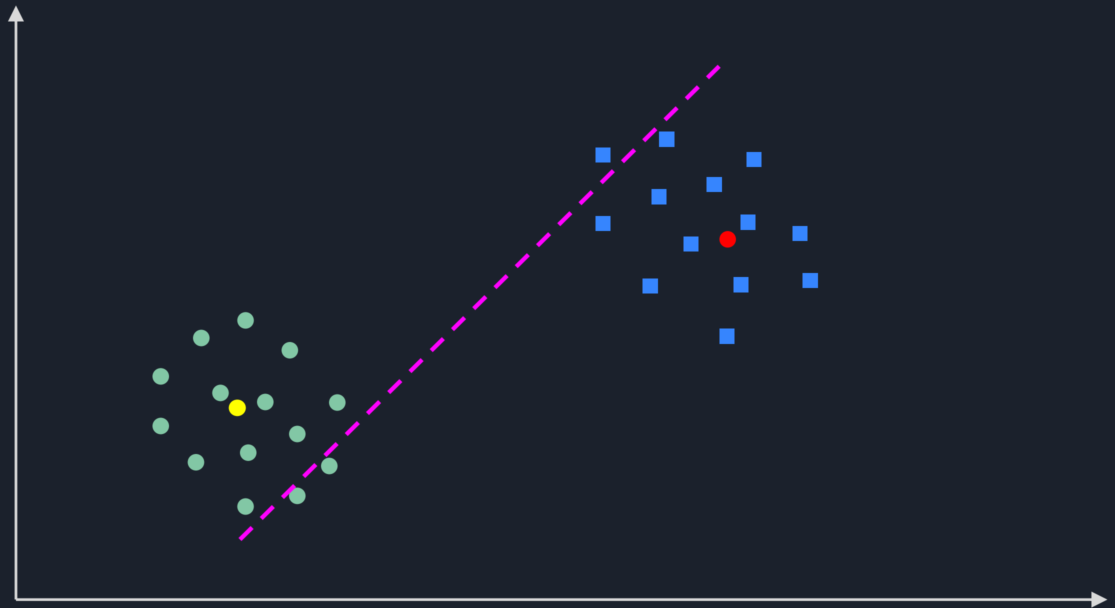
Samples decide again



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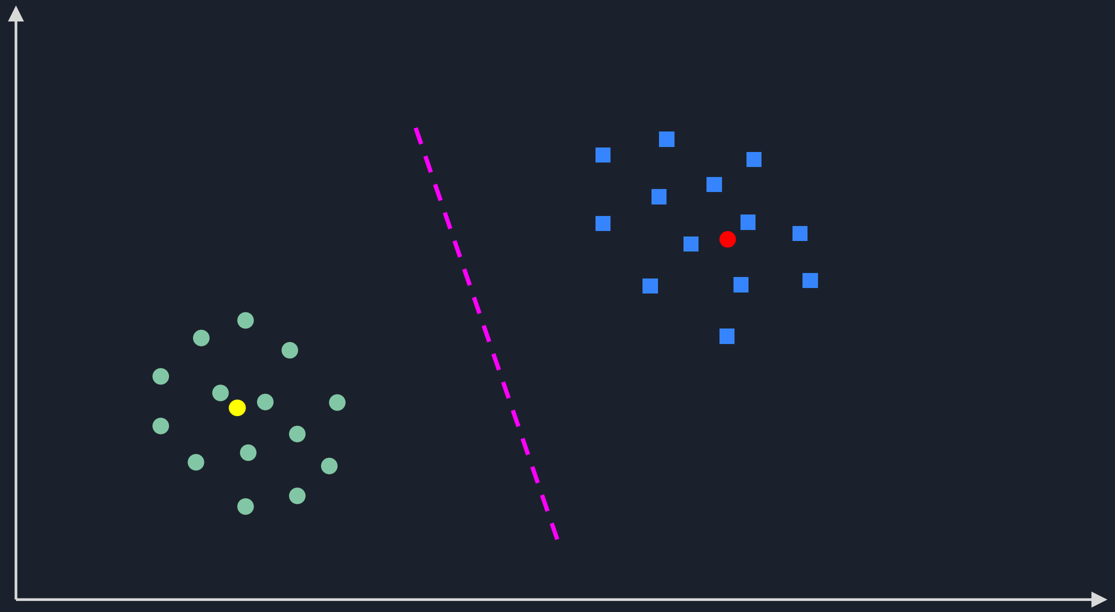
Switching sides



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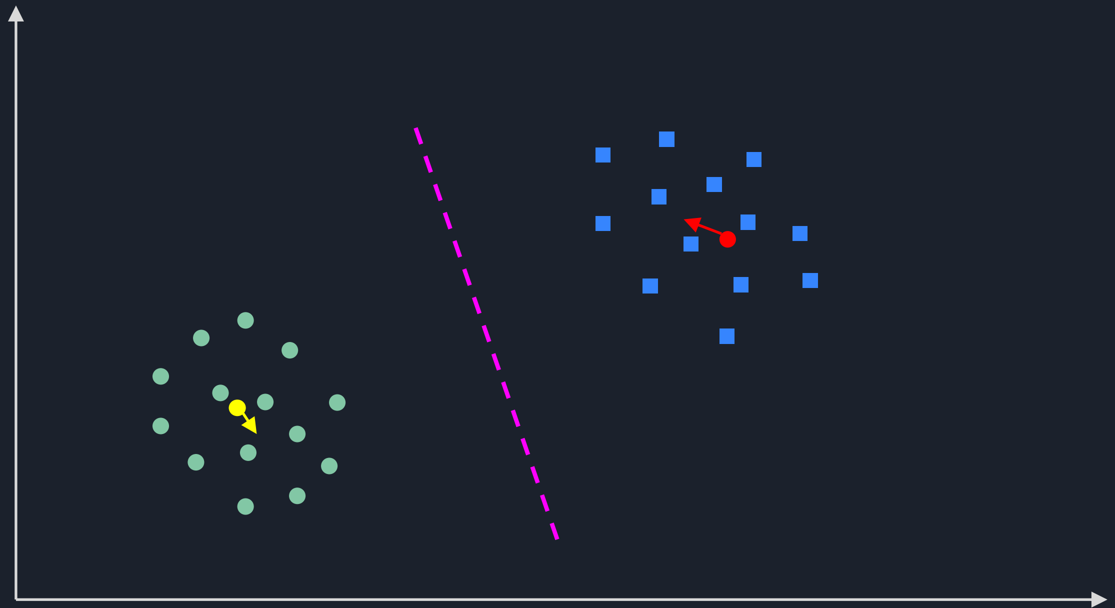
Means move again



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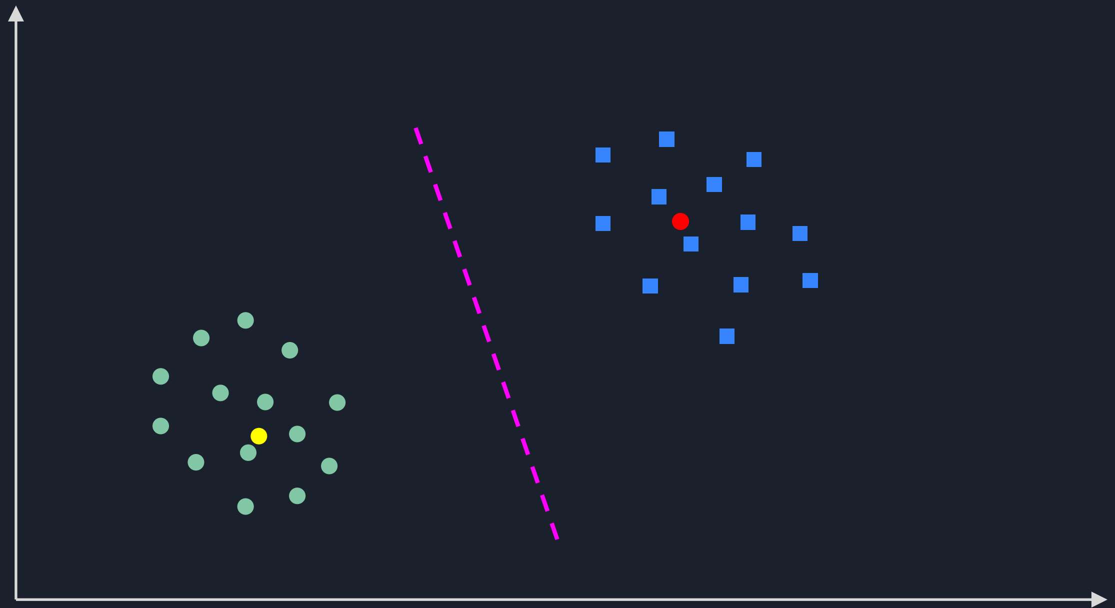
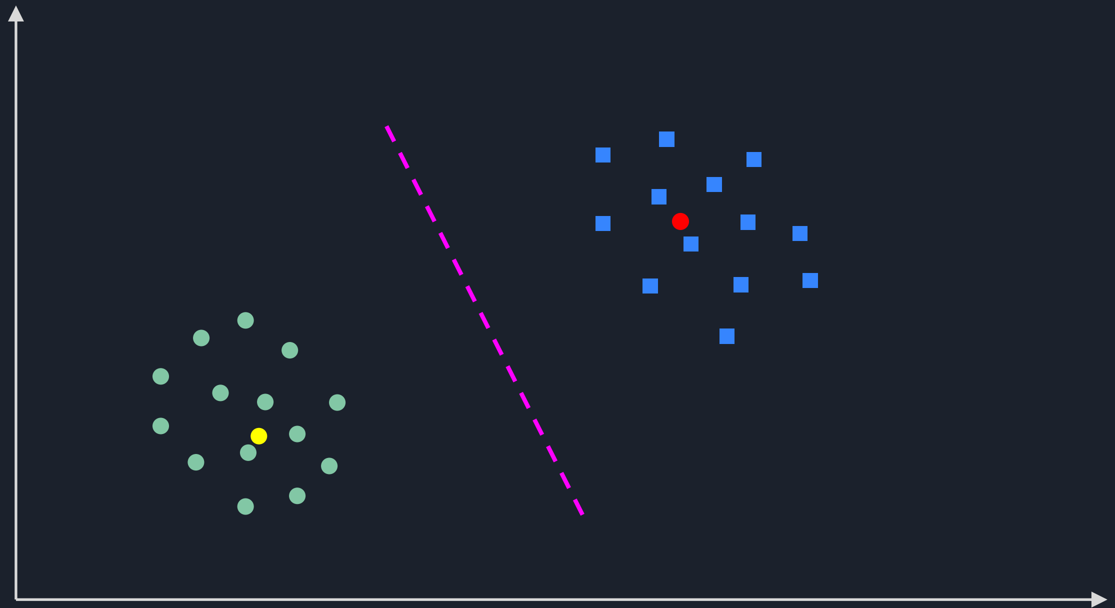
Samples need to decide again .. But ...



No need to switch anymore



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Further References

- Wikipedia -k-means clustering - Wikipedia
- Blogs :
  - Introduction to K-means Clustering - DataScience.com
  - Clustering using K-means algorithm – Towards Data Science
  - K means Clustering - Introduction - GeeksforGeeks
- Demo :
  - http://web.stanford.edu/class/ee103/visualizations/kmeans/kmeans.html
- API
  - sklearn.cluster.KMeans — scikit-learn 0.19.2
  - k-means clustering – MATLAB
  - Weka 3 - Data Mining with Open Source Machine Learning Software
- Books :
  - Pattern Recognition and Machine Learning – C.M. Bishop
- Related Papers
  - An efficient **k-means clustering** algorithm
  - Refining Initial Points for **K-Means Clustering.**
  - An efficient **k-means clustering** algorithm: Analysis and implementation
  - A **k-means clustering** algorithm

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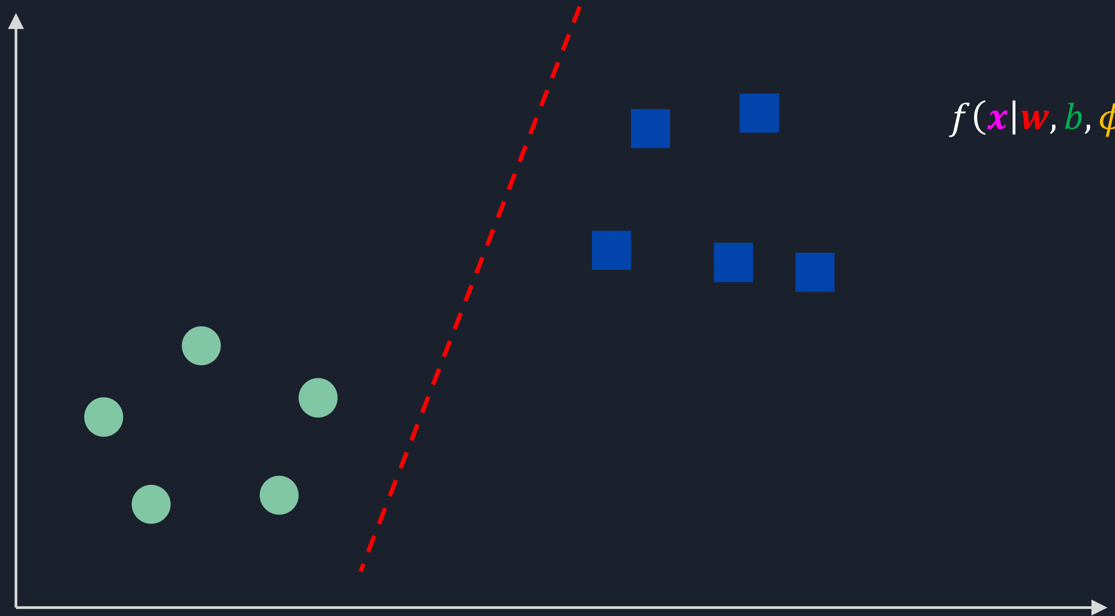
Support Vector Machines (SVM)

It all comes down to drawing a straight line



$$f(\boldsymbol{x}|\boldsymbol{w}, b, \phi) = \boldsymbol{w}^T \phi(\boldsymbol{x}) + b$$

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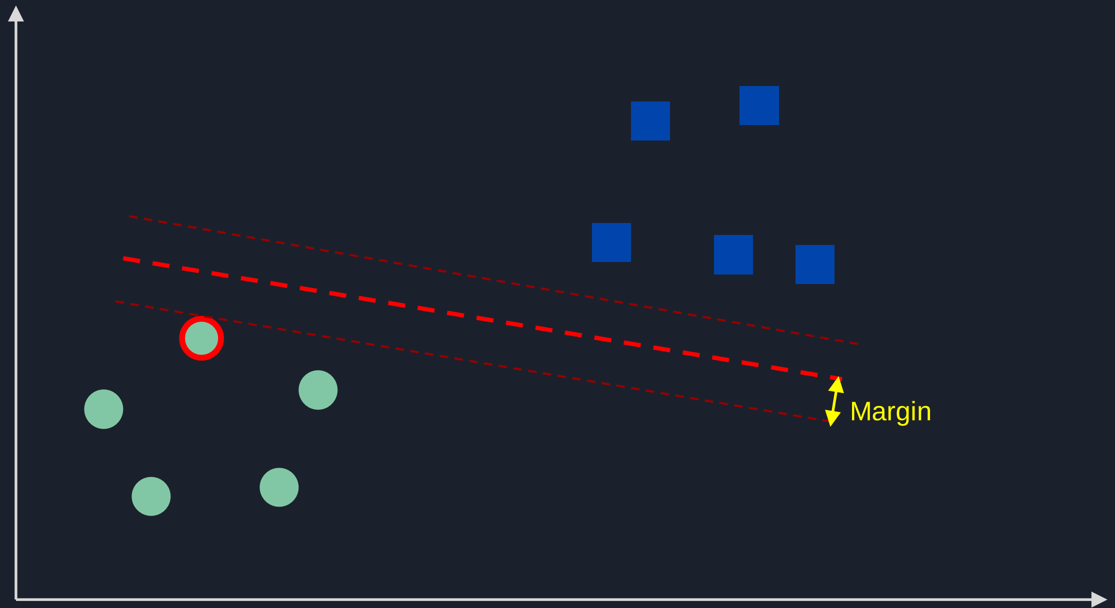
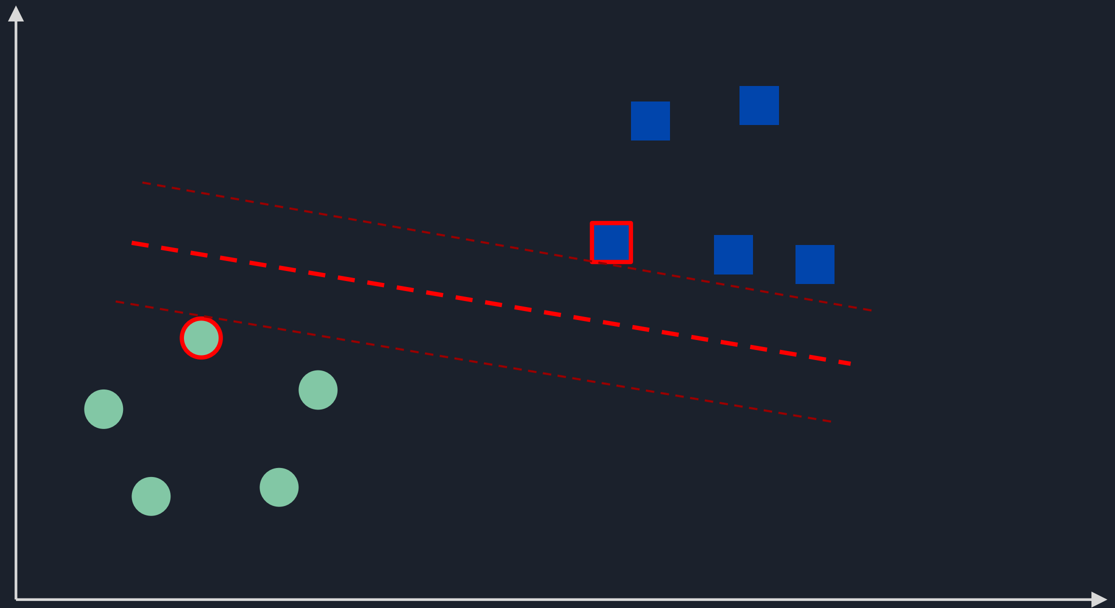
But where to position the line



But lots of options



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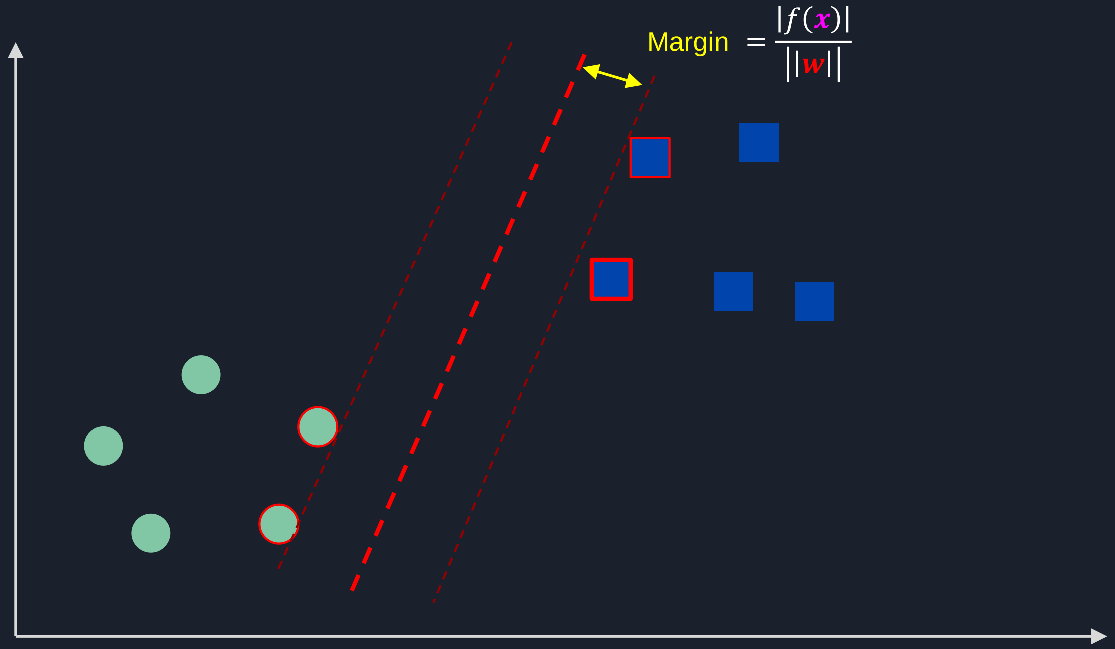
But lots of options



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A little bit of maths and voila

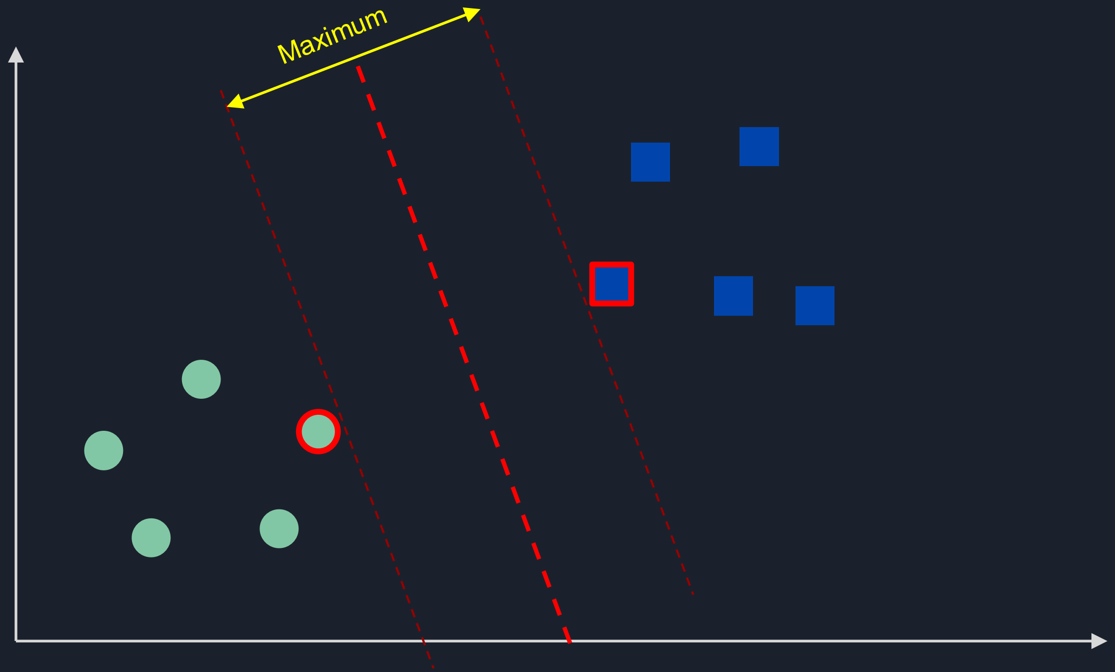
$$\frac{|f(\boldsymbol{x})|}{||\boldsymbol{w}||} = \frac{|\boldsymbol{w}^T\boldsymbol{x} + b|}{||\boldsymbol{w}||}$$

$$= \frac{|\kappa\boldsymbol{w}^T\boldsymbol{x} + \kappa b|}{||\kappa\boldsymbol{w}||}$$

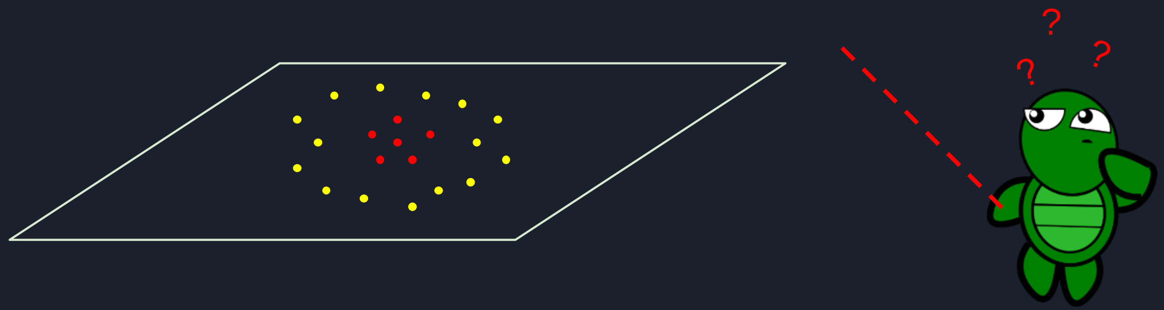
Set κ such a way so that $f(x)$ is 1 or -1 for the points closest to the line.
Then Maximum margin can be obtained by

$$\arg\max_{\boldsymbol{w}} \frac{1}{||\boldsymbol{w}||}$$

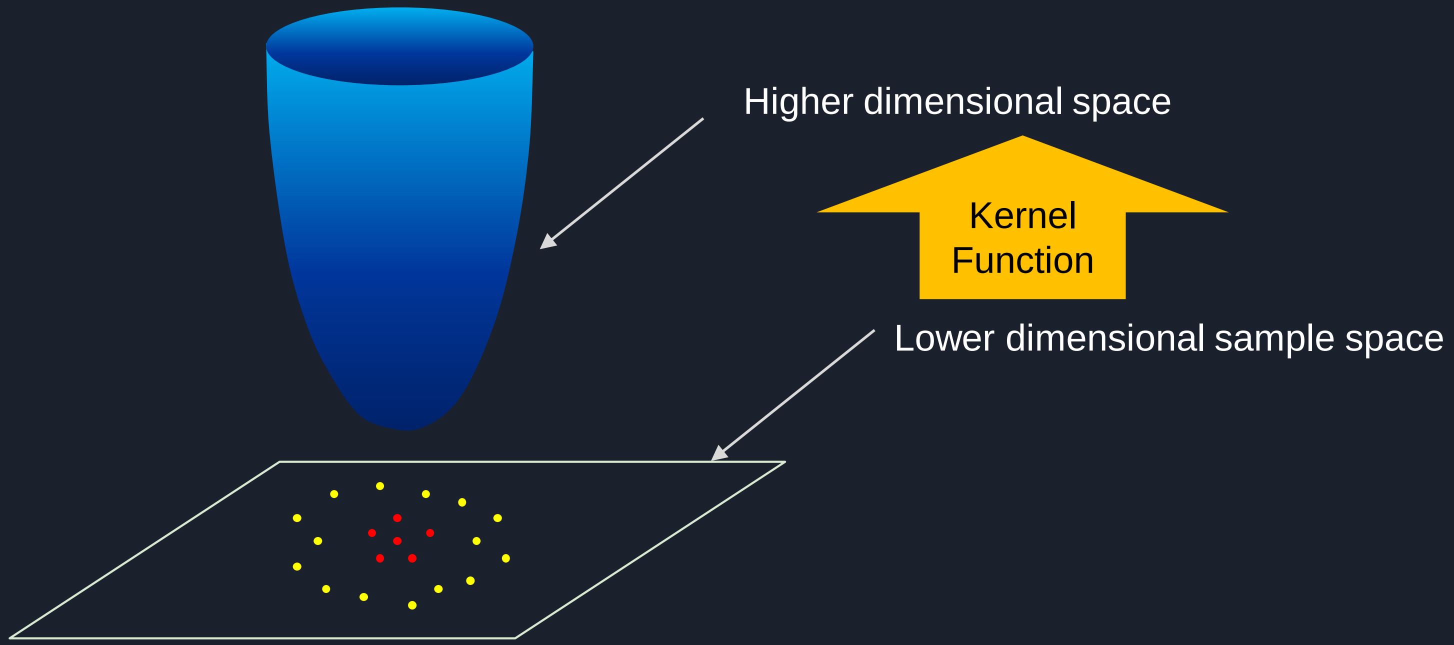
Fat is not always bad...



Is a straight line enough ?



Not in this dimension.. We need more dimensions...



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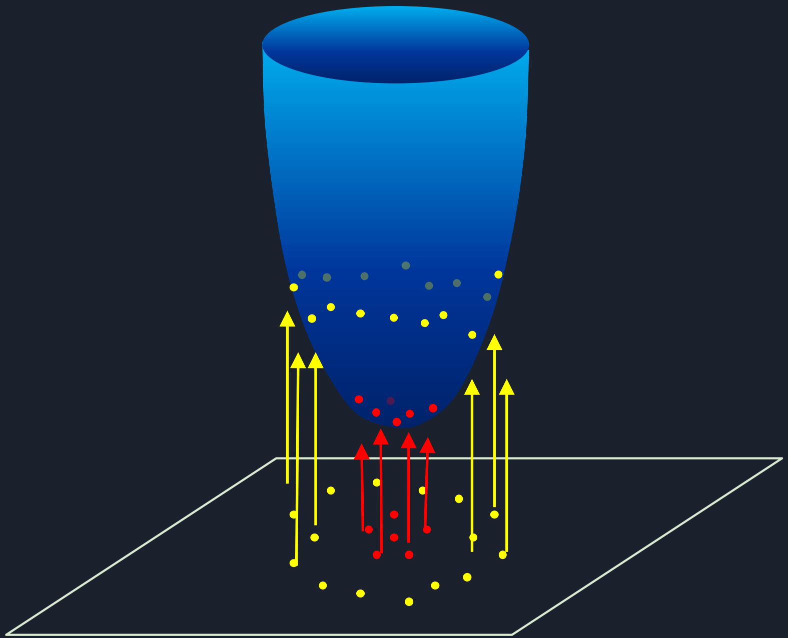
Map values to higher dimensional space



$x \rightarrow \kappa(x)$

κ = Kernel Function

Linear, Polynomial, RBF, Periodic, Gaussian ...

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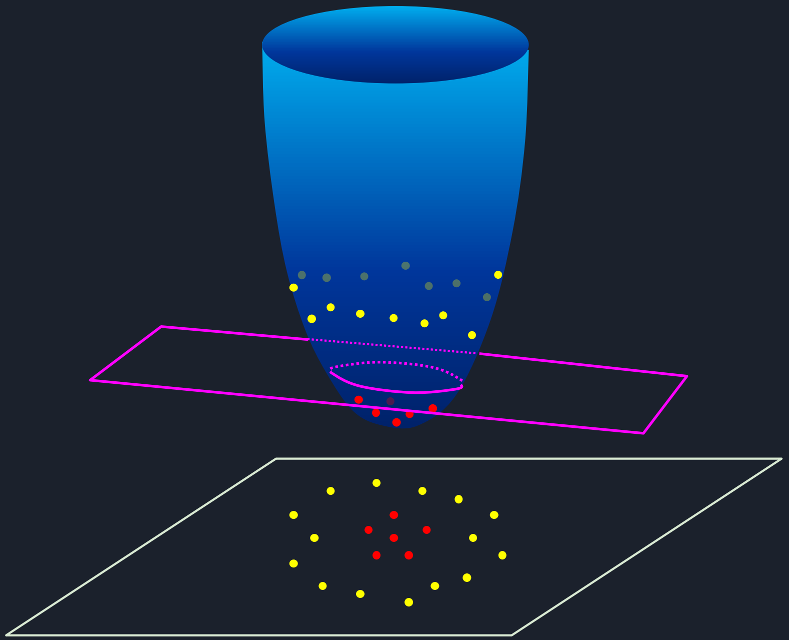
Create a hyperplane in the higher dimension



$$f(\boldsymbol{x}|\boldsymbol{w}, b, \kappa) = \boldsymbol{w}^T \kappa(\boldsymbol{x}) + b$$

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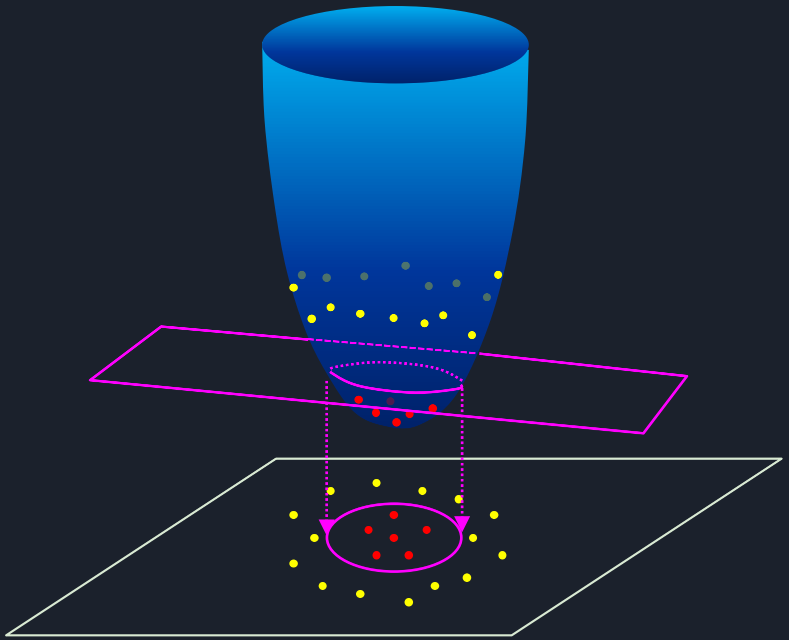
Map values back to the lower dimensional space



$$g(\boldsymbol{x}) = \kappa^{-1}(f(\boldsymbol{x}))$$

Further References

- Wikipedia -Support vector machine - Wikipedia
- Blogs :
  - Understanding Support Vector Machine algorithm from examples
  - Chapter 2 : SVM (Support Vector Machine) — Theory
  - Support Vector Machines for Machine Learning
- API
  - Support Vector Machines — scikit-learn 0.19.2
  - Support Vector Machines for Binary Classification – MATLAB
  - Weka 3 - Data Mining with Open Source Machine Learning Software
  - LIBSVM -- A Library for Support Vector Machines
- Books :
  - Pattern Recognition and Machine Learning – C.M. Bishop
  - Learning with kernels - Bernhard Schölkopf
- Related Papers
  - Support vector machines
  - Measuring the VC-dimension of a learning machine

Multilayer Perceptrons (MLP)

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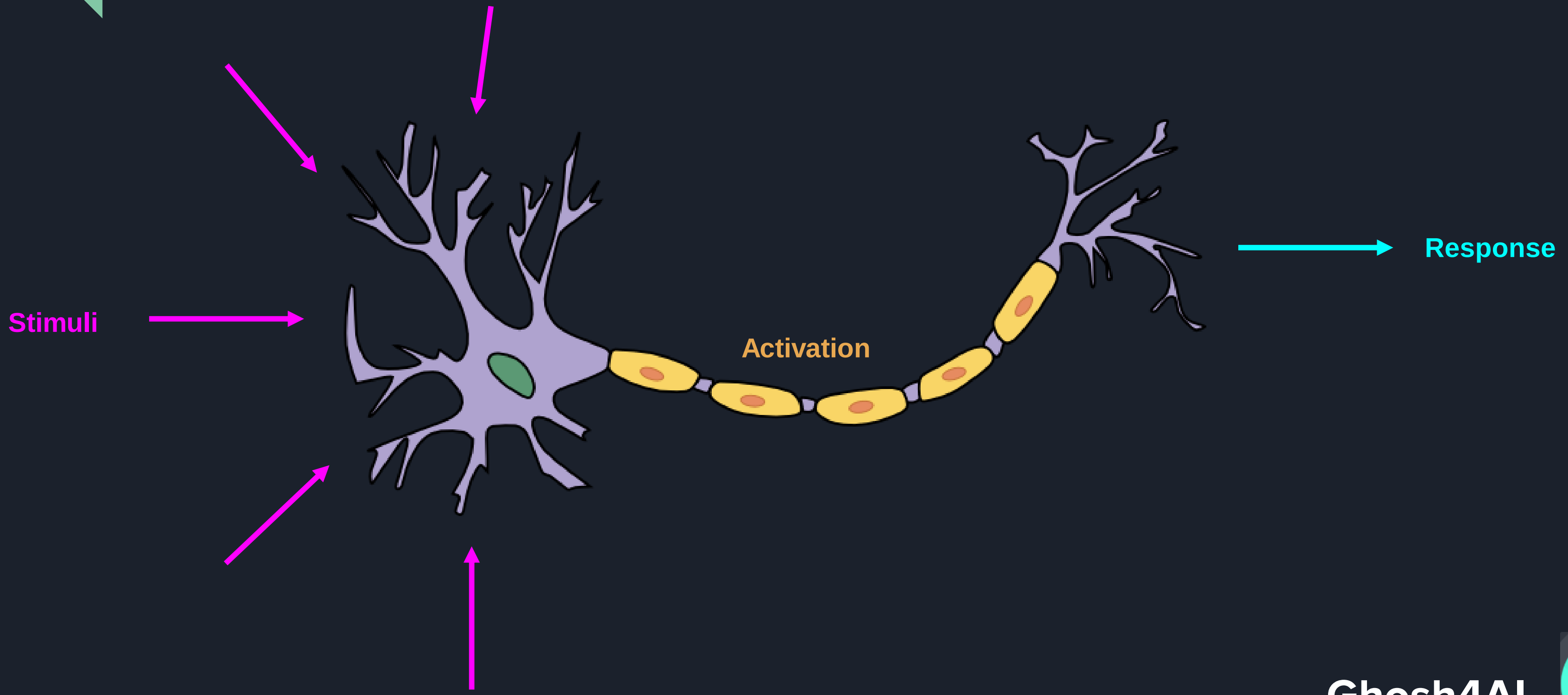
The real neuron



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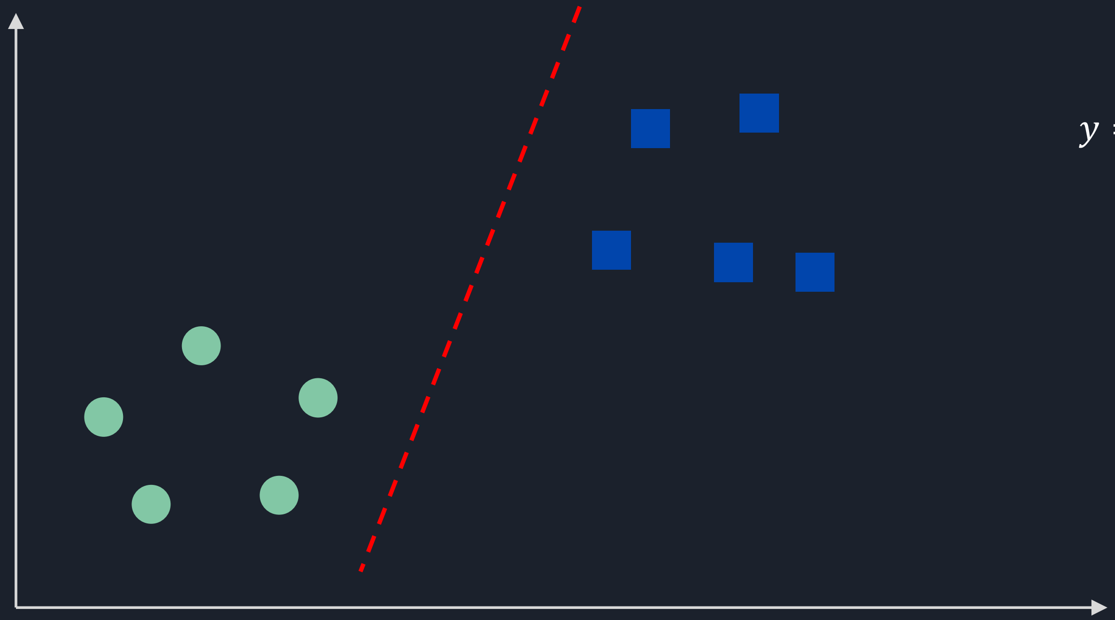
Decision as a straight line



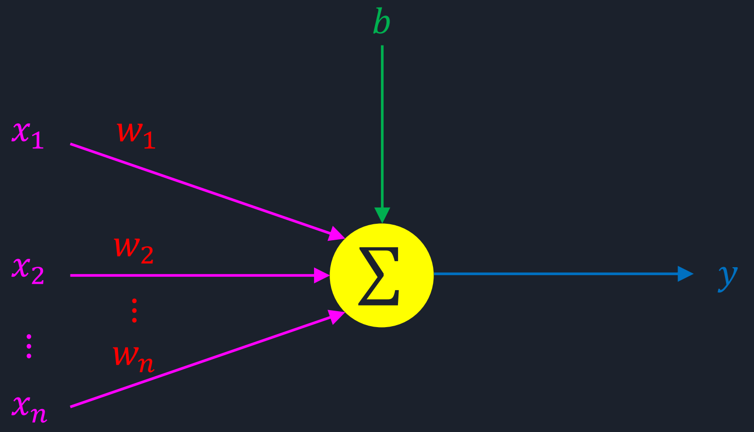
$$y = \boldsymbol{w}^T \boldsymbol{x} + b$$

The straight line

$$y = \boldsymbol{w}^T \boldsymbol{x} + b$$

$$y = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} [x_1 \quad x_2 \quad \dots \quad x_n] + b$$

$$y = \sum_{i}^{n} w_i x_i + b$$



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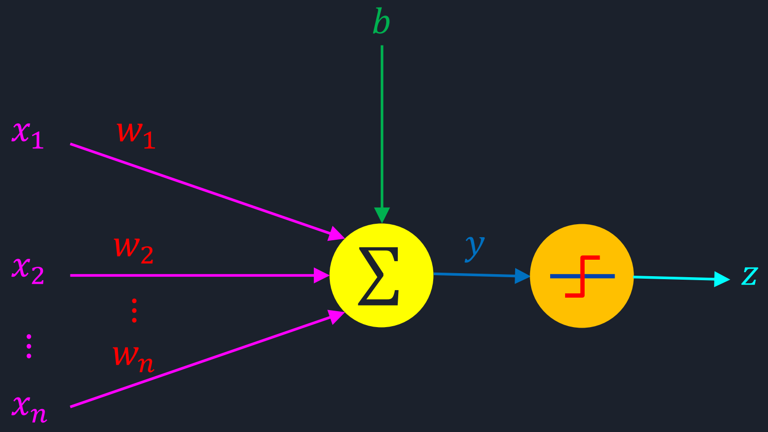
The artificial Neuron making decisions

$$y = \boldsymbol{w}^T \boldsymbol{x} + b$$

$$y = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} [x_1 \ \ x_2 \ \ \ldots \ \ x_n] + b$$

$$y = \sum_{i}^{n} w_i x_i + b$$

$$z = sign\left(\sum_{i}^{n} w_i x_i + b\right)$$



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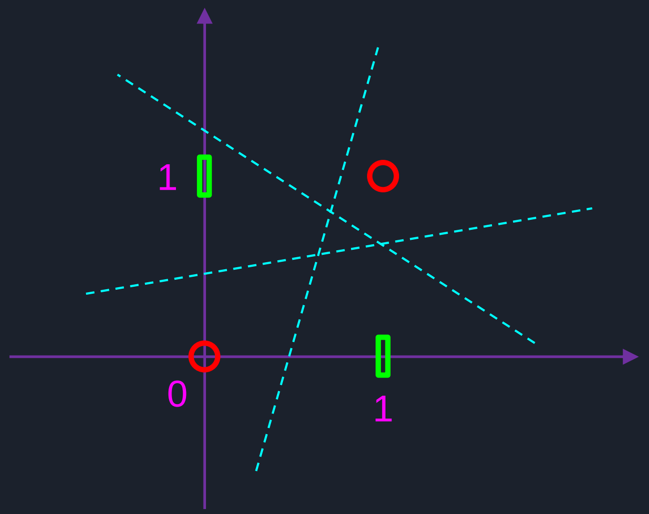
Is a straight line enough ?

$$z = sign(w^T \boldsymbol{x} + b)$$



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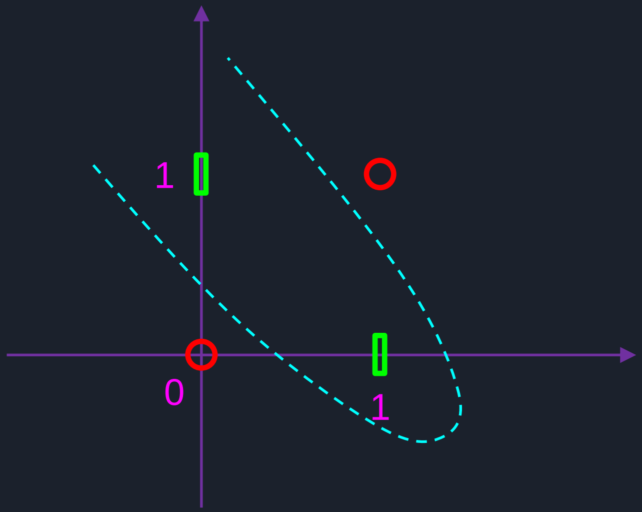
Bend the line

$$z = f_{NL}(\boldsymbol{w}^T \boldsymbol{x} + b)$$

Non Linear Function



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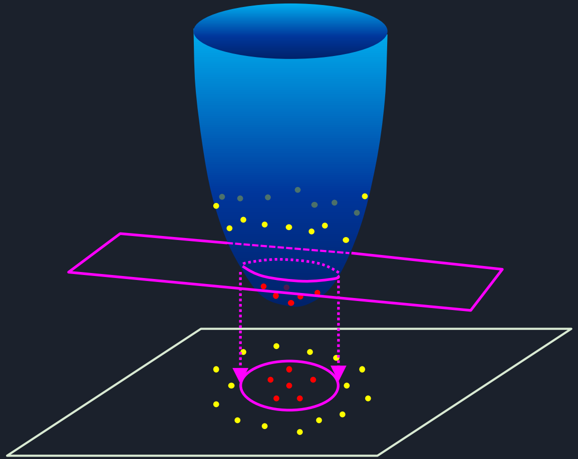
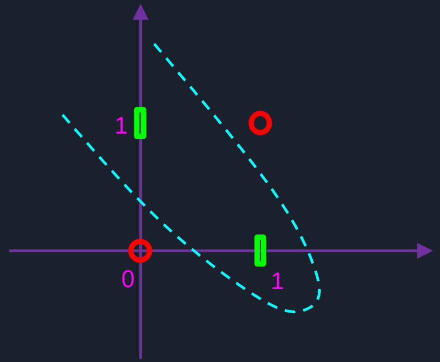
SVM vs Neural Networks



$z = w^T \phi(x) + b$



$z = f_{NL}(w^T x + b)$

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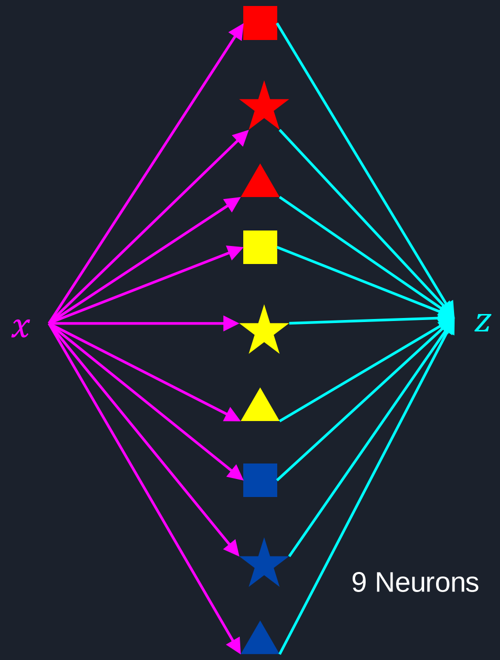
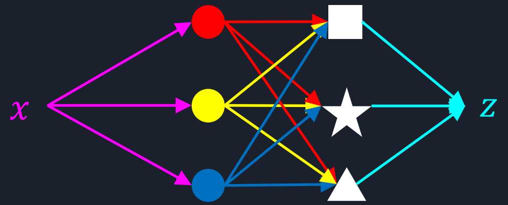
Stack them up...

Colours = { red, yellow, blue }, Shapes = { Square, Triangle and Star }





6 Neurons

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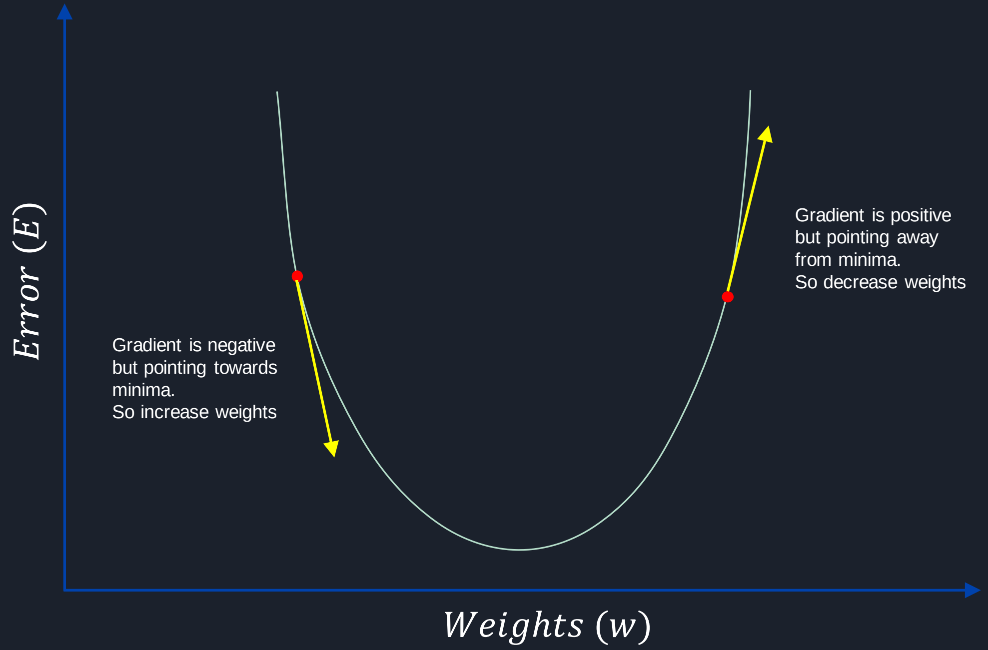
The gradient



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How to calculate weights ?

Change in error
with respect to
change in weights

$$\boldsymbol{w} = \boldsymbol{w} - \eta \frac{dE}{d\boldsymbol{w}}$$

$$E = L(z_{observed}, z_{actual})$$

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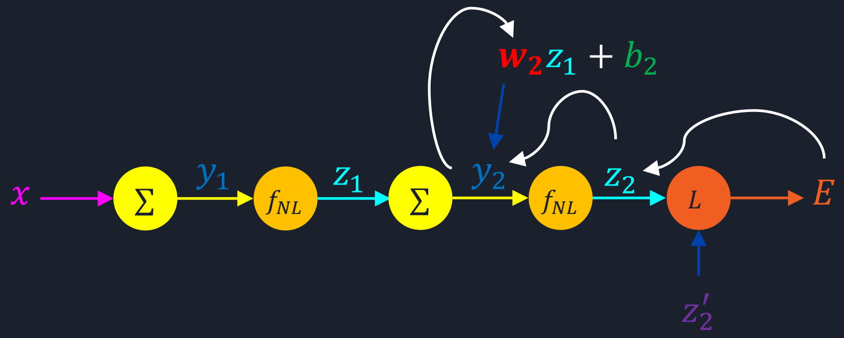
Derivative to chain of partial derivatives



$$E = L(z_2, z_2')$$

$$\frac{dE}{dw_2} = \frac{\delta E}{\delta z_2} \cdot \frac{\delta z_2}{\delta y_2} \cdot \frac{\delta y_2}{\delta w_2}$$

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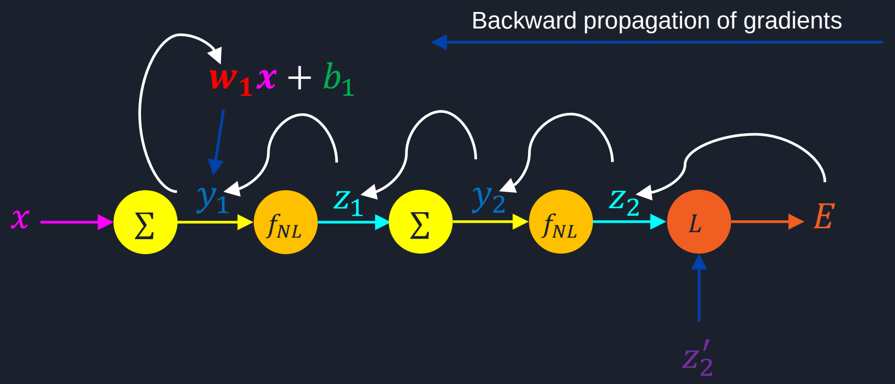
Backpropagation through multiple layers



$$E = L(z_2, z_2')$$

$$\frac{dE}{dw_1} = \frac{\delta E}{\delta z_2} \cdot \frac{\delta z_2}{\delta y_2} \cdot \frac{\delta y_2}{\delta z_1} \cdot \frac{\delta z_1}{\delta y_1} \cdot \frac{\delta y_1}{\delta w_1}$$

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Further References

- Wikipedia -Artificial neural network - Wikipedia
- Blogs :
  - Neural networks and deep learning
  - How to build your own Neural Network from scratch in Python
  - What is a neural network? - Introduction to deep learning
- Demo :
  - A Neural Network Playground
  - Neural Network demo — Preset: Binary Classifier for XOR
- API
  - Neural network models (supervised) — scikit-learn 0.19.2
  - Neural Network Toolbox - MATLAB – MathWorks
  - Weka 3 - Data Mining with Open Source Machine Learning Software
  - TensorFlow
  - PyTorch
- Books :
  - Pattern Recognition and Machine Learning – C.M. Bishop
  - Neural networks- Simon S. Haykin
- Related Papers
  - Learning internal representations by error propagation
  - The perceptron: a probabilistic model for information storage and organization in the brain.
  - A learning algorithm for continually running fully recurrent neural networks
  - 30 years of adaptive neural networks

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Principal Component Analysis (PCA)

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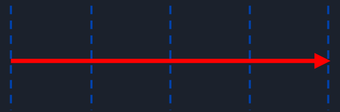
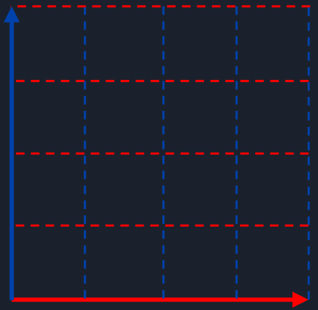
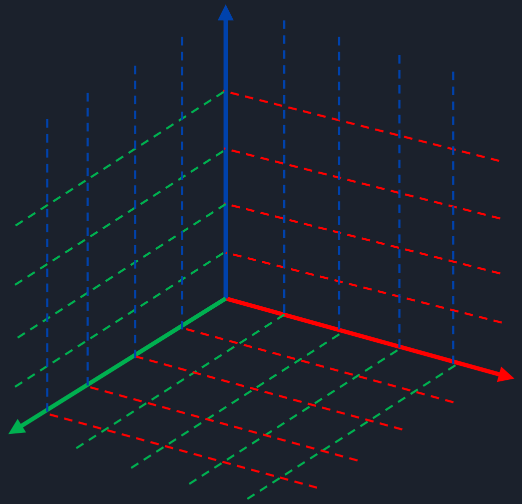
The curse of dimensionality



4 regions



16 regions



64 regions

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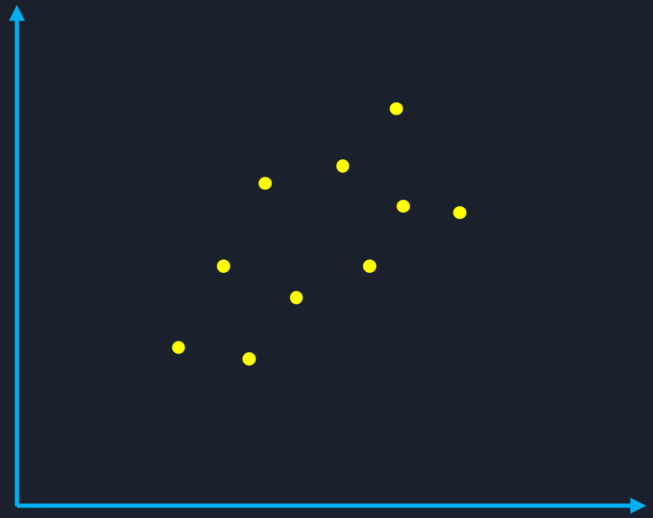
2 dimensions to represent sample space



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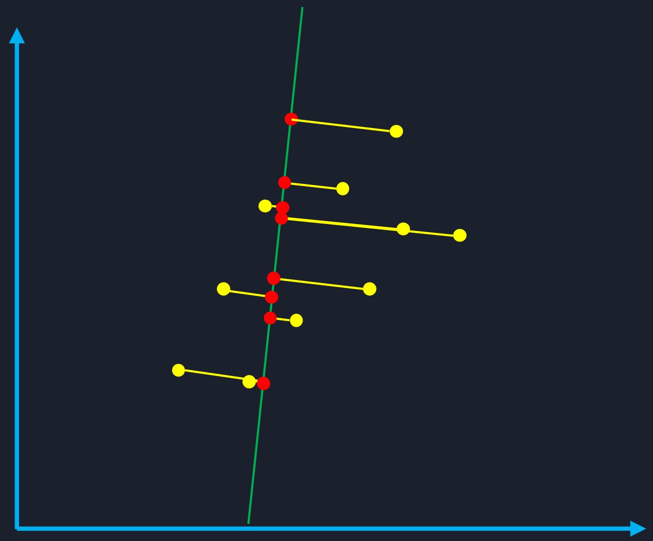
Mapping from 2 dimension to a single dimension.



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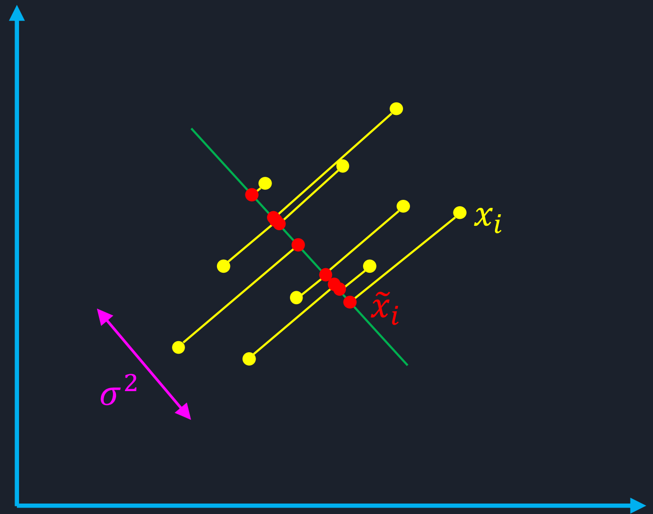
We want the samples to be distinct in the new dimension… so, more variance



Goal :

- $Maximize\ \sigma^2$ or
- $Minimize\ \sum_i (x_i - \tilde{x}_i)^2$.

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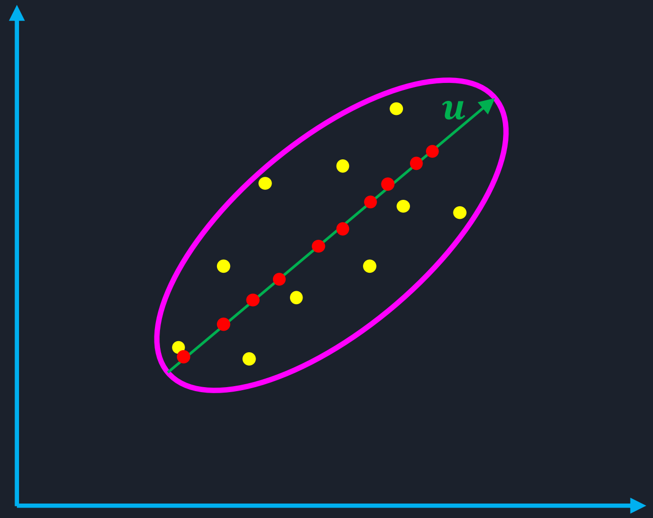
Along the major axis of an ellipse



u is the eigen vector corresponding to the largest eigen value

Further References

- Wikipedia -Principal component analysis - Wikipedia
- Blogs :
  - A One-Stop Shop for Principal Component Analysis – Towards Data Science
  - Understanding Principal Component Analysis – Rishav Kumar - Medium
  - Practical Guide to Principal Component Analysis (PCA) in R & Python
- Demo :
  - http://setosa.io/ev/principal-component-analysis/
- API
  - sklearn.decomposition.PCA — scikit-learn 0.19.2
  - Principal component analysis (PCA) on data - MATLAB princomp
  - Weka 3 - Data Mining with Open Source Machine Learning Software
- Books :
  - Pattern Recognition and Machine Learning – C.M. Bishop
  - **Principal components analysis – GH Dunteman**
- Related Papers
  - **Principal component analysis**