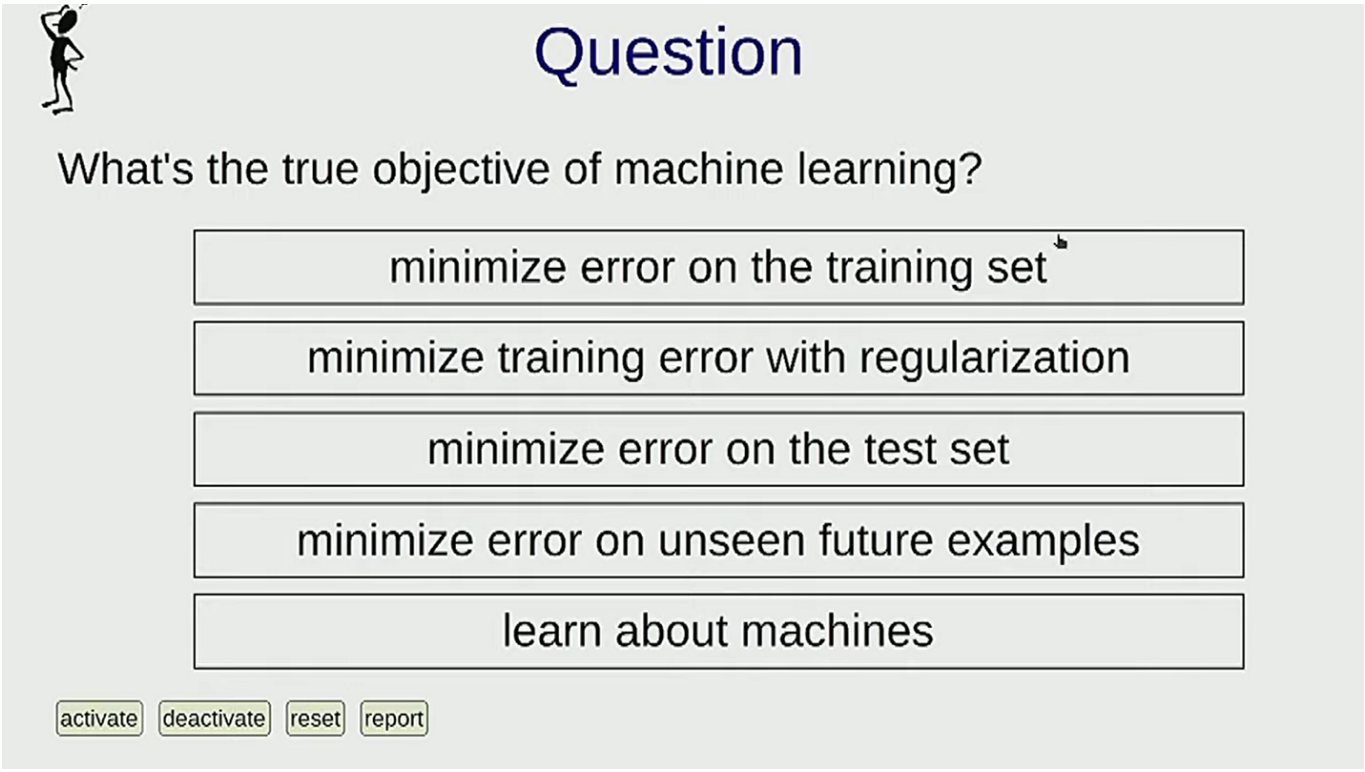
Machine Learning 3 - Generalization, K-means

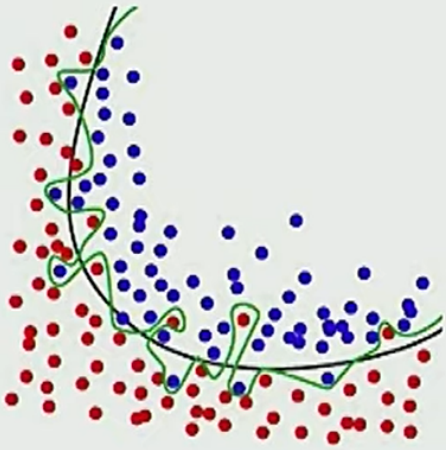
True goal for machine learning

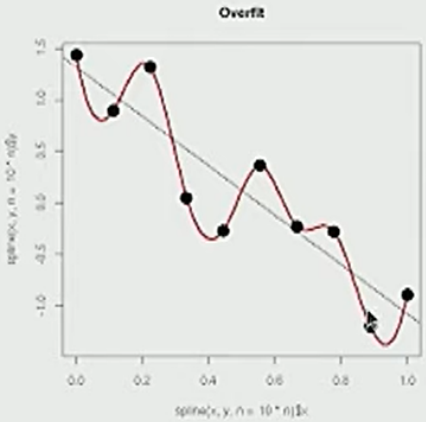


Is to minimize error on unseen future examples

Generalization

Overfitting pictures





Classification

Regression

Evealuation & Prevent overfitting

Evaluation

$\mathcal{D}_{\text{train}}$ → Learner → f

How good is the predictor f?

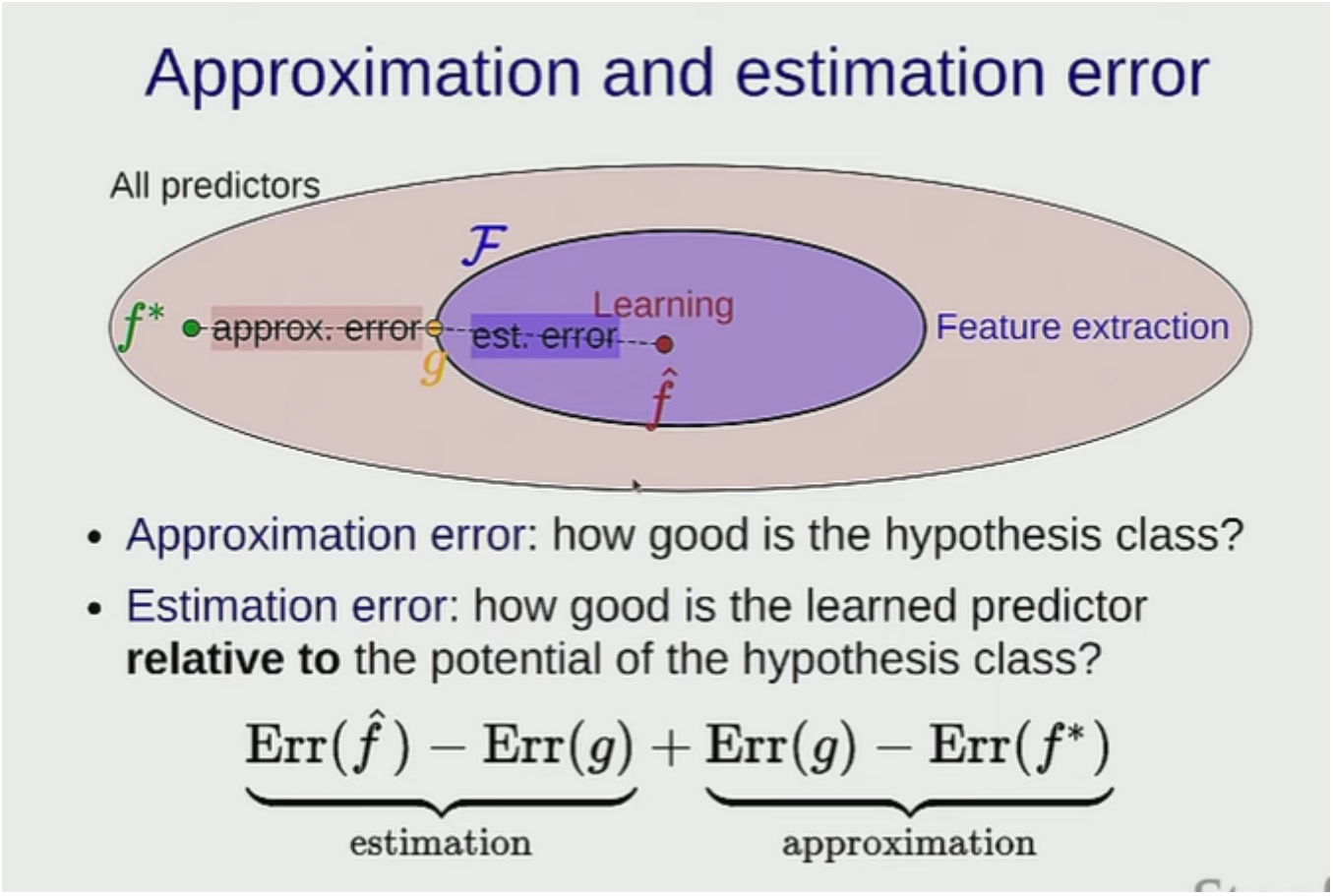
Key idea: the real learning objective

Our goal is to minimize **error on unseen future examples**.

Don't have unseen examples; next best thing:

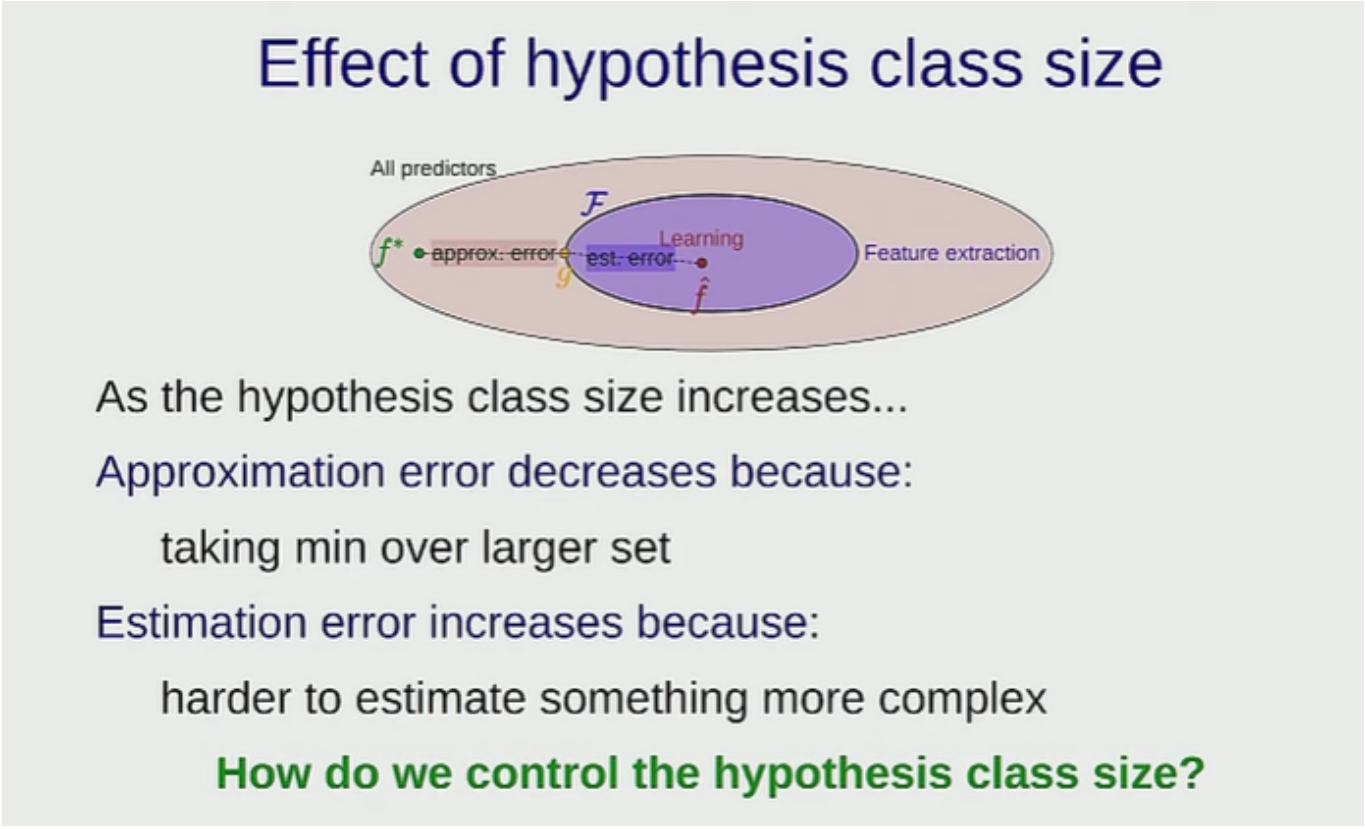
Definition: test set

Test set $\mathcal{D}_{\text{test}}$ contains examples not used for training.

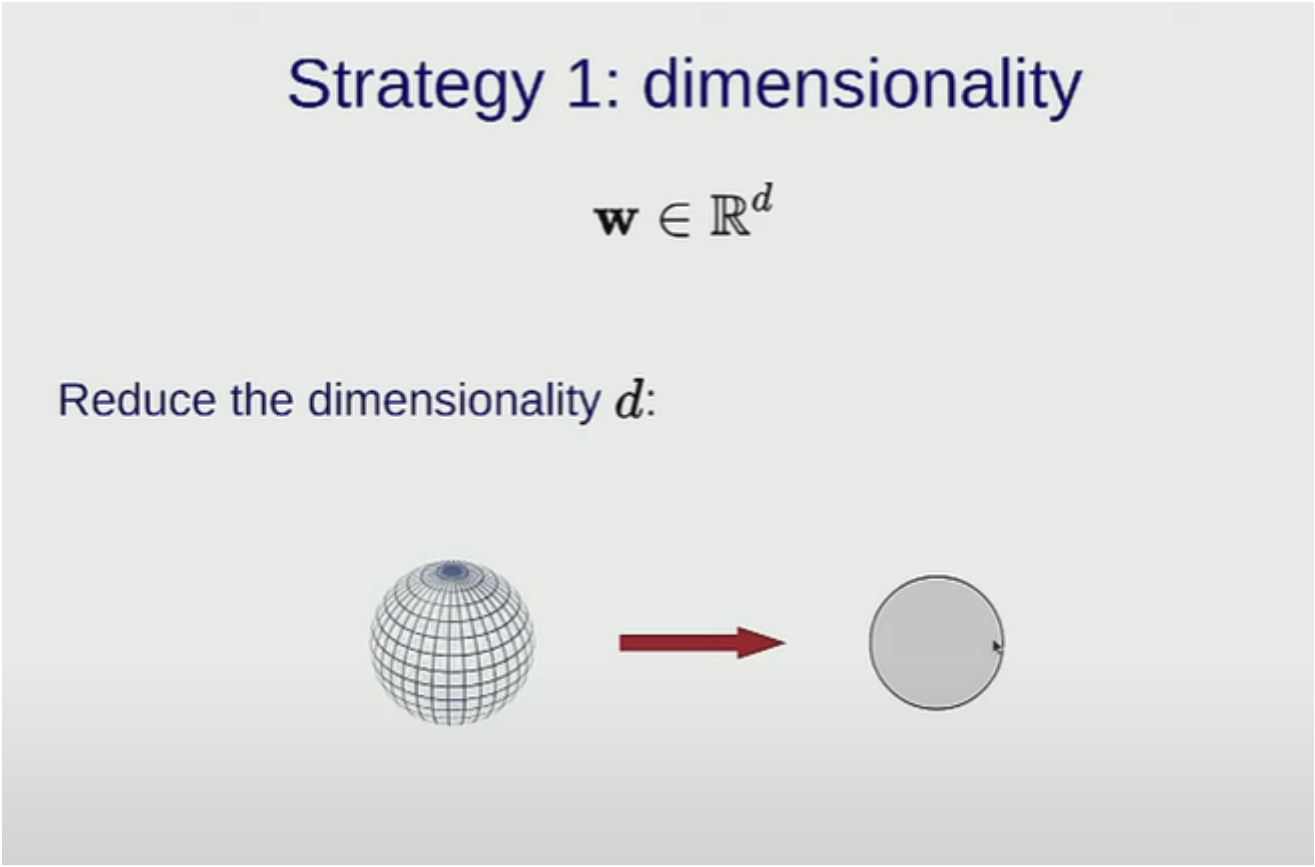


f*: The ture function/answer, the function that always get he right answer g: The best prefictor you can get in your hypothesis calss (The fuctions u get can after feature engineering)

It is quite a trade-off



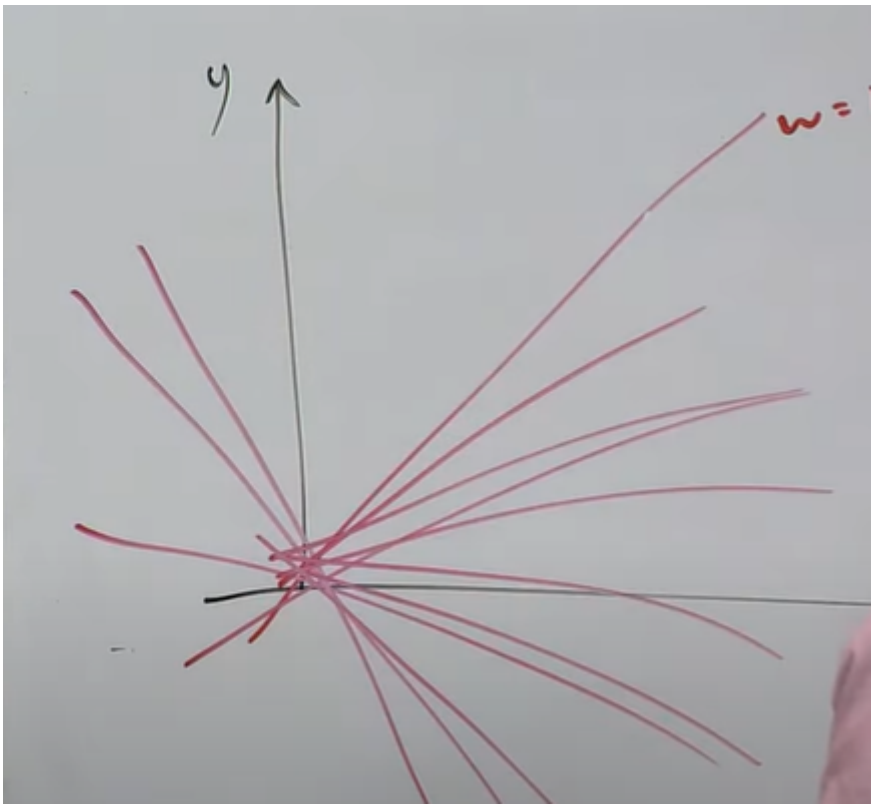
How to control the size of Hypothesis class



Norm

Let say we have a linear regression y = wx The whole function space would be all linears lines that pass the origin

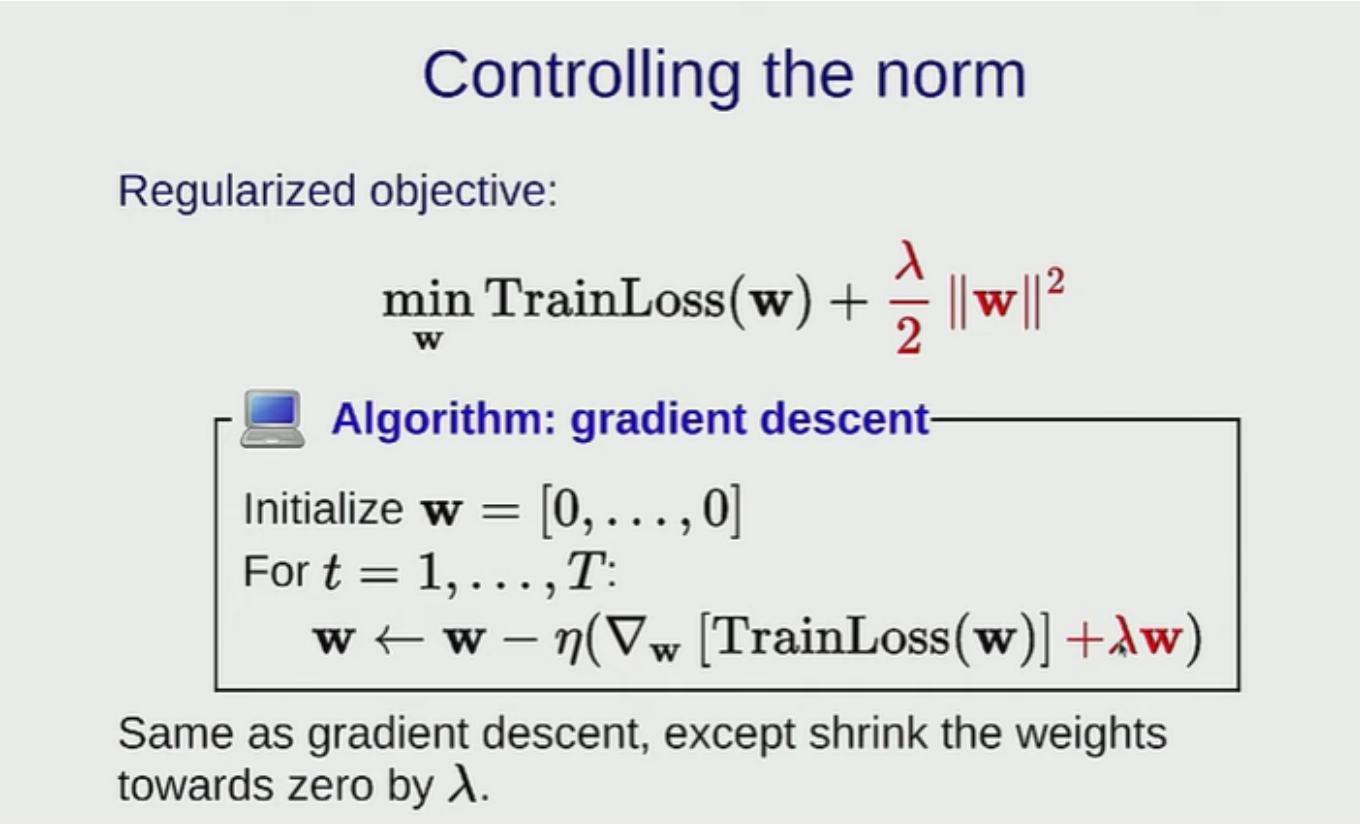
If somehow we can define, let's say the w is smaller or closer to 0, then we can eliminate many useless function, and thus reduce the norm



This means shrink the total number of weight vectors that you are considering, as u putting more constraints, they will be smaller

Regularization

Controlling the norm



You can add some `panelty` to your Traning loss function

This is saying: Optimizer, you should try to make trianing loss small, but also try to make the second part(weight vectors) small as well

So this is saying that, fit the data but not at the costs of having huge weight vectors(Which may be overfitting)

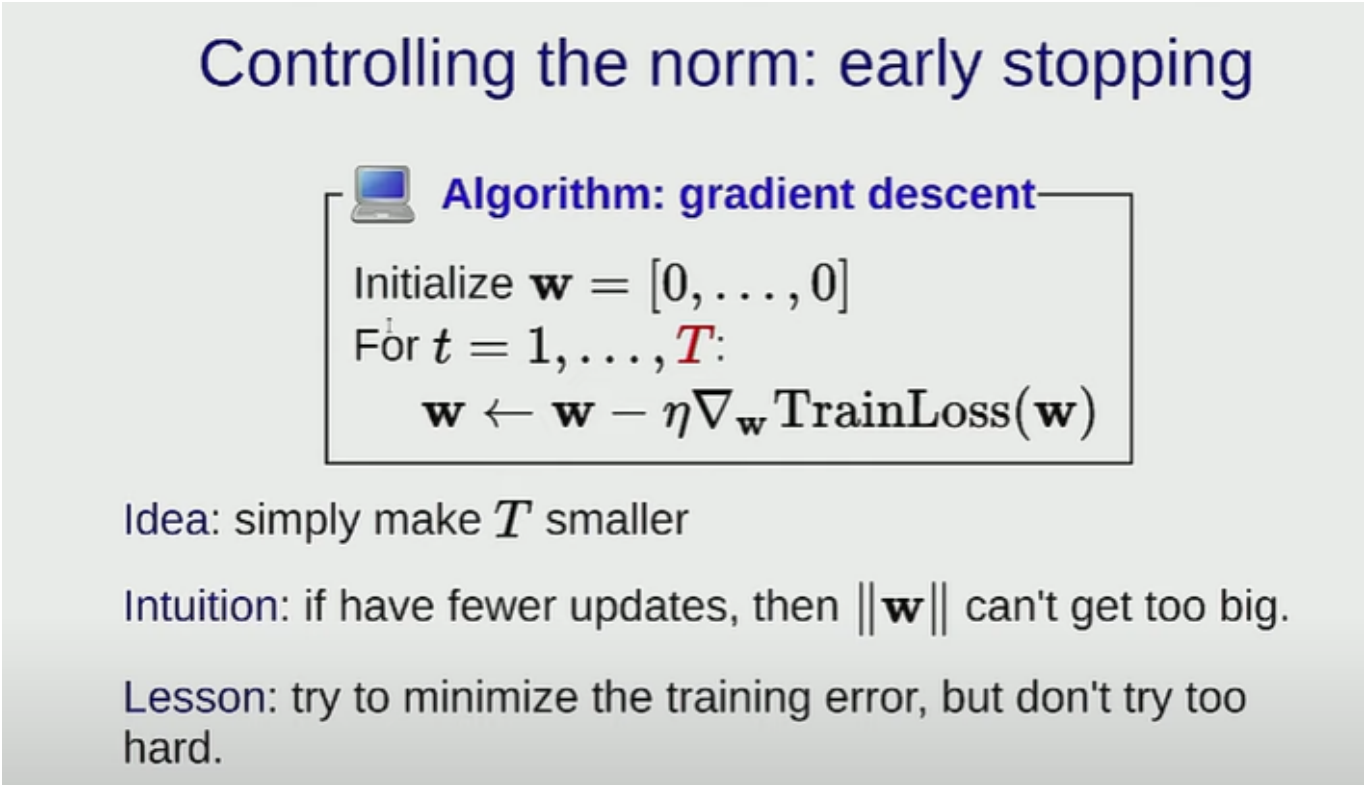
It is important that these need to be the same w and you are optimizing the sum

How to do it

Gradient descent

Controlling the Norm - early stopping

Just stop early



Because normaly we initialize the weights from a baseline near 0, For neural nets, we might give it a random value near 0

IF u have a pre-given weights, then basically ur saying don't go too far from ur initialization

We start the norm/weight vector from 0, and for each training, generally the norm gonna goes up. So if you stop earlier, you won't give norm much chance to grow too big

Hyperparameters

How to choose them?

Hyperparameters

Definition: hyperparameters

Properties of the learning algorithm (features, regularization parameter λ, number of iterations T, step size η, etc.).

How do we choose hyperparameters?

Choose hyperparameters to minimize $\mathcal{D}_{\text{train}}$ error? **No** - solution would be to include all features, set $\lambda = 0$, $T \to \infty$.

Choose hyperparameters to minimize $\mathcal{D}_{\text{test}}$ error? **No** - choosing based on $\mathcal{D}_{\text{test}}$ makes it an unreliable estimate of error!

Validation

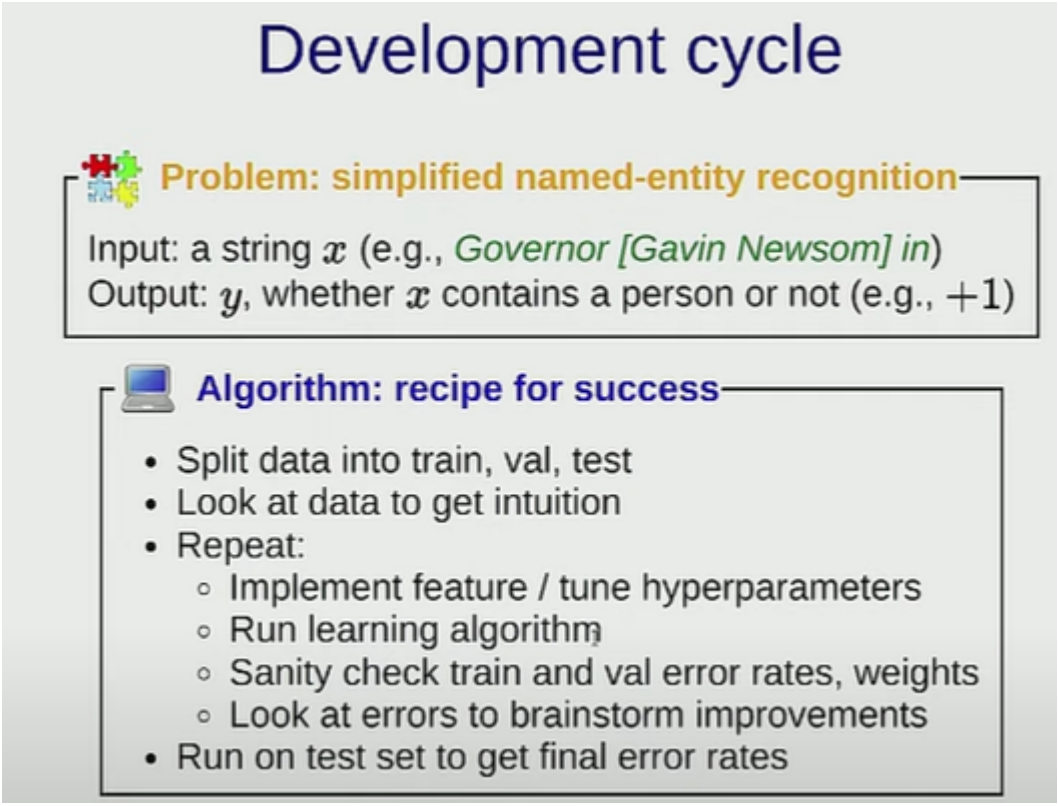
Problem: can't use test set!

Solution: randomly take out 10-50% of training data and use it instead of the test set to estimate test error.

Definition: validation set

A **validation set** is taken out of the training data which acts as a surrogate for the **test set**.

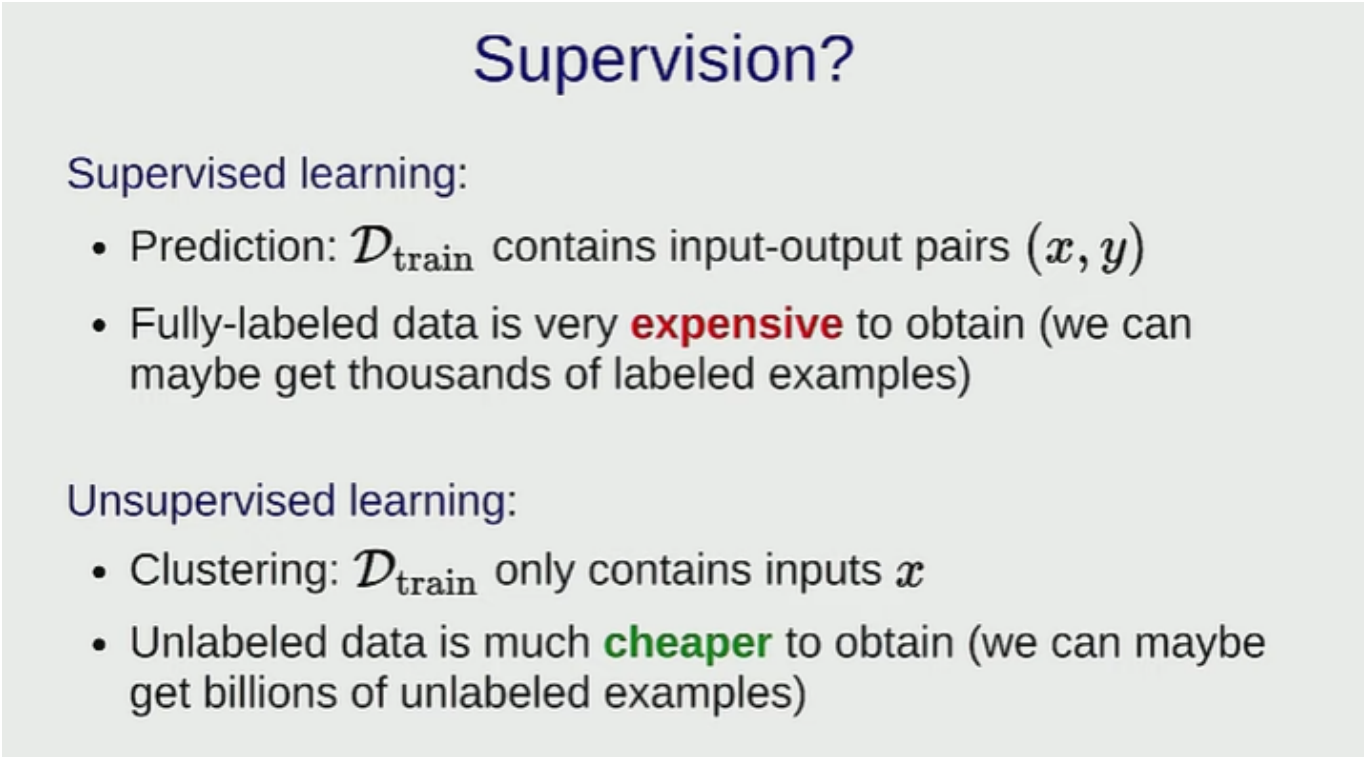
Normal Training Process



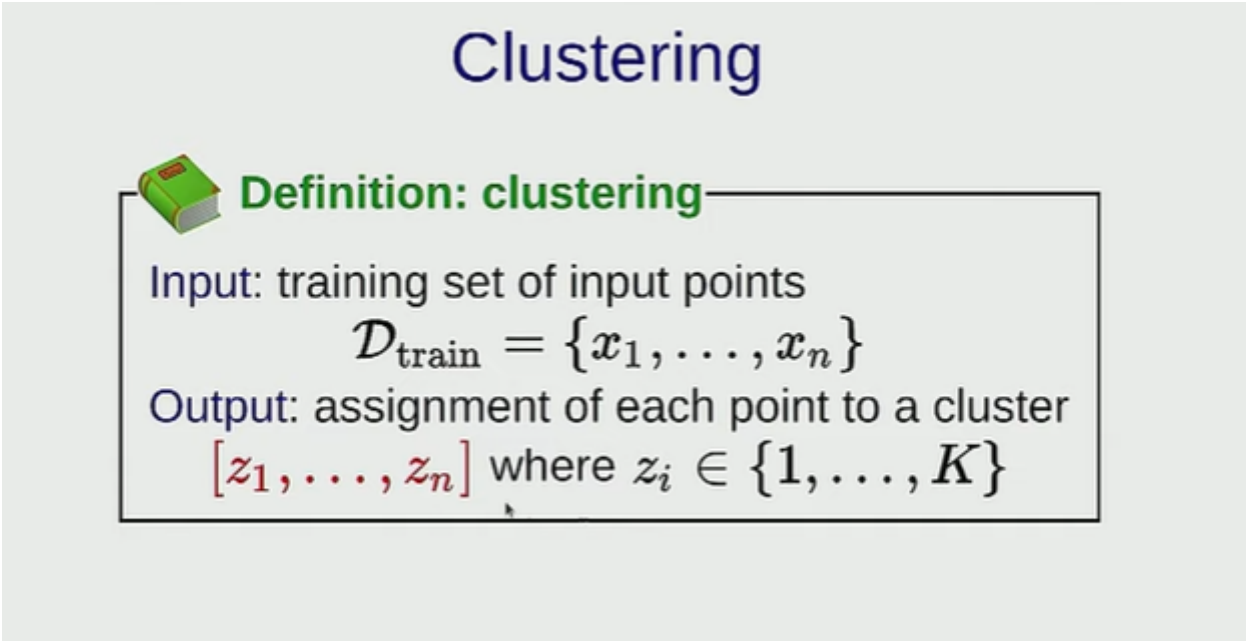
You can start with quite specific features and then generalize it

Unsupervised learning

Fully labaled data is very expensive to obtain

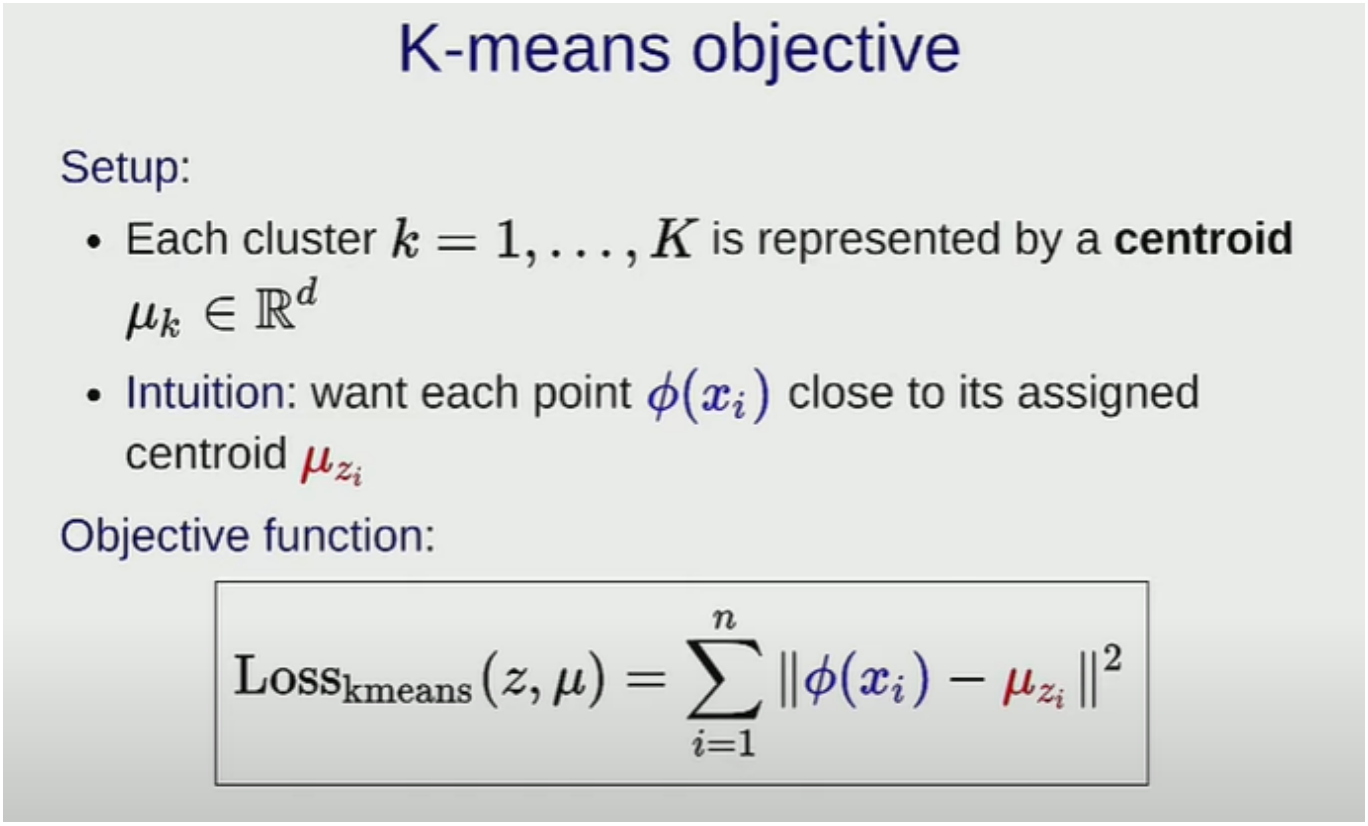


Clustering



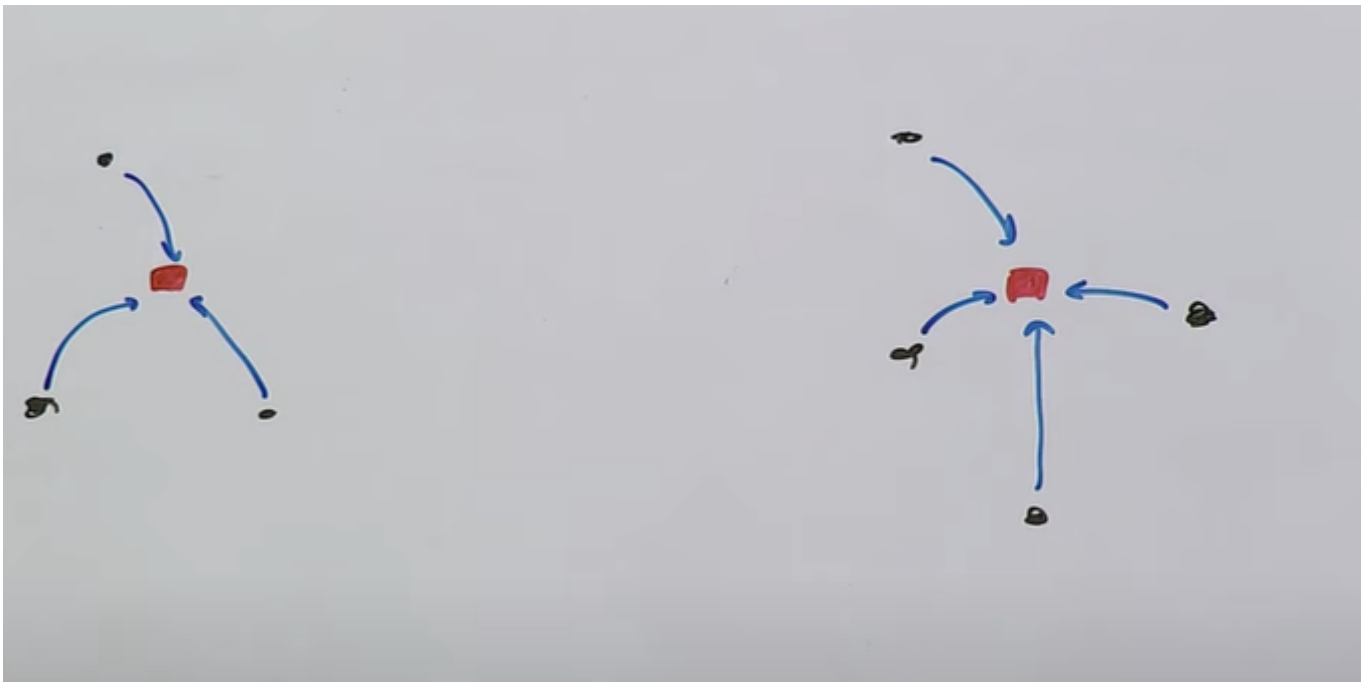
z1 ... zk

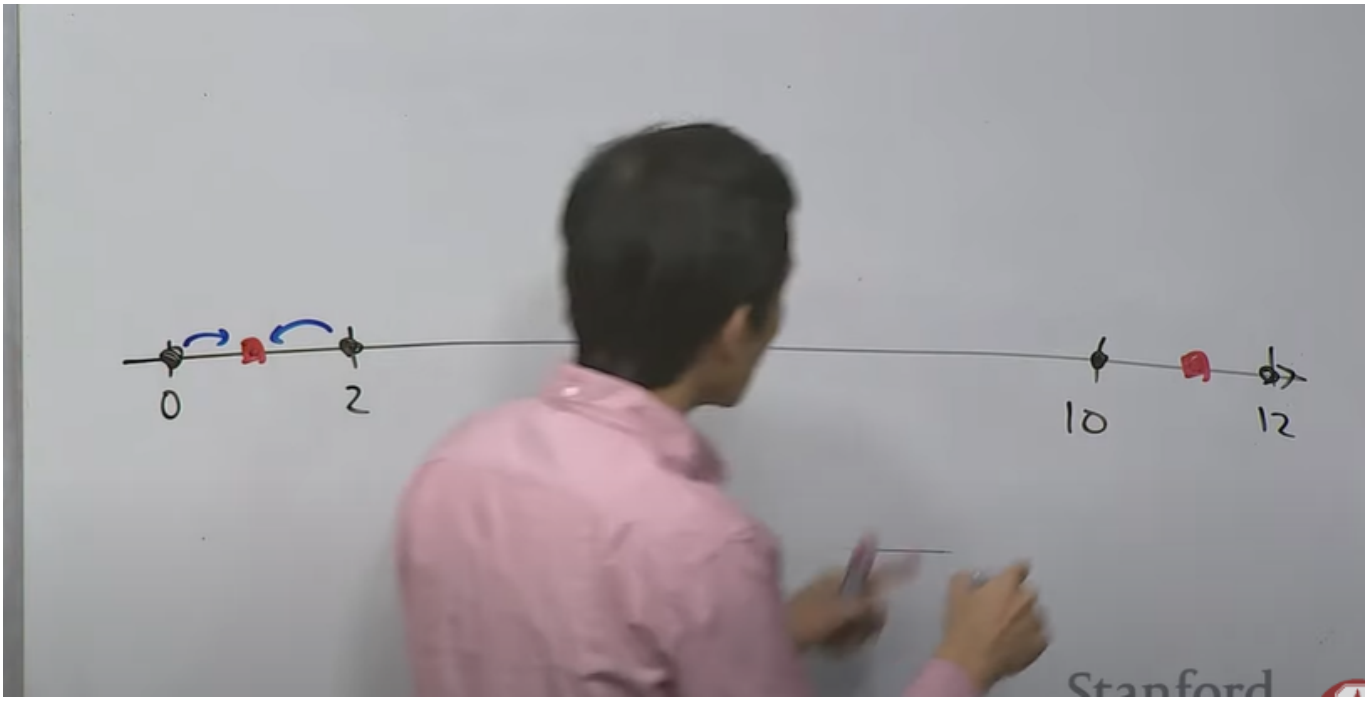
Tells me which of these K clusters I'm in



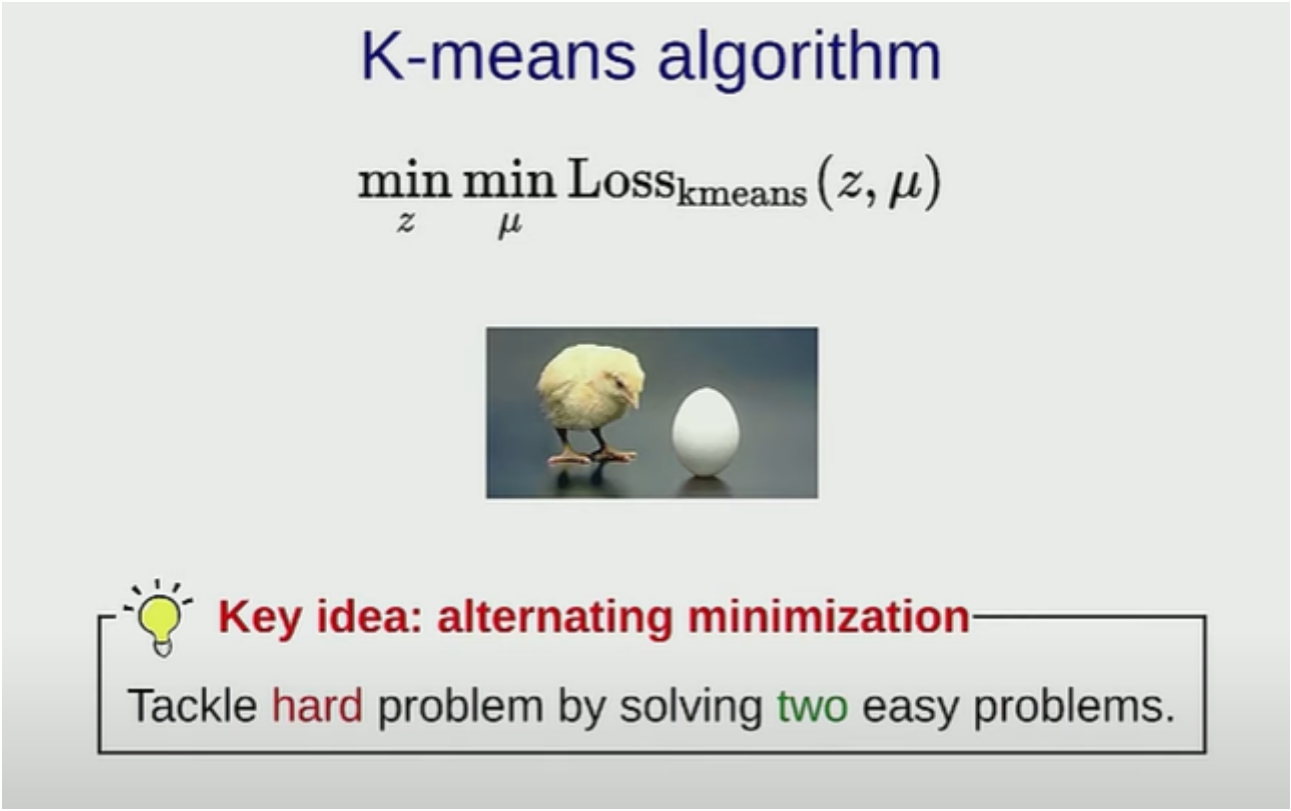
For each cluster, there's ginna be a centriod (质量重心)

The Objective function For each point I meature the distance between that point and the centriod associated And try to make this number as smaller as possible





A simple exapmle, you compare the distance to different centriods, and choose the closet one



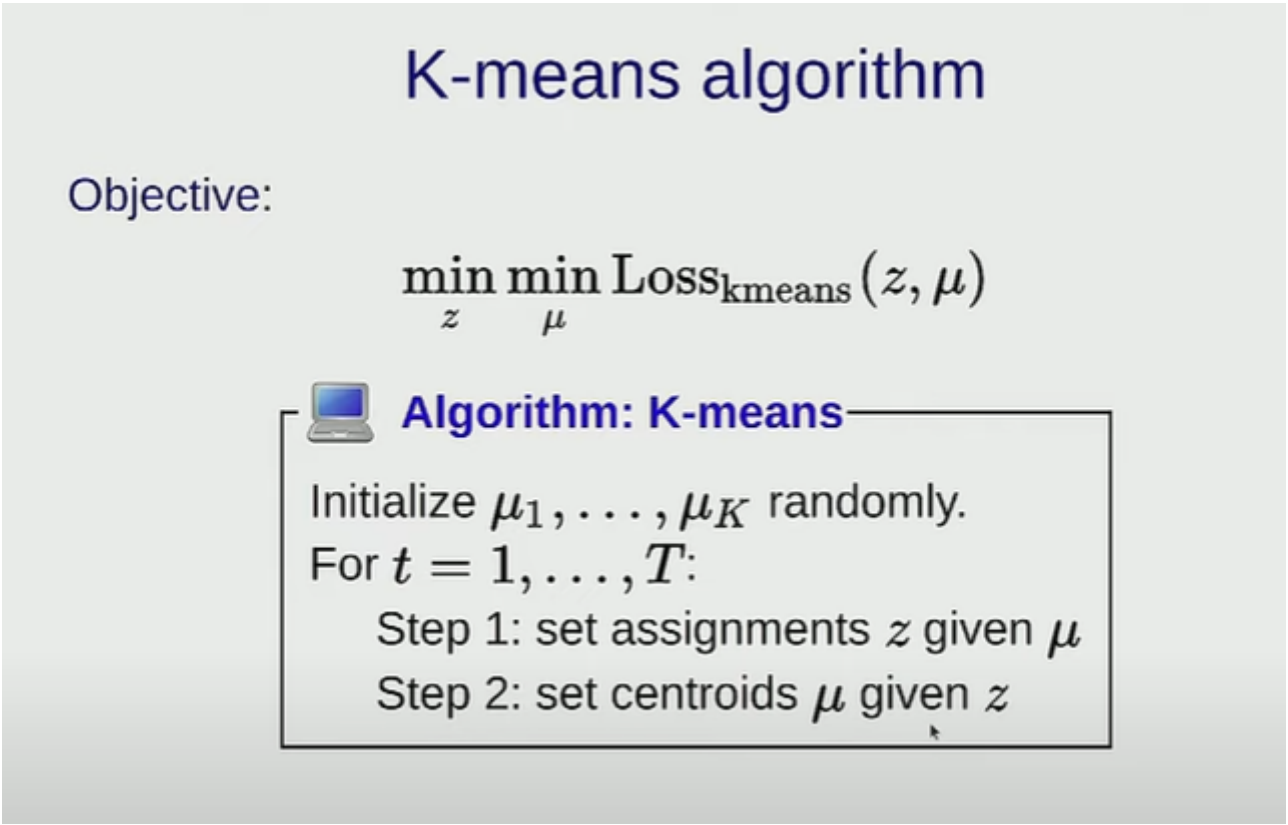
Now it's like the chicken egg problem IF i know the centriod, then I can do assignments IF i know assignmemts, then I can easily figure out the centriod

But how to get those two?

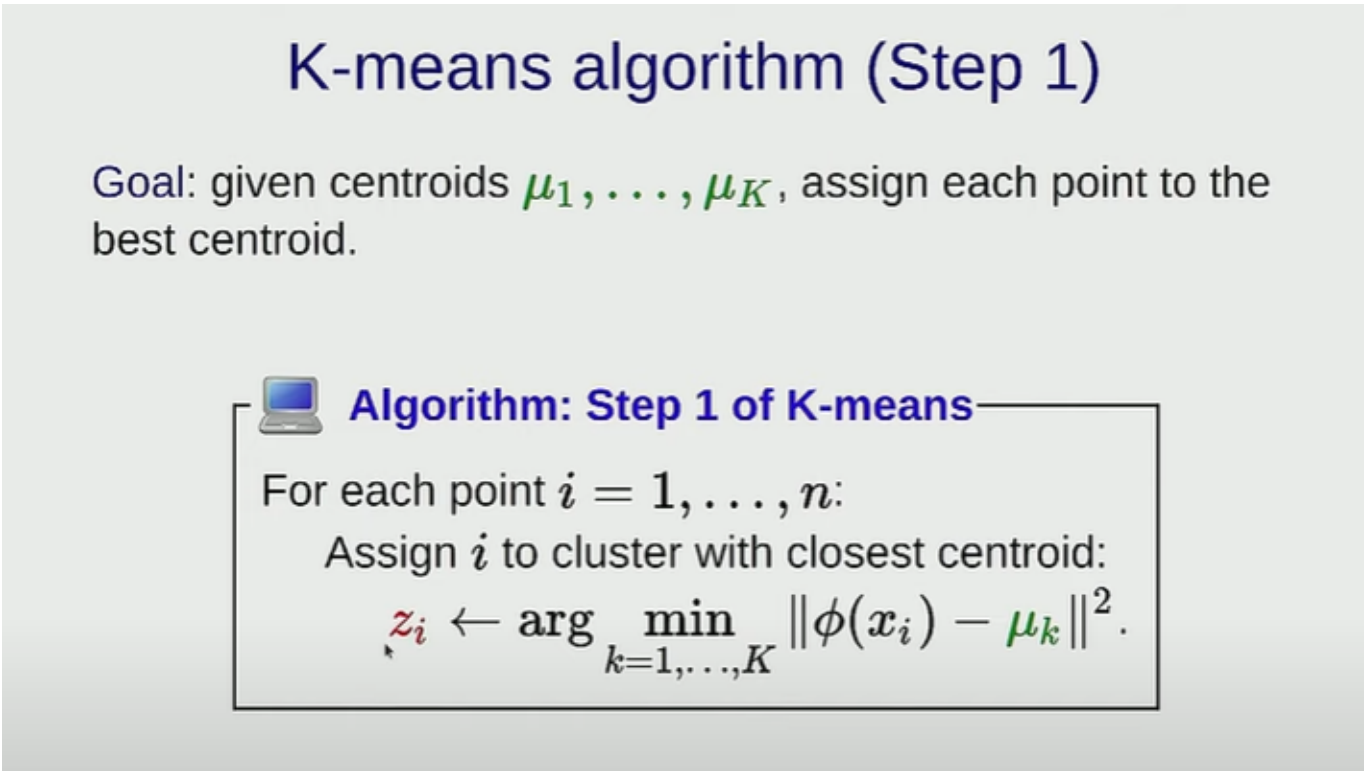
K-mean Algo

K is a hyperparameter How to u choose K? You can try different K and choose based on loss

For a fixed itration of T

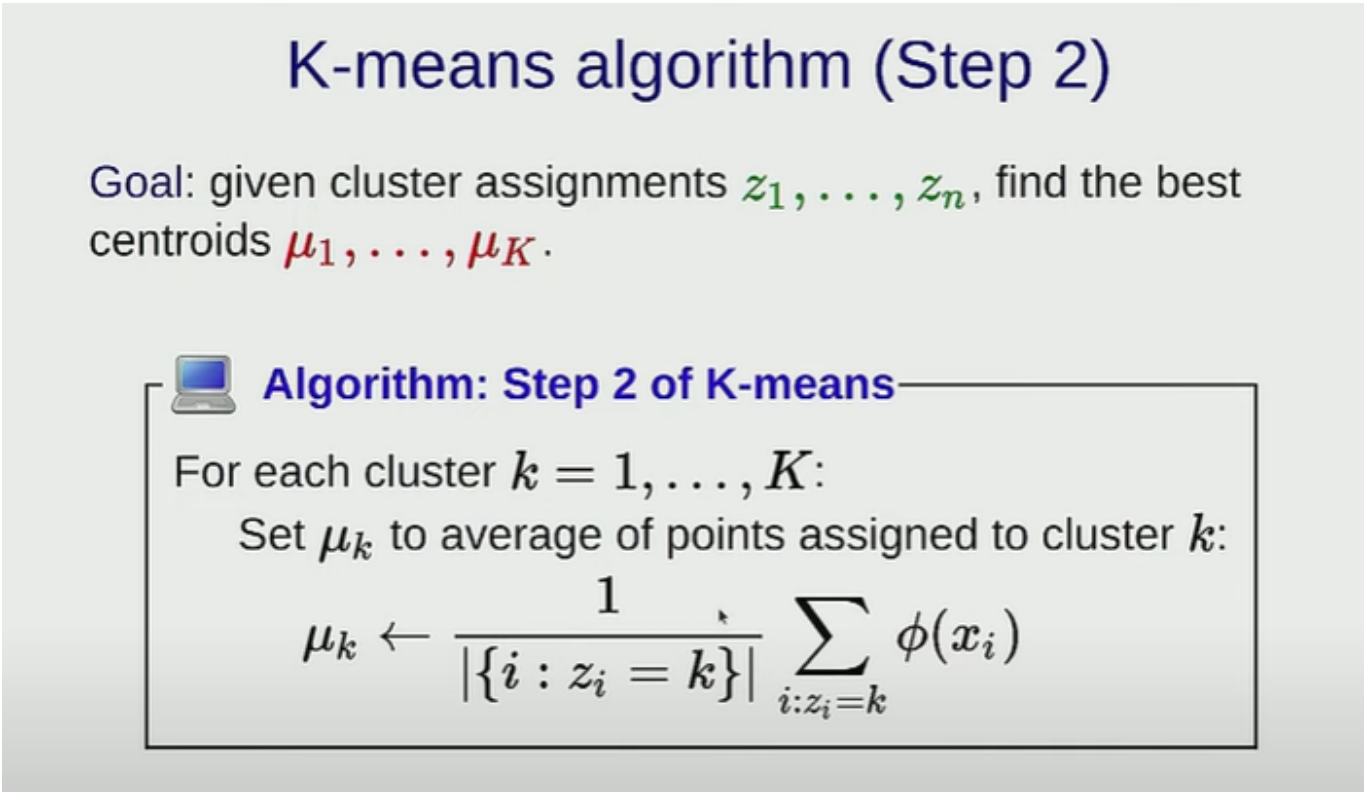


Step 1 Given Centriod and figure out the Cluster Assignments



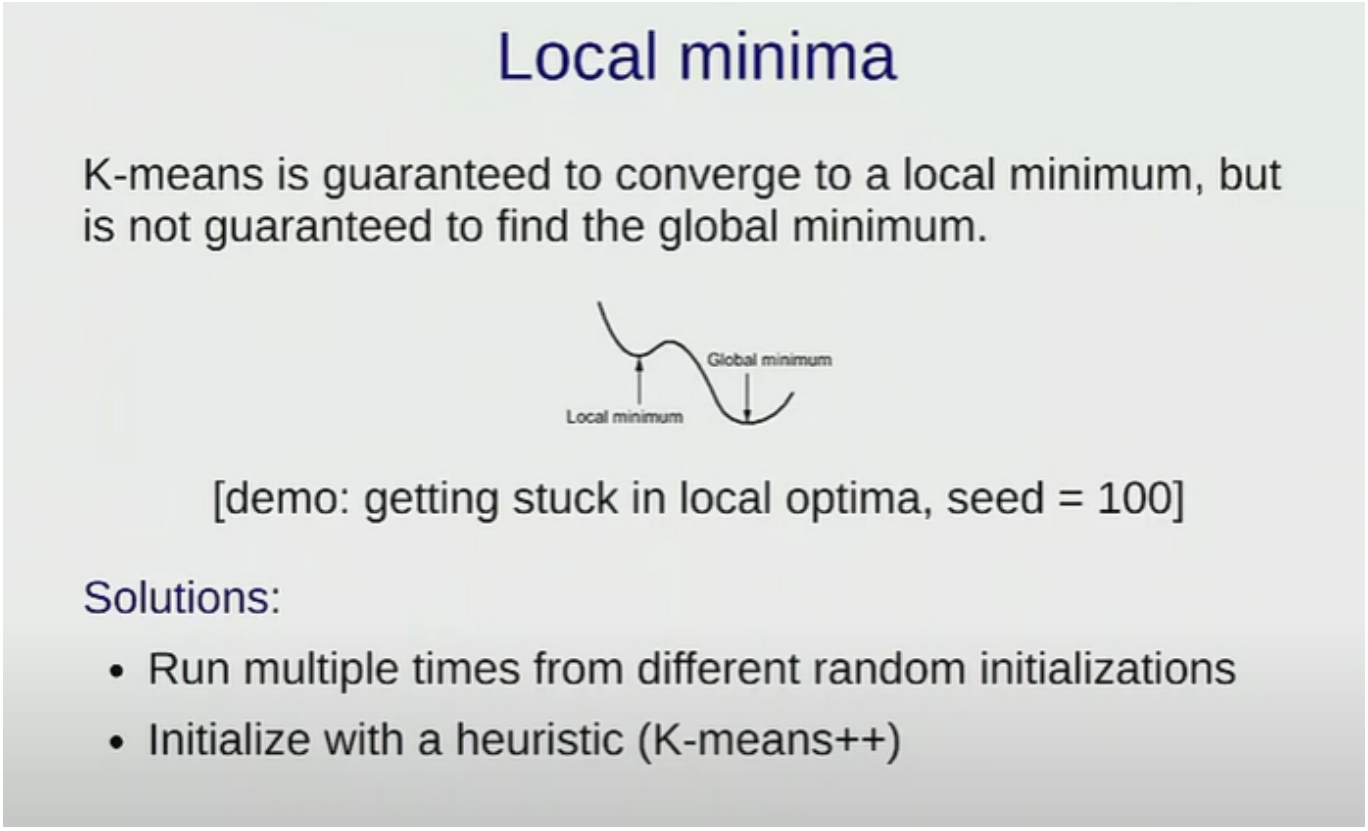
Just check the distance you compare the distance to different centriods, and assign the point to the closet one

Step 2 Given Cluster assignments and try to find the centroid



Mathmatically you sum up all the points (feature vectors) , and devided by the number of points => You get the centroid now!

Limitation



This is guaranteed to converged to a local minimum

K-means++ Initialize points far away from each other, generally works well

Summary

Summary

- Feature extraction (think hypothesis classes) [modeling]
- Prediction (linear, neural network, k-means) [modeling]
- Loss functions (compute gradients) [modeling]
- Optimization (stochastic gradient, alternating minimization) [learning]
- Generalization (think development cycle) [modeling]

Machine learning

Key idea: learning

Programs should improve with experience.

So far: reflex-based models

Next time: state-based models