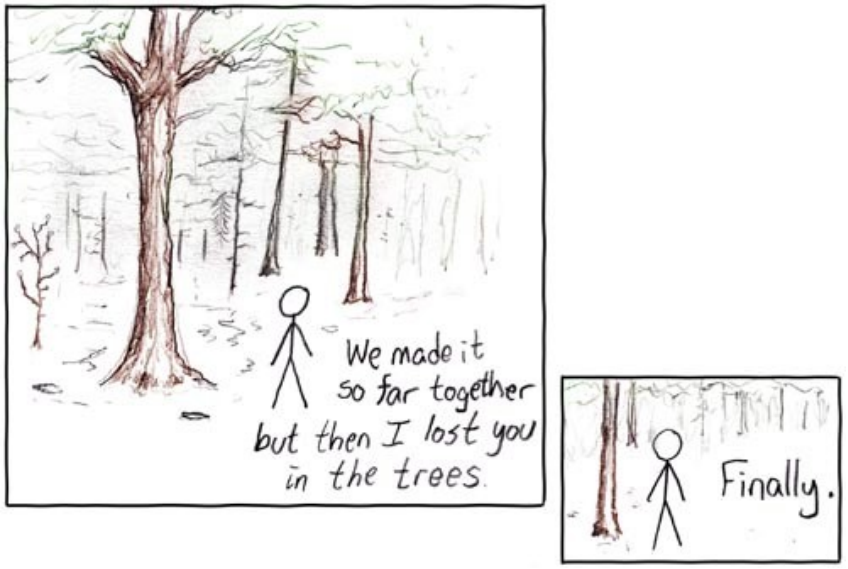
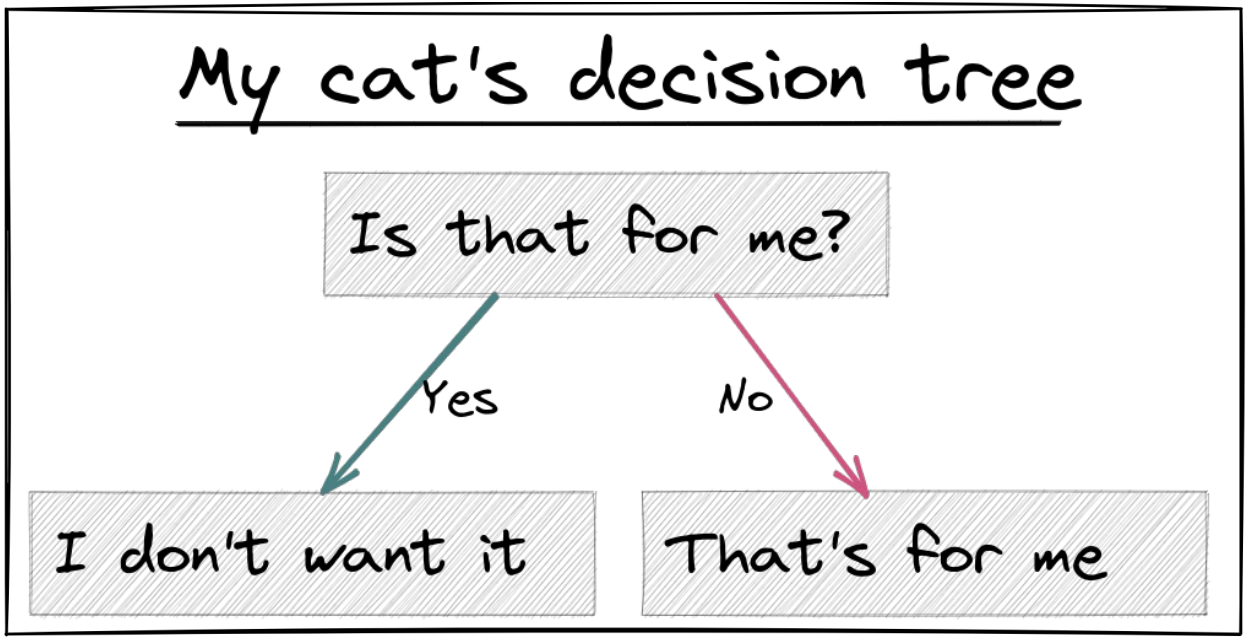
Random forest



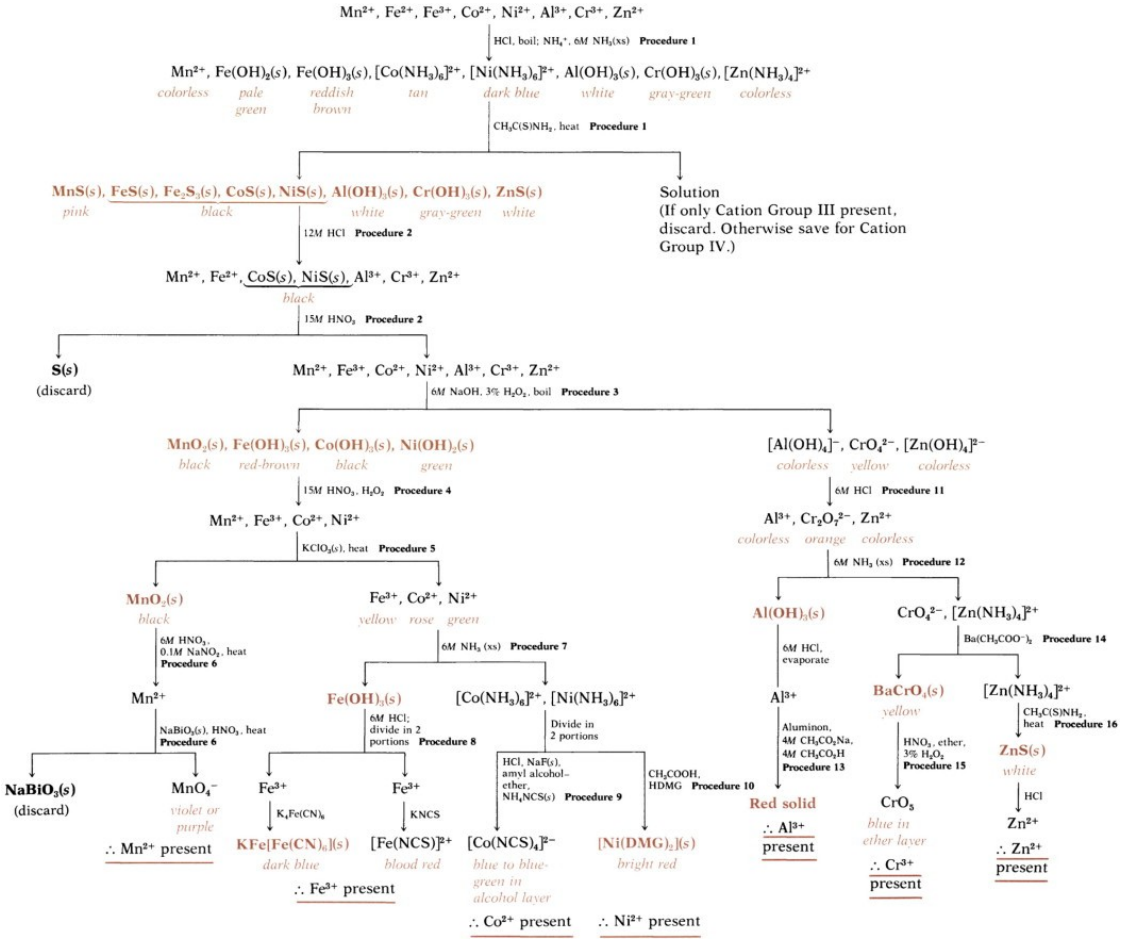
Week 11

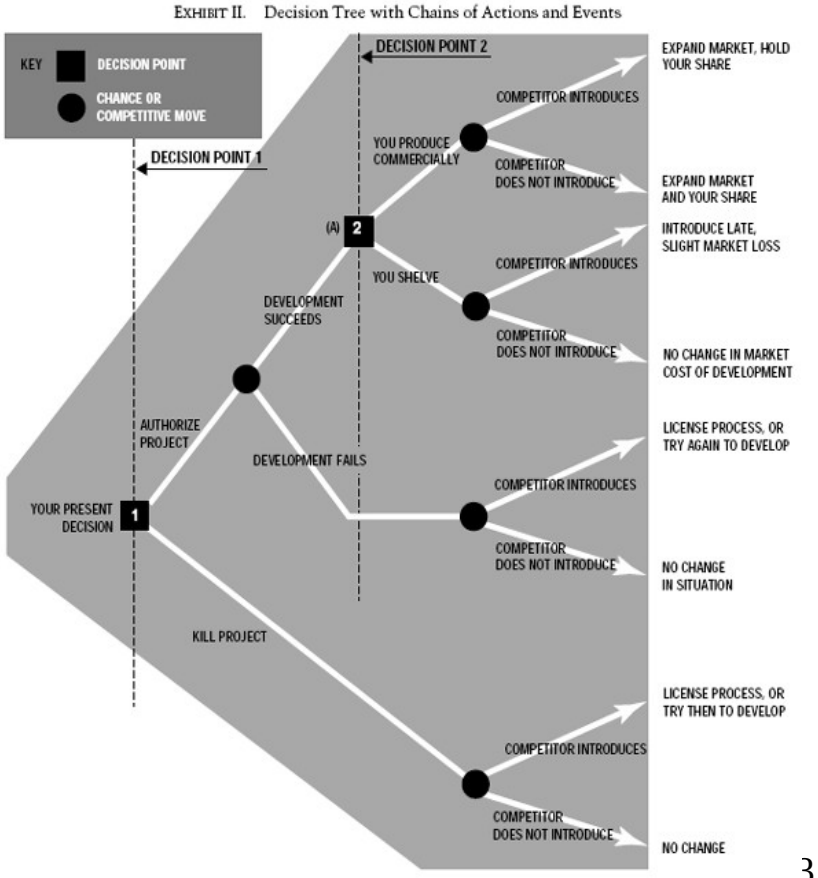
Middlesex University Dubai;
CST4050; Instructor: Ivan Reznikov

Decision trees concept



Decision trees examples



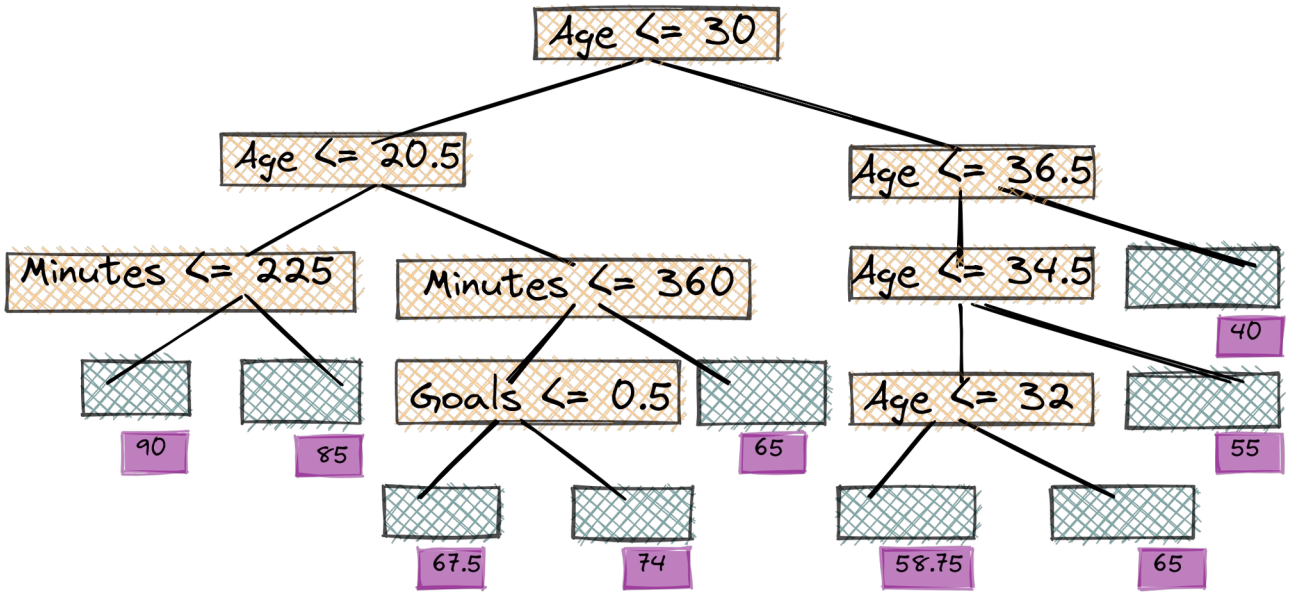


Decision tree: implementation

Original data

target

Overall Rating	Age	Minutes Played	Goals	...
40	37	360	0	0
50	30	900	1	2
55	36	360	0	0
55	31	180	0	3
60	35	180	2	0
60	31	90	3	1
60	28	180	6	1
60	24	90	3	0
65	33	180	0	0
65	30	360	2	0
65	27	90	0	0
65	23	540	2	4
70	34	90	1	2
70	29	90	3	1
70	22	180	0	0
75	25	180	3	0
75	21	90	1	3
80	27	90	3	1
85	20	360	4	1
90	18	90	7	1



Decision Trees

Easy to build
Easy to use
Easy to interpret results

Highly biased => inaccurate

Random Forests

Step 1. Run a lot of trees:

Step 1.1. Create bootstrapped dataset

Step 1.2. Create a decision tree with random set of features at each step

Step 2. Aggregate results

Step 3. Evaluate RF model

Step 4. Optimize RF model

Step 1.1 Bootstrapping

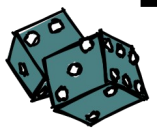
Original data

target						
Overall Rating	Age	Minutes Played	Goals	...		
40	37	360	0	0	x1	
50	30	900	1	2		
55	36	360	0	0	x2	
55	31	180	0	3	x1	
60	35	180	2	0		
60	31	90	3	1	x3	
60	28	180	6	1		
60	24	90	3	0		
65	33	180	0	0	x1	
65	30	360	2	0		
65	27	90	0	0	x1	
65	23	540	2	4	x1	
70	34	90	1	2		
70	29	90	3	1	x2	
70	22	180	0	0	x1	
75	25	180	3	0		
75	21	90	1	3	x2	
80	27	90	3	1	x1	
85	20	360	4	1	x3	
90	18	90	7	1	x1	

Bootstrapped data

target					
Overall Rating	Age	Minutes Played	Goals	...	
40	37	360	0	0	x1
55	36	360	0	0	x2
55	36	360	0	0	x2
55	31	180	0	3	x1
60	31	90	3	1	x3
60	31	90	3	1	x3
60	31	90	3	1	x3
65	33	180	0	0	x1
65	27	90	0	0	x1
65	23	540	2	4	x1
70	29	90	3	1	x2
70	29	90	3	1	x2
70	22	180	0	0	x1
75	21	90	1	3	x2
75	21	90	1	3	x2
80	27	90	3	1	x1
85	20	360	4	1	x3
85	20	360	4	1	x3
85	20	360	4	1	x3
90	18	90	7	1	x1

Step 1.2a Build decision tree



Bootstrapped data

target

Overall Rating	Age	Minutes Played	Goals	...	
40	37	360	0	0	x1
55	36	360	0	0	x2
55	36	360	0	0	x2
55	31	180	0	3	x1
60	31	90	3	1	x3
60	31	90	3	1	x3
60	31	90	3	1	x3
65	33	180	0	0	x1
65	27	90	0	0	x1
65	23	540	2	4	x1
70	29	90	3	1	x2
70	29	90	3	1	x2
70	22	180	0	0	x1
75	21	90	1	3	x2
75	21	90	1	3	x2
80	27	90	3	1	x1
85	20	360	4	1	x3
85	20	360	4	1	x3
85	20	360	4	1	x3
90	18	90	7	1	x1

Split candidates:

- Age
- Goals

Best to split on: **Age**

Age <= 30

Step 1.2b Build decision tree

Bootstrapped data

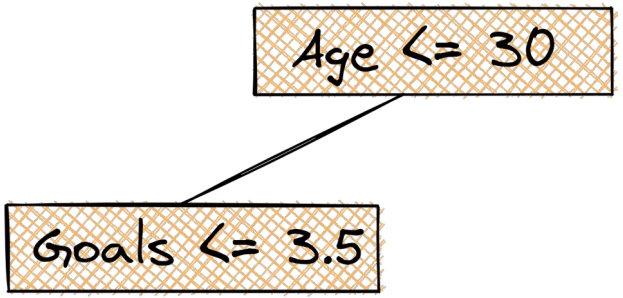
target

Overall Rating	Age	Minutes Played	Goals	...	
40	37	360	0	0	x1
55	36	360	0	0	x2
55	36	360	0	0	x2
55	31	180	0	3	x1
60	31	90	3	1	x3
60	31	90	3	1	x3
60	31	90	3	1	x3
65	33	180	0	0	x1
65	27	90	0	0	x1
65	23	540	2	4	x1
70	29	90	3	1	x2
70	29	90	3	1	x2
70	22	180	0	0	x1
75	21	90	1	3	x2
75	21	90	1	3	x2
80	27	90	3	1	x1
85	20	360	4	1	x3
85	20	360	4	1	x3
85	20	360	4	1	x3
90	18	90	7	1	x1

Split candidates:

- Goals
- Minutes Played

Best to split on: **Goals**



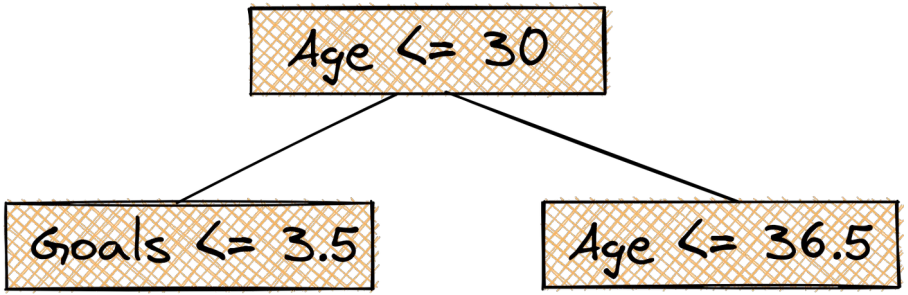
Step 1.2c Build decision tree

Split candidates:

- Age
- ...

target					
Overall Rating	Age	Minutes Played	Goals	...	
40	37	360	0	0	x1
55	36	360	0	0	x2
55	36	360	0	0	x2
55	31	180	0	3	x1
60	31	90	3	1	x3
60	31	90	3	1	x3
60	31	90	3	1	x3
65	33	180	0	0	x1
65	27	90	0	0	x1
65	23	540	2	4	x1
70	29	90	3	1	x2
70	29	90	3	1	x2
70	22	180	0	0	x1
75	21	90	1	3	x2
75	21	90	1	3	x2
80	27	90	3	1	x1
85	20	360	4	1	x3
85	20	360	4	1	x3
85	20	360	4	1	x3
90	18	90	7	1	x1

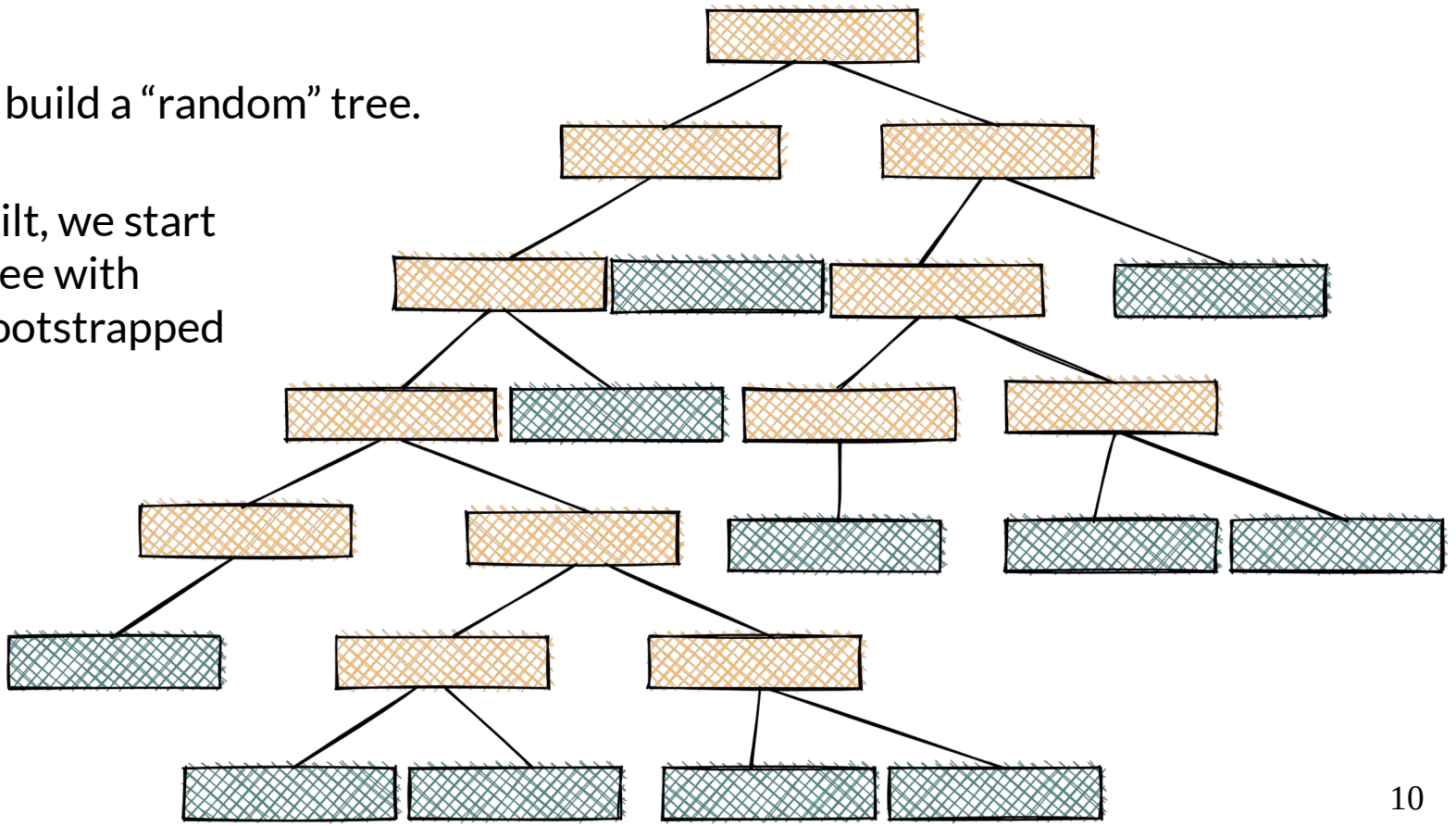
Best to split on: **Age**



Step 1.2d Build decision tree

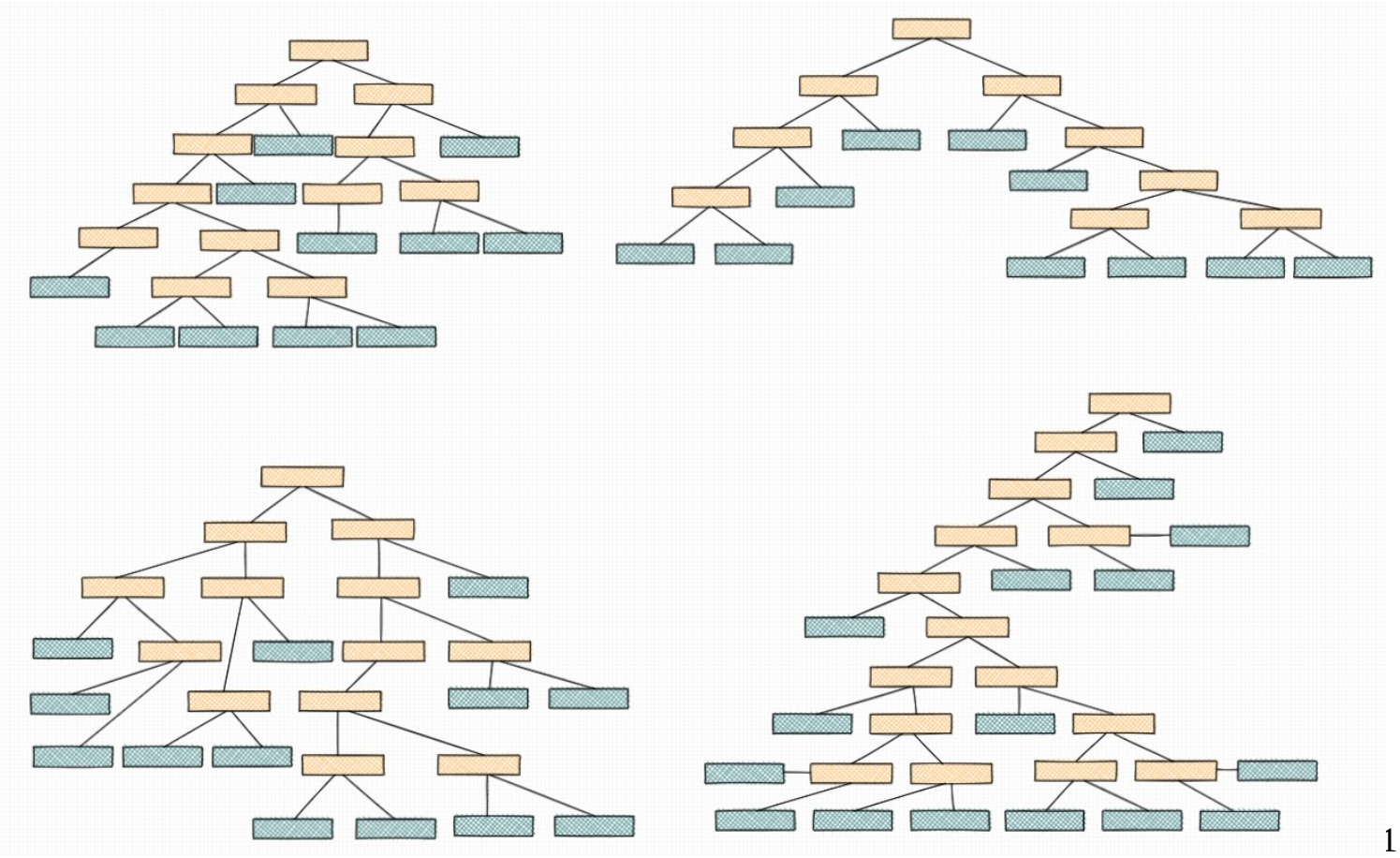
Step-by-step we build a “random” tree.

Once a tree is built, we start building a new tree with new randomly bootstrapped data.

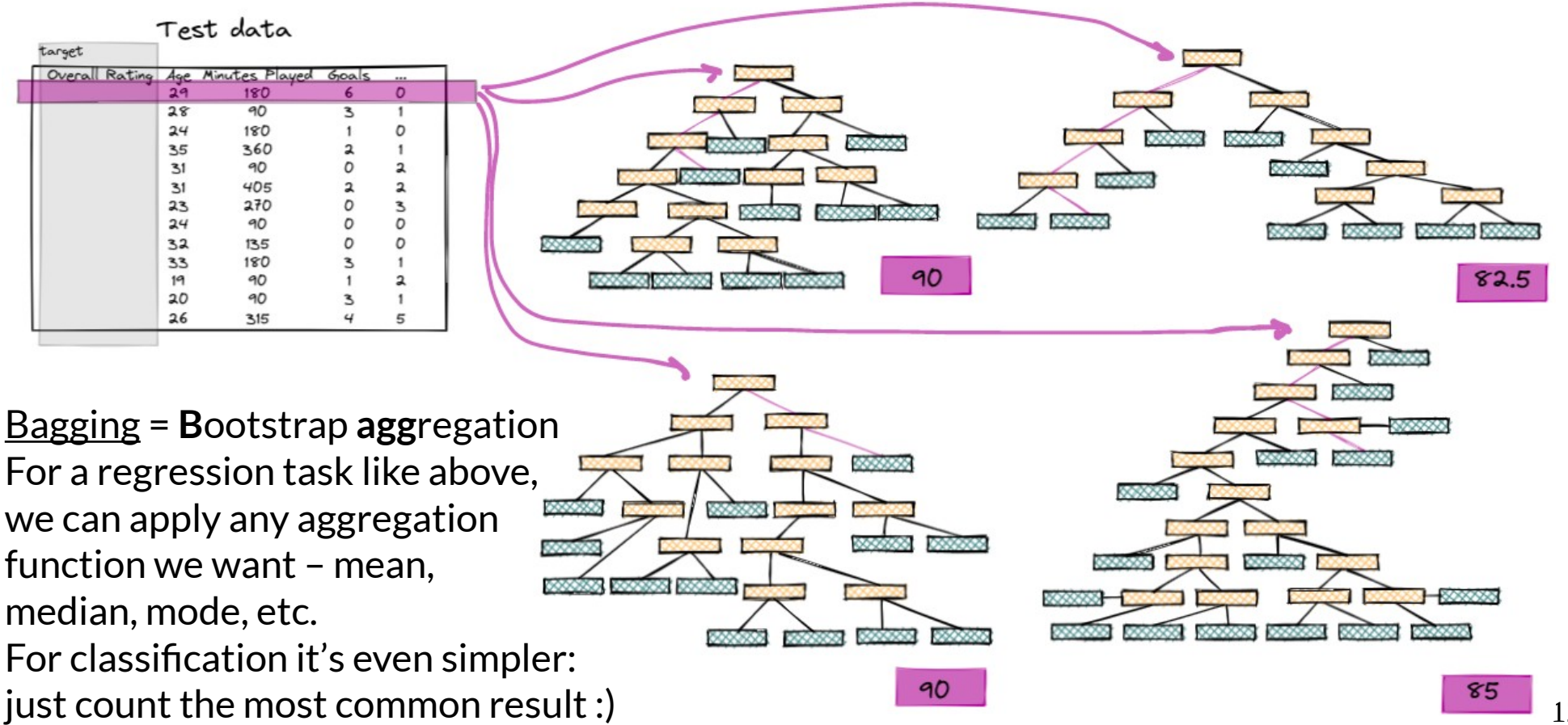


Step 1. Build a lot of trees

We will result in a lot of trees – a random forest



Step 2. Aggregate results



Bagging = **B**ootstrap **agg**regation
For a regression task like above, we can apply any aggregation function we want – mean, median, mode, etc.
For classification it's even simpler: just count the most common result :)

Step 3. Evaluate RF model

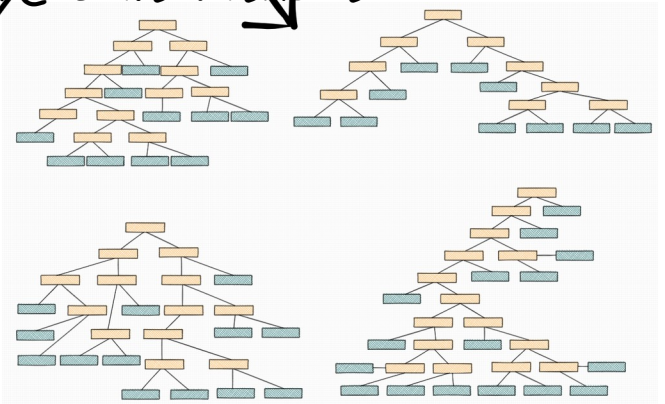
Original data

target

Overall Rating	Age	Minutes Played	Goals	...	
40	37	360	0	0	x1
50	30	900	1	2	
55	36	360	0	0	x2
55	31	180	0	3	x1
60	35	180	2	0	
60	31	90	3	1	x3
60	28	180	6	1	
60	24	90	3	0	
65	33	180	0	0	x1
65	30	360	2	0	
65	27	90	0	0	x1
65	23	540	2	4	x1
70	34	90	1	2	
70	29	90	3	1	x2
70	22	180	0	0	x1
75	25	180	3	0	
75	21	90	1	3	x2
80	27	90	3	1	x1
85	20	360	4	1	x3
90	18	90	7	1	x1

Out-of-Bag (OOB) dataset can be used to calculate model accuracy

Each OOB sample we run on trees that were built without using it



Aggregation and return result

Evaluate with RMSE, etc.

Step 4. Optimizing RF model

- Decision Trees tuning
  - Trees parameters: max depth, split model, etc
  - Node/Leaf parameters: min split samples, min leaf samples
- Random Forest tuning:
  - Number of trees built
  - Number of features used during bagging
  - Metric for Out-of-Box evaluation