

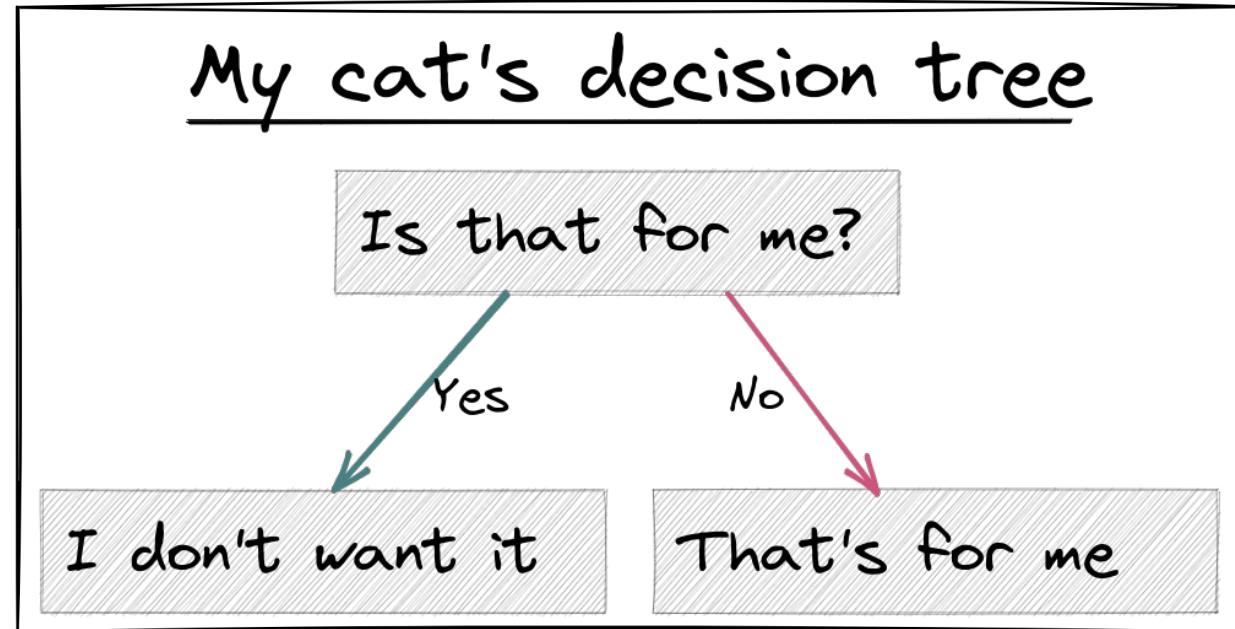
Random forest



Week 11

Middlesex University Dubai;
CST4050; Instructor: Ivan Reznikov

Decision trees concept



Decision trees examples

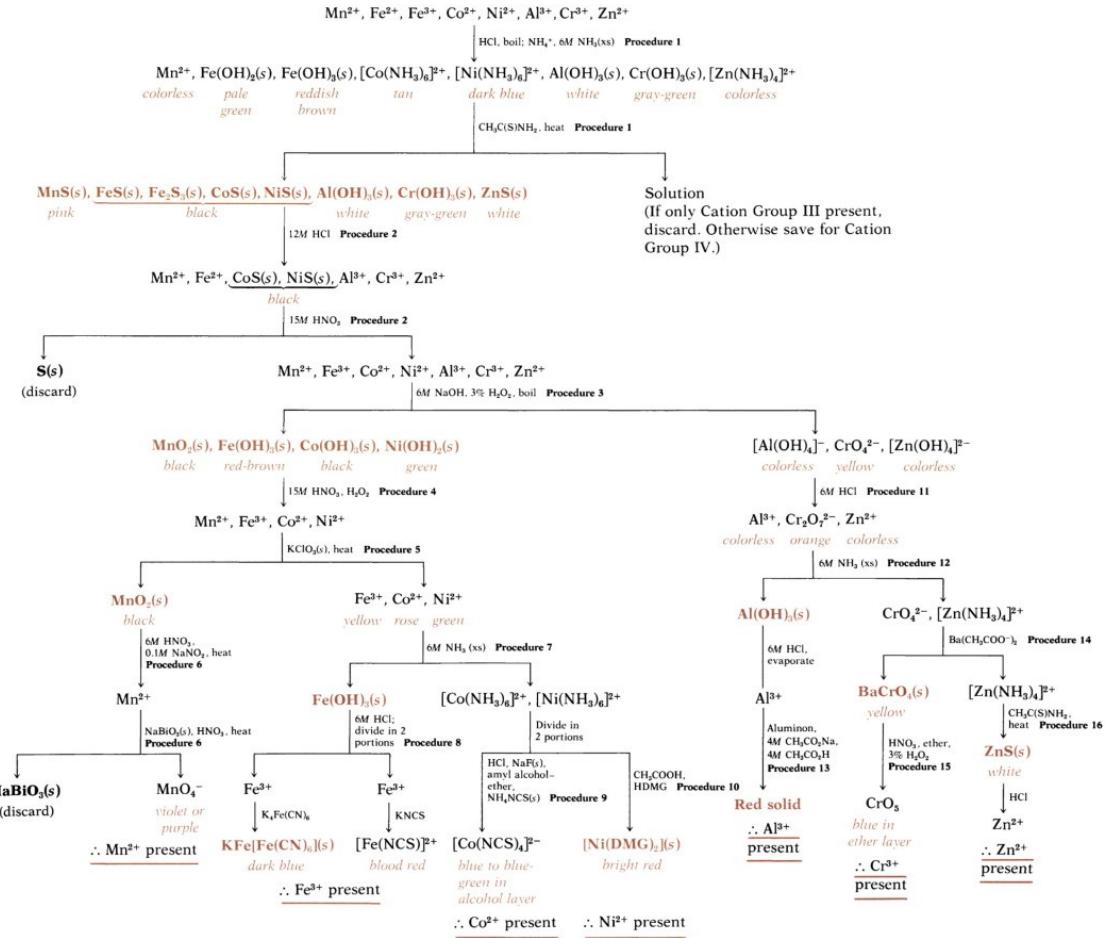
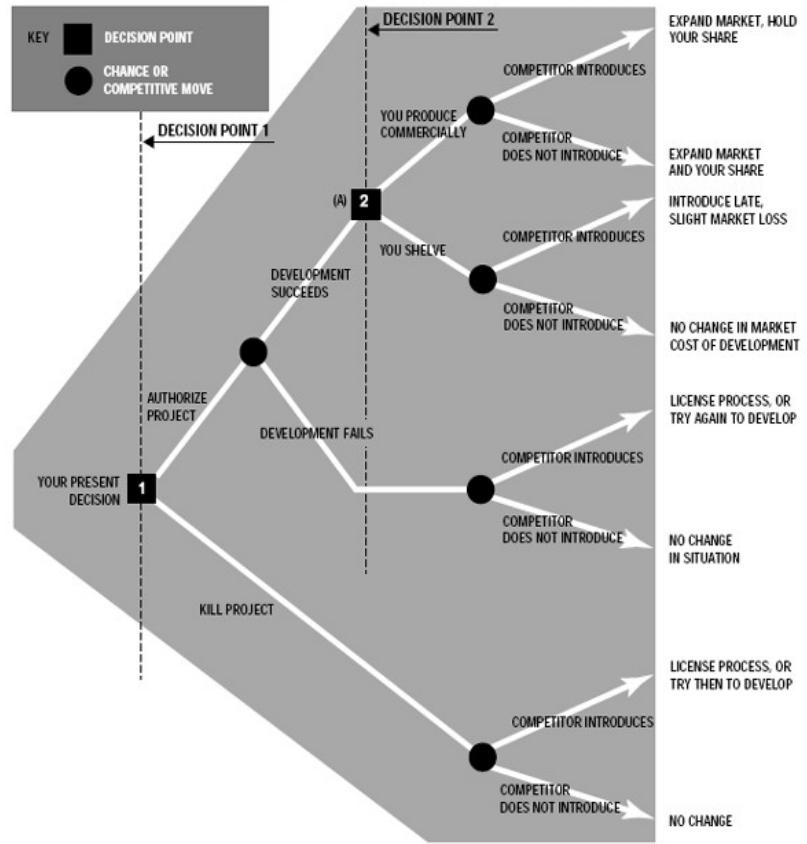


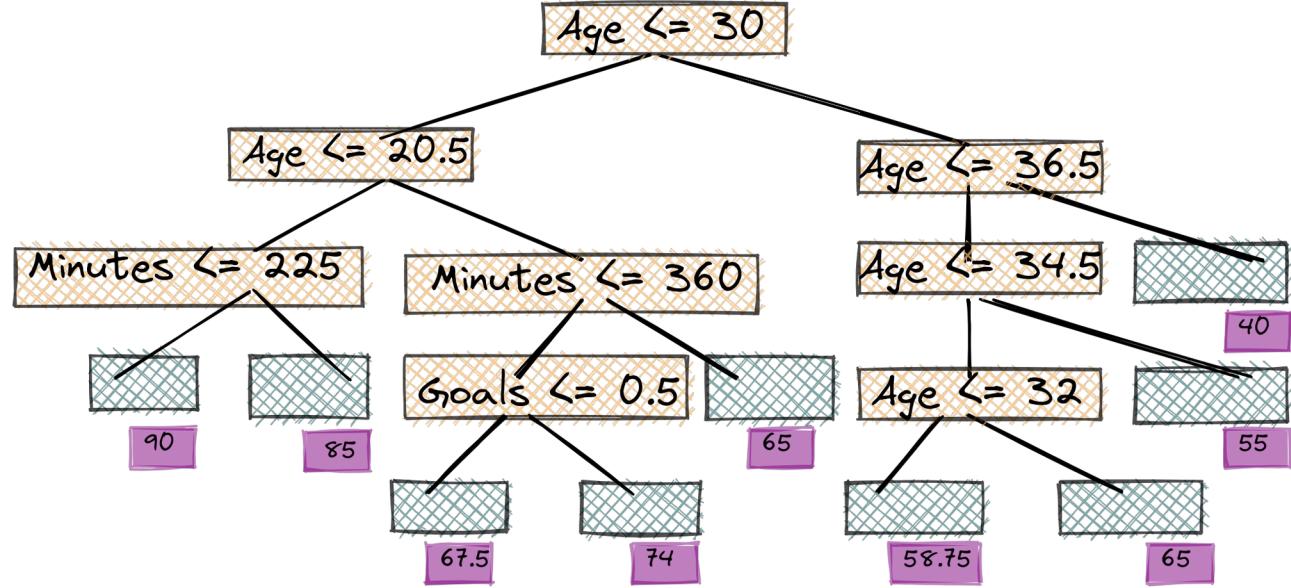
EXHIBIT II. Decision Tree with Chains of Actions and Events



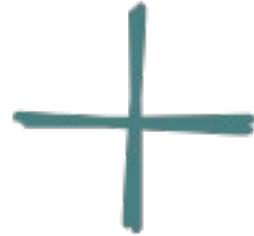
Decision tree: implementation

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	4	1
	85	20	360	7	1
	90	18	90	1	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

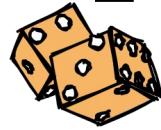
Step 3. Evaluate RF model

Step 4. Optimize RF model

Step 1.1 Bootstrapping

Original data

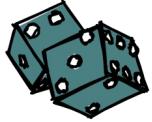
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	40	37	360	0	0
	50	30	900	1	2
	55	36	360	0	0
	55	31	180	0	3
	60	35	180	2	0
	60	31	90	3	1
	60	28	180	6	1
	60	24	90	3	0
	65	33	180	0	0
	65	30	360	2	0
	65	27	90	0	0
	65	23	540	2	4
	70	34	90	1	2
	70	29	90	3	1
	70	22	180	0	0
	75	25	180	3	0
	75	21	90	1	3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



Bootstrapped data

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

Step 1.2a Build decision tree



Split candidates:
→
- Age
- Goals

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

Age ≤ 30

Step 1.2b Build decision tree



Split candidates:
→
- Goals
- Minutes Played

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: Goals

Age ≤ 30

Goals ≤ 3.5

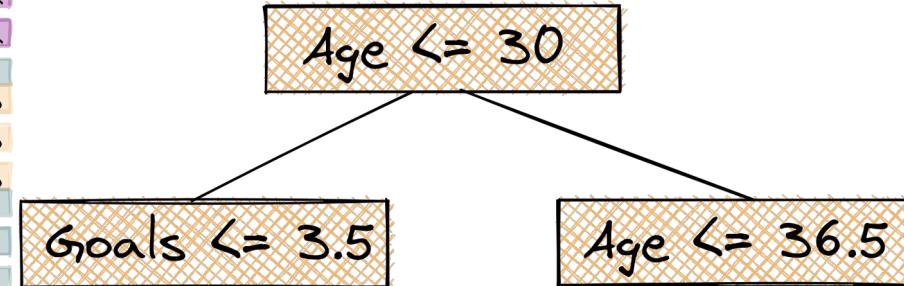
Step 1.2c Build decision tree



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
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	85	20	360	4	1	x3
	90	18	90	7	1	x1

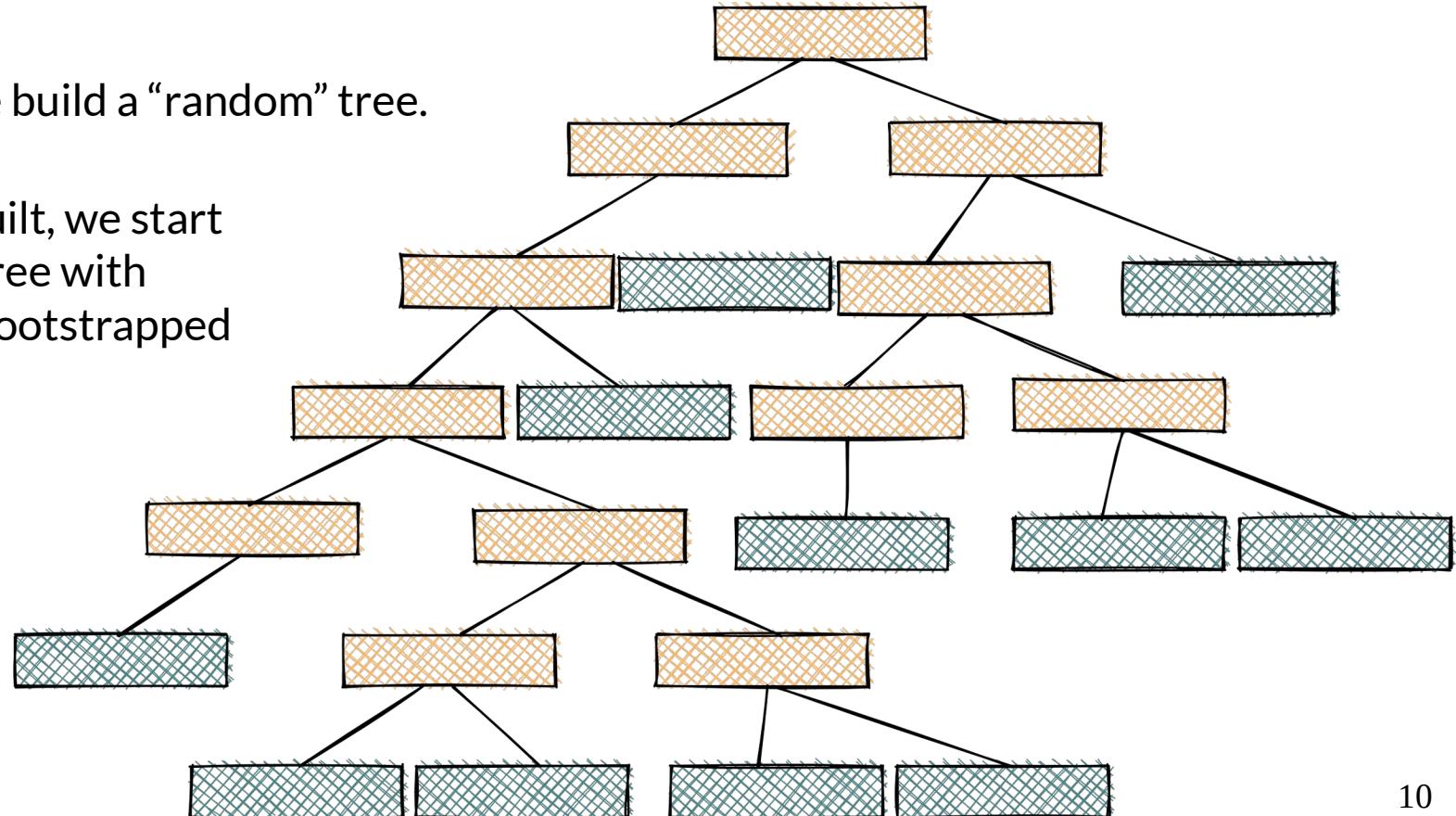
Best to split on: Age



Step 1.2d Build decision tree

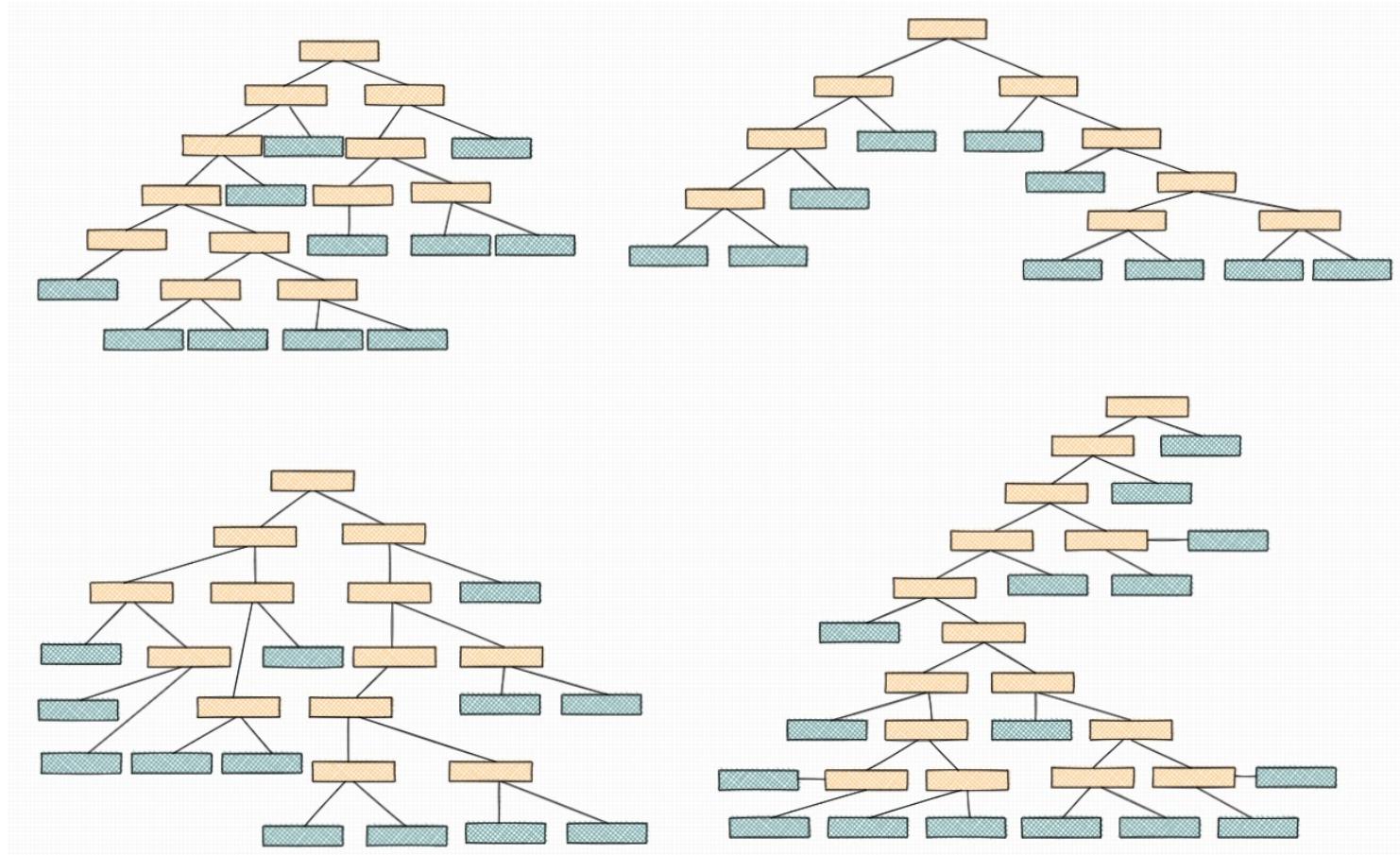
Step-by-step we build a “random” tree.

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

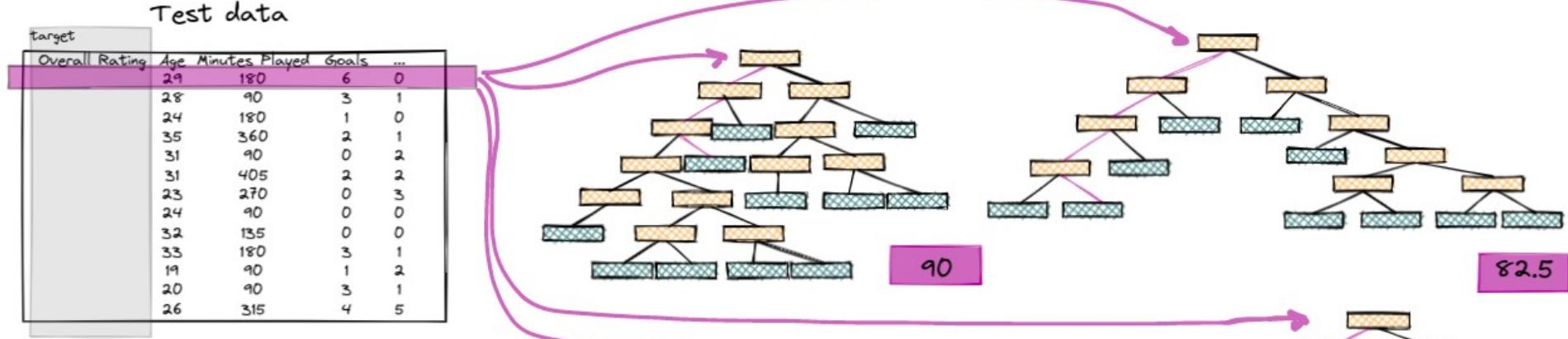


Step 1. Build a lot of trees

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



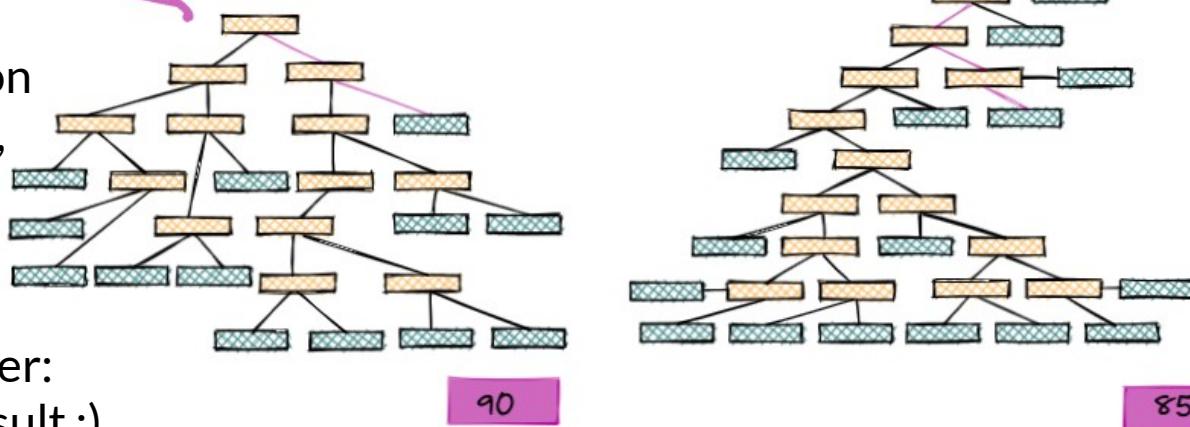
Step 2. Aggregate results



Bagging = Bootstrap aggregation

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 :)



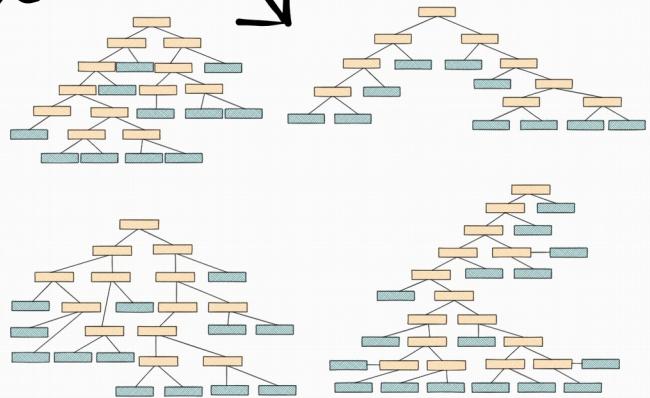
Step 3. Evaluate RF model

Original data

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	55	36	360	0	0
	55	31	180	0	3
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	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

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

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



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