Pokerbots 2025

Lecture 9: Decision Trees

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Announcements

Last Night's Lightning Tournament #2

1. Pineapple	$400
2. Encore 1/2 Regs	$300
3. heyo394	$225
4. pink fluffy sheep	$175
5. DKE juniors	$150

Week 3 Bot Deadline!

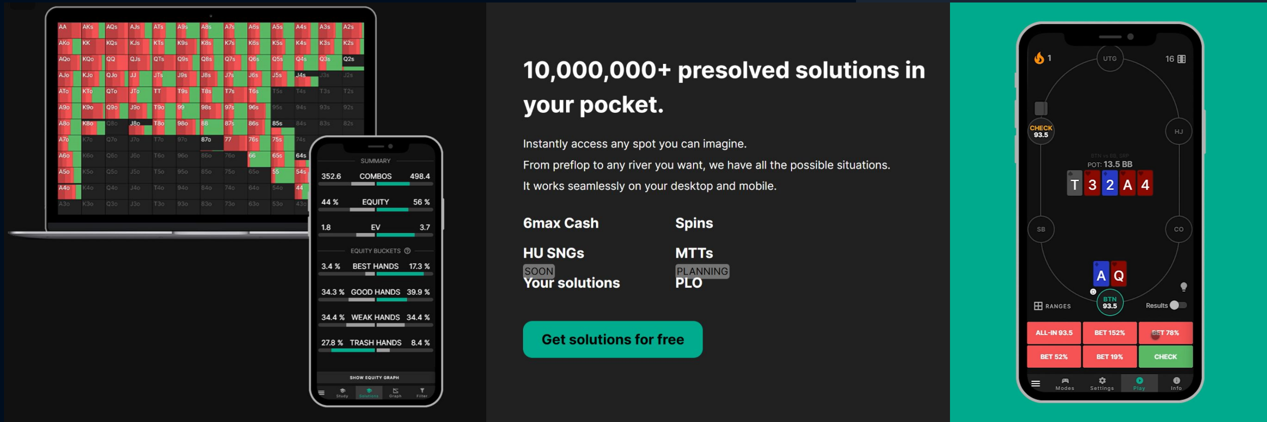
- Third pokerbot due Tomorrow 1/24, 11:59PM EST
- Submission on scrimmage server
- Mini-tournament 3 will occur shortly after

Next Week…

Monday 1/27

Guest Lecture: GTO Wizard

- Current state of the art Poker Solver and Study tool
- Developed by team of top AI researchers and engineers
- Core team will be presenting their journey and research
- RSVP at **pkr.bot/gto**



Tuesday 1/28

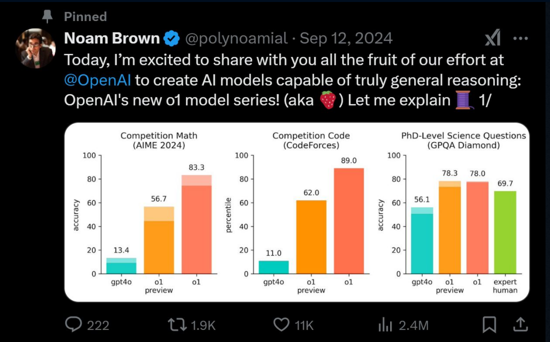
Team Strategy Reports due 11:59PM EST

- No Lecture
- 3-5 pages, double spaced, ≥1 member must submit
- Assignment details and submission on Canvas: **pkr.bot/canvas**
- Description also available in syllabus: **pkr.bot/syllabus**

Wednesday 1/29

Guest Lecture: Dr. Noam Brown

- Won Pokerbots and co-created Deep CFR while PhD at CMU
- Created Libratus and Pluribus, the world's first superhuman poker AIs
- Research scientist currently at OpenAI, previously worked at Meta AI
- Leading role in developing OpenAI's latest GPT o1 and o3 LLMs



Wednesday 1/29 (cont.)

Poker Social After!

- During office hours block
- Come play with Noam!

Wednesday 1/29 (cont.)

Final Bot Submission due 11:59PM EST

- Upload and select bot as active on scrimmage server
- Both report and bot needed to pass this class!
- Bot will compete in last and final Pokerbots tournament
- Non-secret prize amounts listed on syllabus

Final Tournament Prizes	
First place	$10,000
Second place	$6,500
Third place	$3,500
Fourth place	$2,000
Fifth place	$1,000
First place in language (Python, Java, or C++)	$500 x 3
Second place in language (Python, Java, or C++)	$250 x 3
Third place in language (Python, Java, or C++)	$125 x 3
Best freshman-majority (>51%) team	$2,000

Friday 1/31

Pokerbots Final Event 4:30-7PM in Kresge Auditorium

- Presentation of Awards
- Closing Ceremony
- Sponsor Event and Puzzle Hunt
- Lots of free merch and raffle prizes!
- Dinner provided 😋

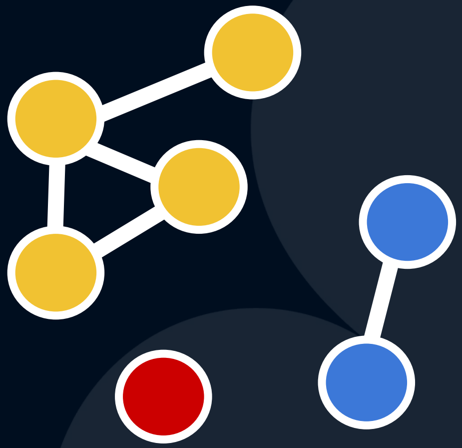
All in all...

1/24 Tomorrow	Week 3 Bot Due
1/27 Monday	GTO Wizard Talk
1/28 Tuesday	Final Report Due
1/29 Wednesday	Noam Brown Talk Social Event Final Bot Due
1/31 Friday	Final Event

Giveaways!

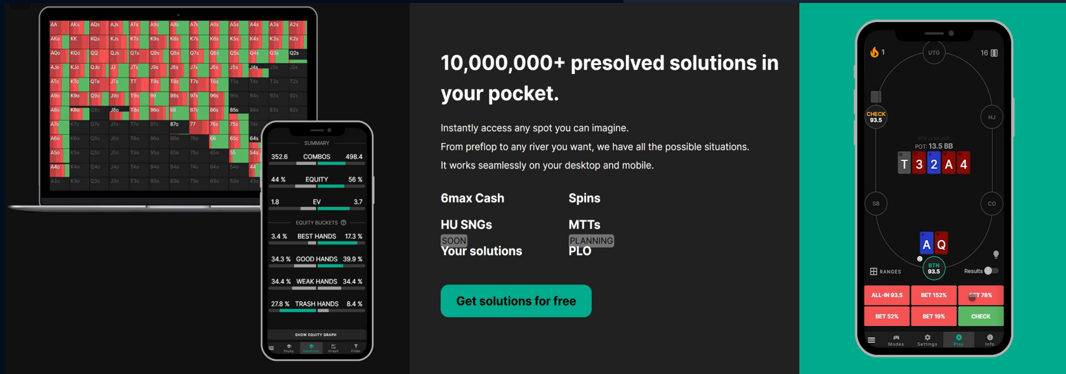
Connection Game: pkr.bot/connect

- List the kerbs of up to 3 other classmates in your submission
- Two people are **connected** if they list each other (strings must match exactly)
- A **connected component** is a group of people who are all directly or indirectly connected
- **Four winners** are randomly drawn from the largest connected component(s)!



Feel free to get up and travel!
But be back to your seat in 4 min

Prize: One year's worth of GTO Wizard Full Subscription <u>each</u>



RSVP for GTO Wizard: **pkr.bot/gto**

- Indicate whether you plan to attend next Monday's talk
- Winner selected at random
- Prize: Sony XM4

Decision Trees

From last lecture...

Model training steps on a large representation (tabular CFR) causes issues

→ Use compressed approximation method like a neural network to store model,
Making training require less steps and inference (or evaluation) less costly

Why we use neural networks:

- Expressive
- Flexible over different data types
- Does well with large amounts of data

What other approximation methods could we use?

What are some processes we'd like to be able to express?

From pot odds bot:

```
if RaiseAction in legal_actions:
    if random.random() < 0.5:
        if strength > 2*pot_odds:
            raise_amount = int(min_raise + 0.1 * (max_raise - min_raise))
            return RaiseAction(raise_amount)
        return RaiseAction(min_raise)
if CheckAction in legal_actions:  # check-call
    return CheckAction()
if random.random() < 0.25:
    return FoldAction()
return CallAction()
```

What are some processes we'd like to be able to express?

We'd like:

- Qualitative selection of variables to condition a decision on
  - Pot odds
  - Legal actions
  - Hole strength
  - Randomly generated values

- Quantitative tuning of how to decide based on that variable
  - Pot odds threshold
  - Ratio of p:pot odds
  - Threshold for random values

Can neural networks do this?

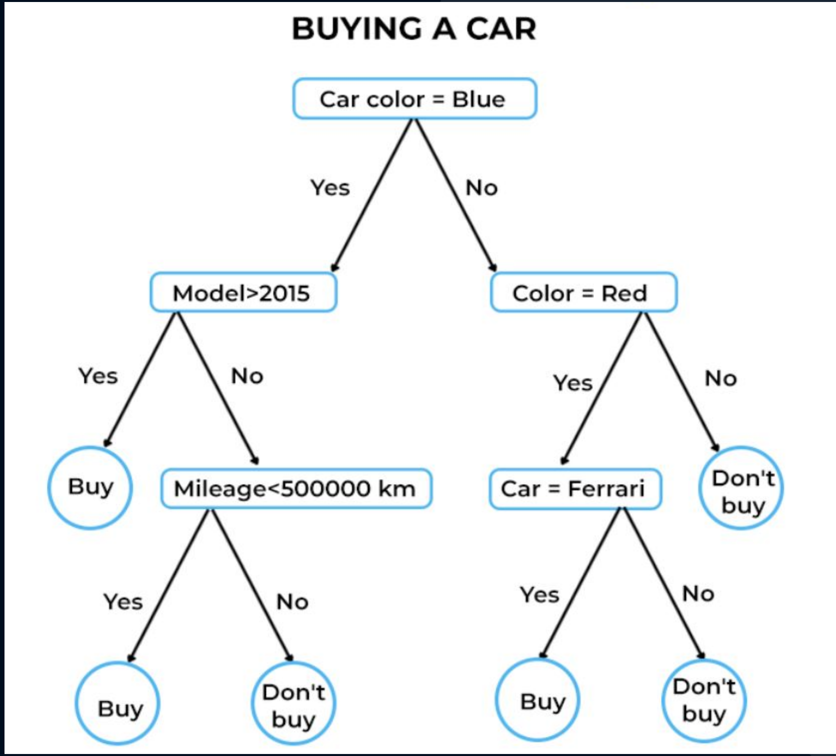
Well, yes…

- Nonlinear activations like ReLU and Sigmoid can capture qualitative regions of similar behavior (‘step functions’)
- Linear layers can learn weights for specific thresholds needed
- So for a large enough neural network, all the if statements and thresholds could be encoded as linear transformations and nonlinear activations

But this seems like overkill if we desire to capture a simple relationship…

Decision Trees

- Definition: A tree-like model used to make decisions by splitting data based on feature values.
- Structure:
  - Nodes: Represent a feature to split on.
  - Edges: Represent decision outcomes.
  - Leaves: Represent the final prediction (class or value).
- Example: Classifying if we'd like to buy a car based on various characteristics



How Decision Trees are Trained

- Start with some tree (initially root node), that sends the dataset into a number of leaves with a label on each leaf
- Performance of the tree is related to how many dataset examples are sent to a leaf with a good prediction. We'd like to consider how we can add additional splits at each leaf to improve this performance.
- Split data on a feature that maximizes information gain or reduces impurity (e.g., Gini index, entropy).
- Repeat recursively until a stopping condition is met (e.g., maximum depth, minimum samples per leaf).
- Predict based on majority class (classification) or average value (regression).

Feature Selection

Incredibly important in decision trees

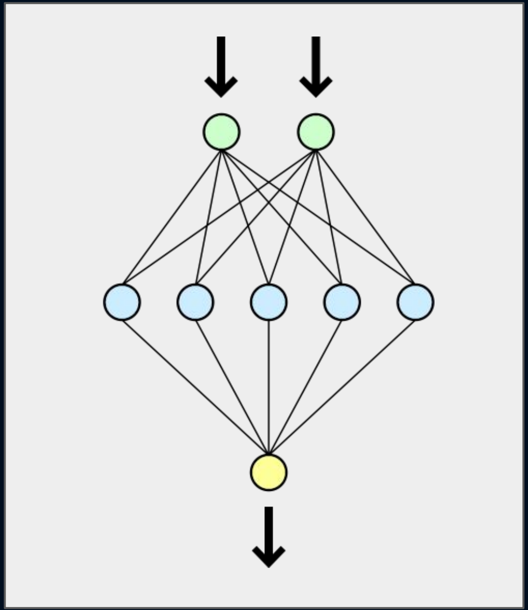
- If we want a quality of data to play a factor in our output, we need to construct it as a feature.
- Ex: We want to raise if $p > c * pot\_odds$, for a learned constant c.
  - This condition is not immediately representable in terms of features over/under a constant
  - We have to *transform* existing features to make it easier for the decision tree to pick up on this condition.
  - New feature: p/pot_odds
  - Raise if this new feature is greater than a learned constant c

Disadvantages to NNs

- Have to construct features
- Prone to overfitting or variance if not enough examples
    - Creating a leaf for each data point is too much fitting
    - A single data point can greatly sway behavior
- Meanwhile neural nets create their own features and do well at smoothly reacting to each data point via gradient descent.

Advantages

Interpretable!



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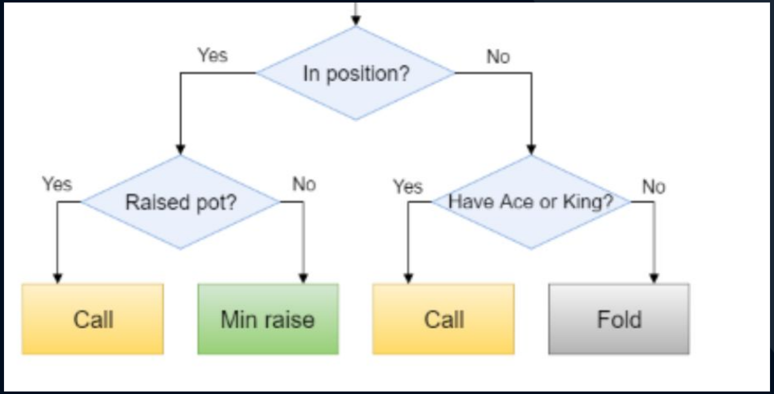
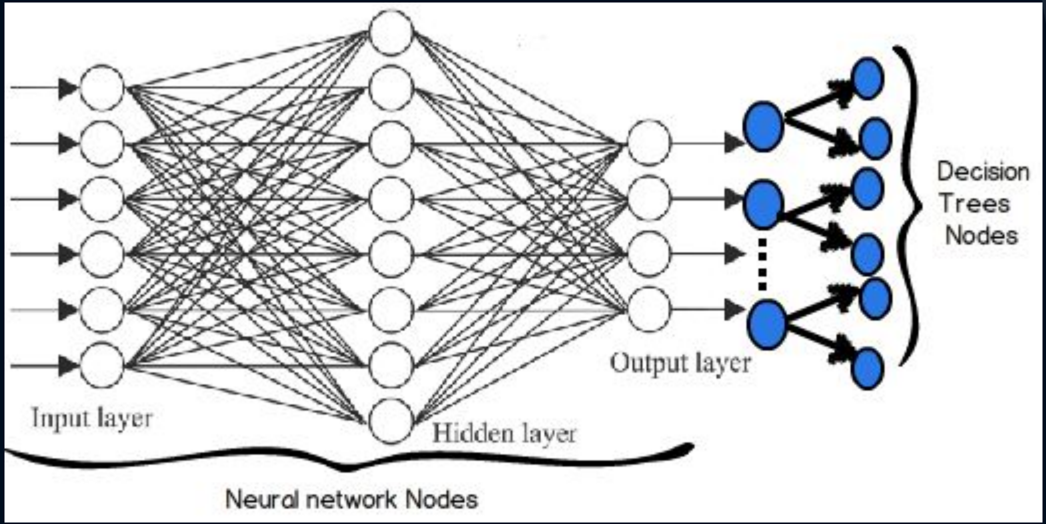


What about both?

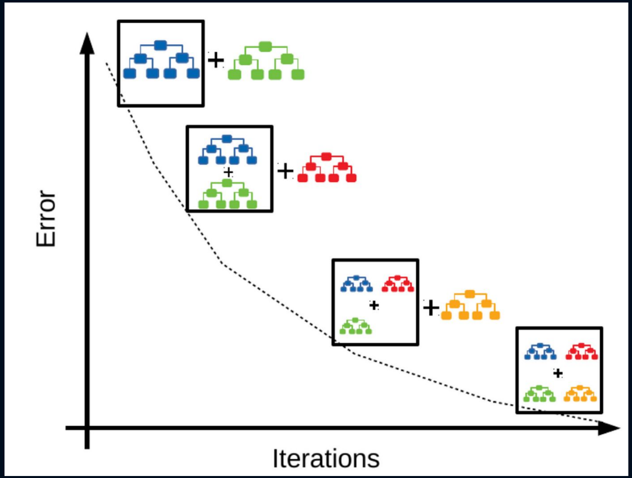


Boosting

Another way to resolve disadvantages

- An ensemble technique that builds multiple weak learners (e.g., decision trees) iteratively, where each new tree corrects errors of the previous one.
- Key Idea: Combine many weak models to form a strong one.
- Loss Minimization:
- Fit each tree to minimize the residual error of the previous trees.

Boosting



- Result: smooths out variance while being able to make more complex decisions
- General result that can be used to improve additive models

Lunch 😋

Leave any type of feedback at **pkr.bot/feedback**!

reference-9-2025

Giveaway Winners

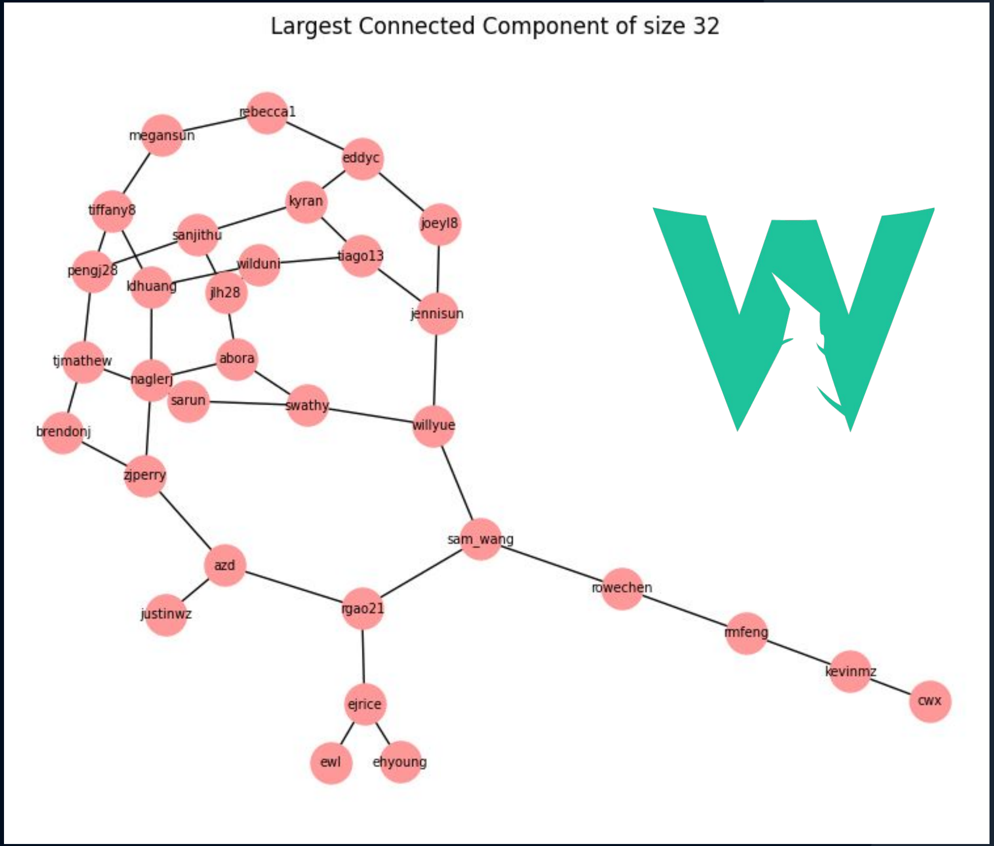
GTO RSVP Raffle: kerb “cleve195”

Connection Game: kerbs

['kyran', 'ehyoung', 'abora', 'tiago13']

N=48 total entries
44 successful connections
15 failed connections

```
{'jorgevas', 'jiange12', 'eposondu'}
{'mandoj', 'mattzhou'}
{'emilyc', 'rlsalas'}
{'merey'}
{'kjiang77'}
{'ljkeller'}
{'gsjau'}
{'decoudav'}
{'tjwshu'}
{'akshaya7'}
{'bocchi'}
{'pky'}
```



Closing Remarks…

Thanks for coming!

Slides will be posted on **pkr.bot/resources**

Repo will be pushed to **pkr.bot/github**

Make sure to check **pkr.bot/piazza** for updates

Lecture recordings at **pkr.bot/panopto**

Leave feedback at **pkr.bot/feedback**!