Predicting Human Behavior Using Tic-Tac-Toe

Team Tic Tac Toe Tac Tic
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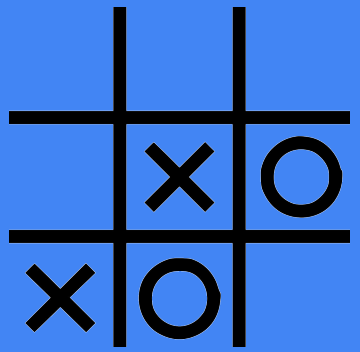


Project Summary

Neural net based implementation of tic tac toe.

- Relatively simple to implement. We all had identified with playing tic tac toe when we were younger, and we all were familiar with the multiple ways in which you could win the game.

Bordering AI & Play.

- We decided to research a bit more on whether there were behavioral observations made by others in the game of tic tac toe. There are strategic ways to win in tic tac toe that resemble a smarter and more creative way of thinking. We ultimately wanted to observe whether the neural net would be able to predict specific strategy/method of winning used by the user .

Motivation - Why is this important?

Objective: Explore how AI systems and human decision making influence each other, how human behavior is displayed and represented in the context of gameplay

Why through gameplay?

- Decision making, strategies, and tactics

Why Tic-Tac-Toe?

- Easy to implement with room to expand to 3x3 (each cell is an individual game)
- Observations to be made in the strategy used in connection with the outcome of the game. (Flat out win, playing to draw/not lose, winning by mistake of opponent)
- Much smaller branching factor and state-space compared to games such as chess or hangman - easier to observe and understand the human decisions being made

Previous Research & Studies

The prediction of human player in Tic Tac Toe

- “Assessing the intelligence of a student through Tic-Tac-Toe game for Career guidance”
  - Cognitive model that analyzes intelligence, patience, perseverance, speed of solving problem etc.
- “The Wisdom of Tic Tac Toe”
  - A perspective on the human/emotional aspect behind the control that players have throughout the game. (Forking/blocking)
- Others that outline the same concept of control throughout the game + behavioral response that comes with that.

Tic-Tac-Toe Tactics (Basic)

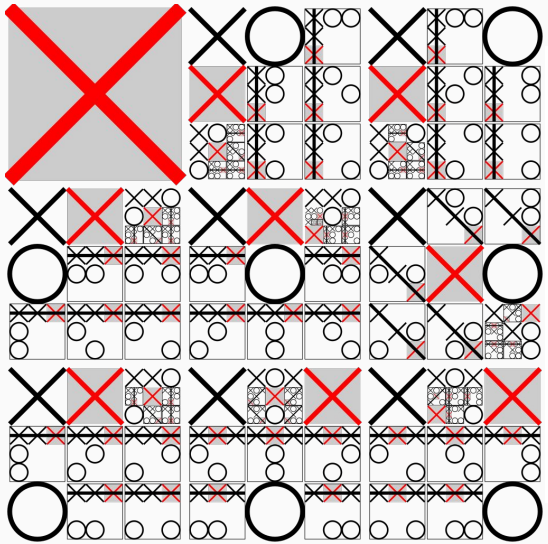
1) **Threaten** your opponent by creating 2 symbols in a row with an empty 3rd spot
2) **Block** your opponent if they have 2 symbols in a row
3) **Fork**: create 2 different threats so your opponent can't block both in one move

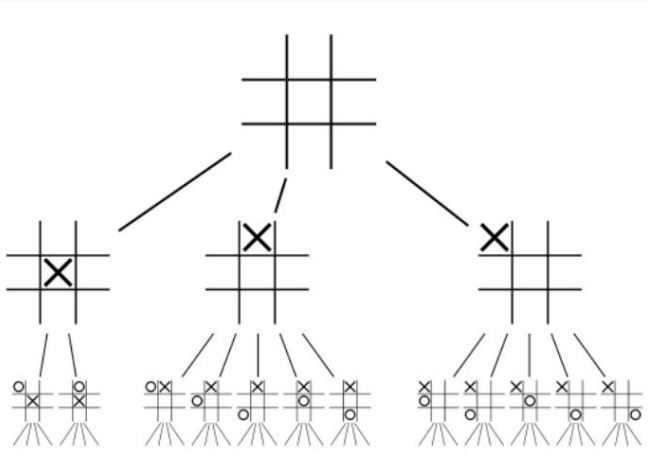
Else: center > corners > middles

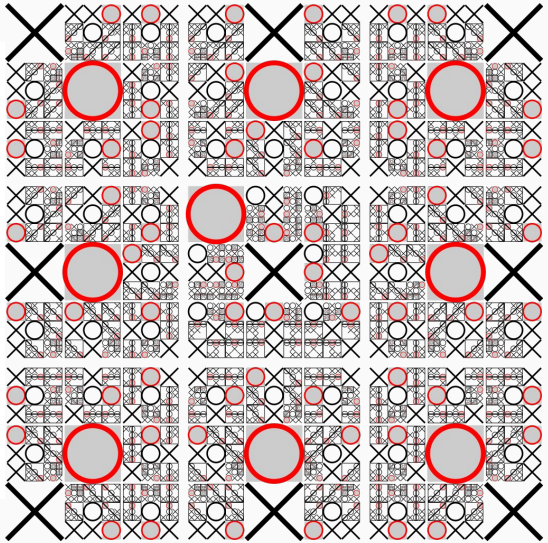
Game Theory & Psychological Lessons

- **Futile**, no-win scenario (as seen in WarGames)
- **Zero-sum game**. First player always has advantage, second player must defend or lose
- **Nash equilibrium** is a tie: each player prevents the other from winning
- **Zermelo's Theorem**: any finite, two-person game of perfect information and alternating moves, either a) one of the sides can force a win, or b) both can force a draw

The General Solution (using combinatorial Game Theory)







Human Cognition & Tic-Tac-Toe

Cognitive benefits for children:

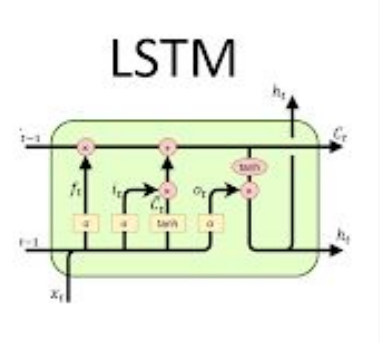
- Encourages logical thinking: looking ahead and making predictions
- Develop spatial and problem solving skills

Carnegie Mellon University Experiment [1993]

- Playing to win → failing to block → lose
- Playing to not lose → draw

Our Solution: Neural Network Model (really? why?)

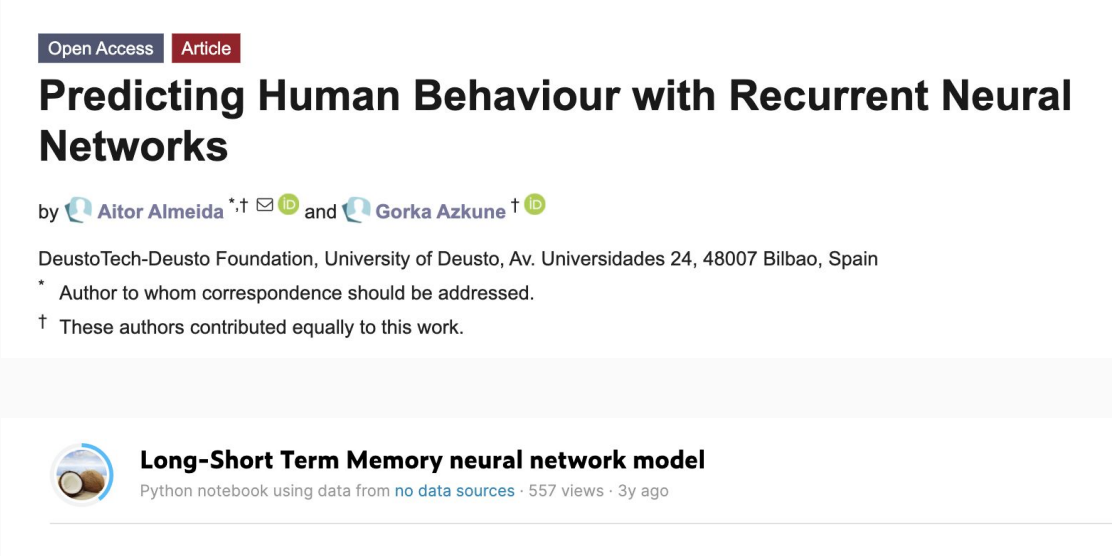
Long Short-Term Memory model: Learning order dependence in sequence prediction problems.



It’s a type of recurrent neural network

- Connect past action sequences to predict the next action
- Well-suited to classifying, processing and making predictions based on time series data.
- A very useful model for human behavior prediction!

Why LSTM model?



Open Access Article

Predicting Human Behaviour with Recurrent Neural Networks

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Long-Short Term Memory neural network model

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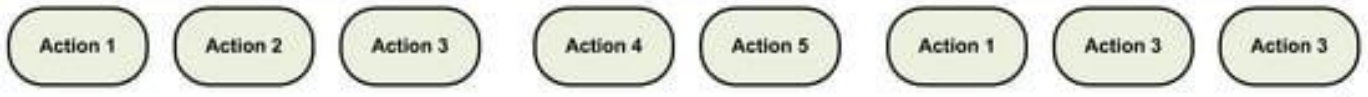
LSTM model used to predict user behaviour using *actions*, *activities*, and *intra*- and *inter-activity behaviour*.

Used a Long-Short Term Memory (LSTM) neural network in order to predict, from a sequence of plays in a finished game of Tic Tac Toe, one of the three outcomes: either it's a draw, or one player won.

Why LSTM model?

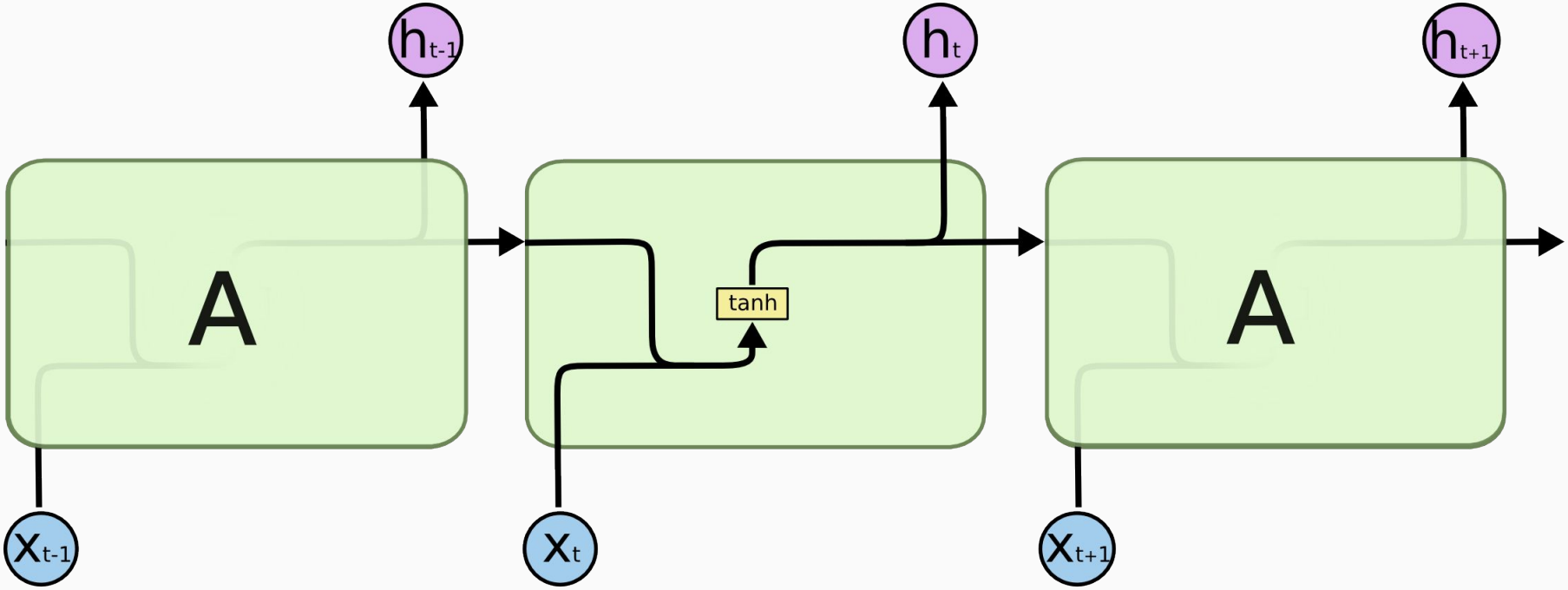
LSTM models the inter-activity behaviour. The presented architecture offers a probabilistic model that allows us to predict the user's next actions and to identify anomalous user behaviours.



A very useful model for tic tac toe human behavioral prediction!

Connections to AI/CogSci in recurrent neural networks

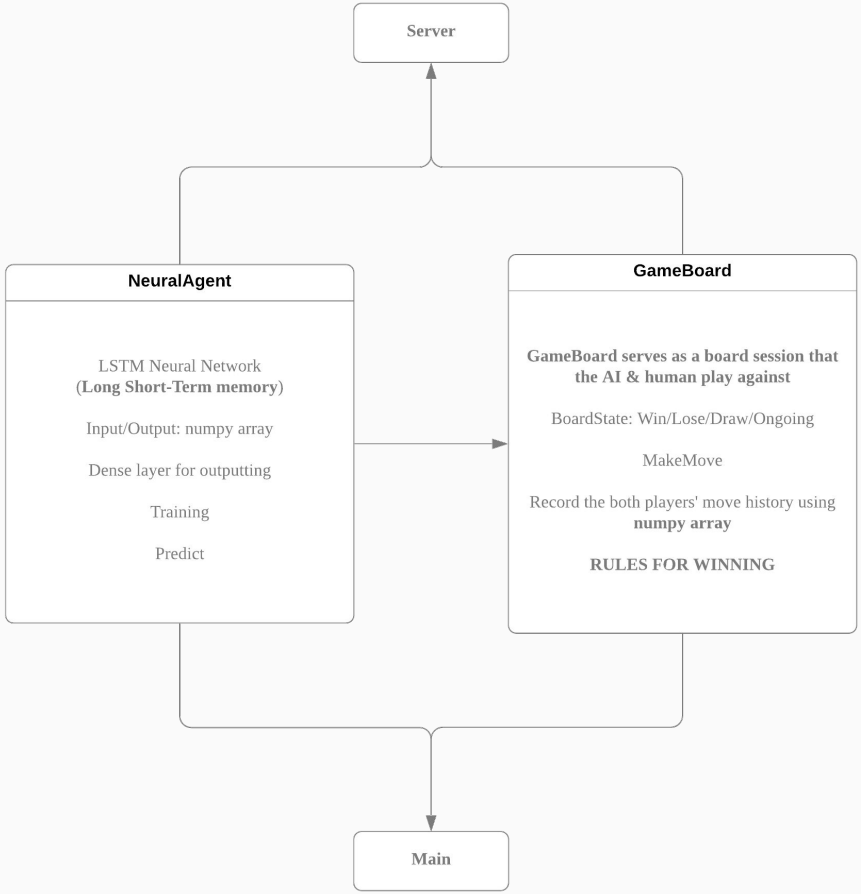
The repeating module in a standard LSTM layer



Previous actions **Current actions** **Future actions**

Assign weights and importances **Predict**

UML diagram design

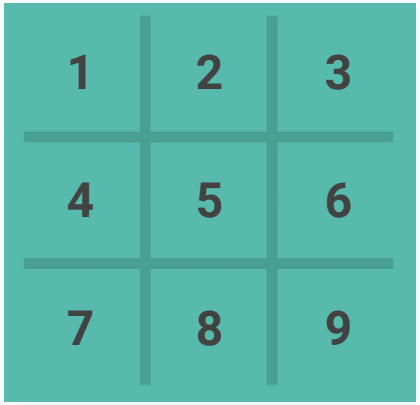


Training using numpy arrays!

```
     |   | O
  ---+---+---
   X | O |
  ---+---+---
     |   | X

Numpy array representation:
[[3 3 0]
 [1 0 3]
 [3 3 1]]
```

```
np.array([[1, 2, 3],
          [4, 5, 6],
          [7, 8, 9]])
```



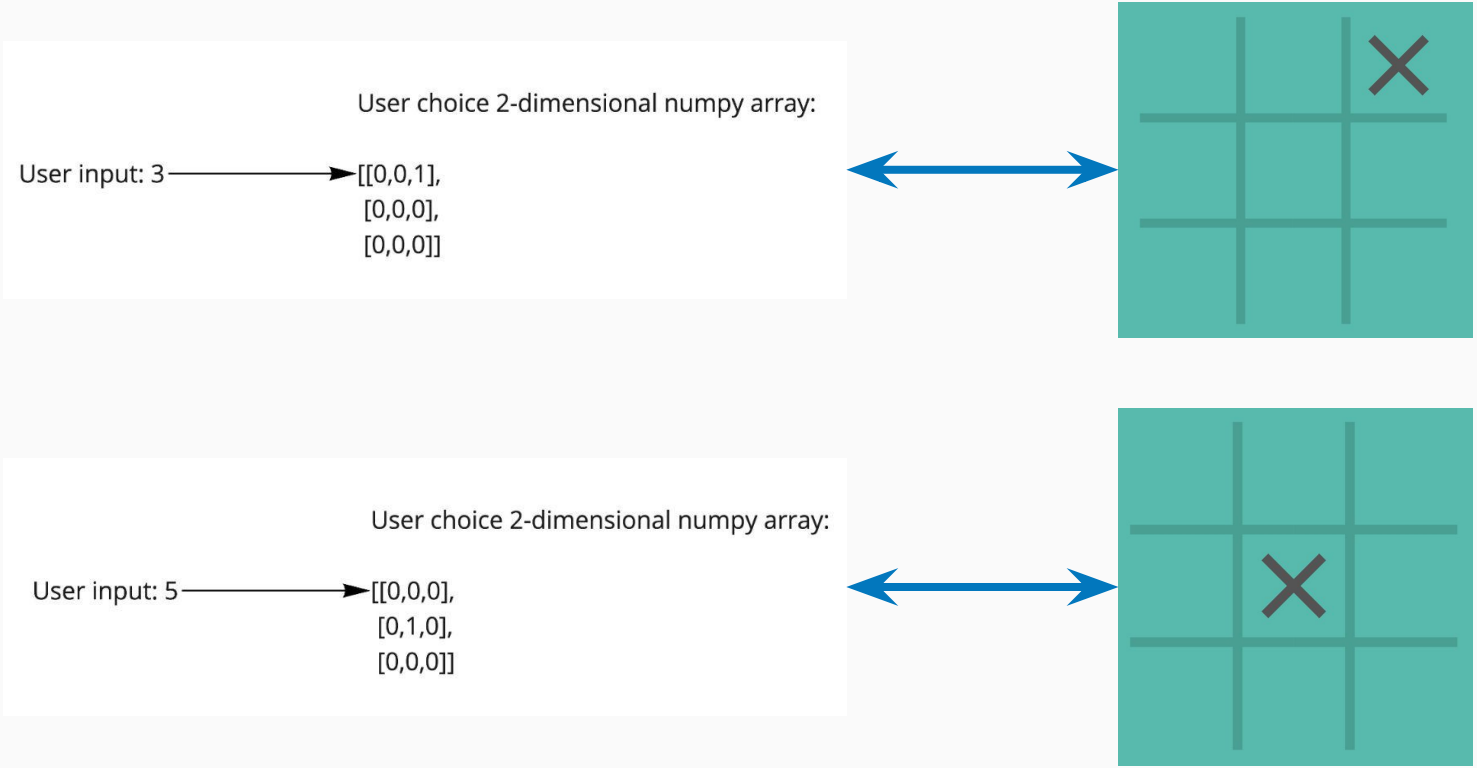
We use 2-dimensional numpy array to represent the game board and the user choice.

0: The slot where the “O” is

1: The slot where the “X” is

3: The slot that is still open

Integer 1 to 9: user input number

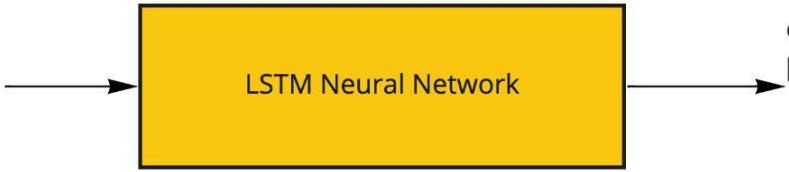


Each user input integer is also converted to a 2-dimensional numpy array as shown above.

A GameBoard representation of
current state using numpy array:

e.g.
[[3, 1, 3],
 [3, 0, 3],
 [3, 3, 3]]

3: Empty slot
0: User slot
1: Computer (opponent) slot



Training/Prediction

User choice represented as numpy array:

e.g.
[[0, 0, 0],
 [0, 0, 0],
 [1, 0, 0]]

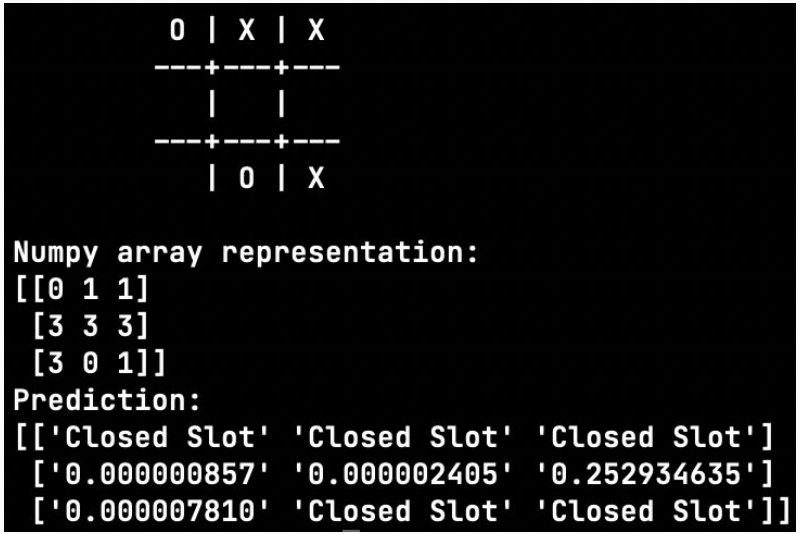
1: User's choice

Input

Output

Results

Training Entries	Training Accuracy
1	0.4166666567325592
2	0.8888888955116272
3	0.7777777910232544
4	0.4444444477558136
5	0.6666666865348816
6	0.3333333432674408
7	0.7777777910232544
8	0.75
9	0.5555555820465088
10	0.7777777910232544
Average	**0.6388888985**



Example prediction result from the LSTM model

It’s Demonstration Time!

Ethical analysis

Connections to AI and society

Human & Behavior aspects

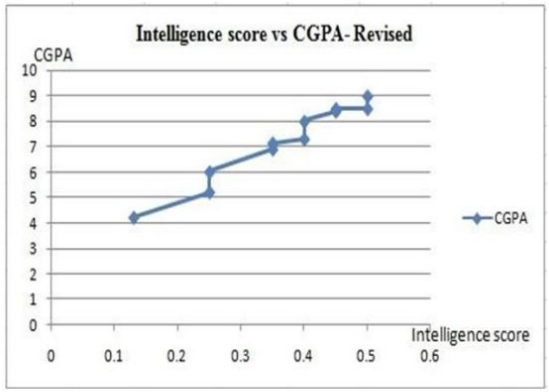


Figure 3. Revised intelligence vs. CGPA

- **Tic-Tac-Toe Game Playing Career Guidance System (TTT-GP-CGS)**
  - Used to assess the intelligence, problem solving speed, patience, perseverance, and quality of learning ability, in order to determine likelihood of success in a field

- **What are the potential risks/ethical issues?**
  - Sample population: Who was involved in the testing of this system?
    - Biased Datasets/Groups
    - Different exposure to the game
  - Attempting to generalize assumptions of students' intelligence is problematic **in and of itself.**
  - Directly correlate likelihood of success as a software engineer with Tic-Tac-Toe performance?!?

Utopia

- Our understanding of human brain function, as well as that of human behavior skyrockets!
- We develop a Neural Agent capable of perfectly understanding and emulating human behavior
- Mental health facilities, criminal activity, political decisions/responses

Dystopia

- Utilized for inappropriate purposes and scenarios
- Human interaction replaced by computer interaction → a lack of empathy for others
- Instrumental convergence

Challenges

1. **Formatting predictions**
    a. Probabilities for each slot?
    b. Predict one slot?

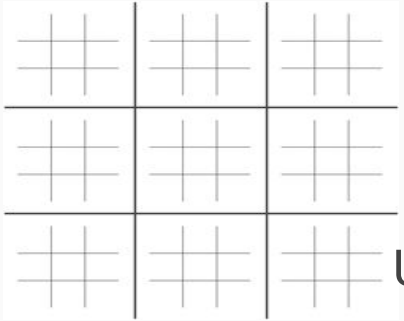
2. **Implementing the probability predictions**
    a. Use 2-dimensional array with 0 and 1

What we learned...

1. Connecting the game to the neural network
    a. By numpy array
2. Generating training data
3. Determining the prediction format
4. Tic Tac Toe and human behavior, and career implications

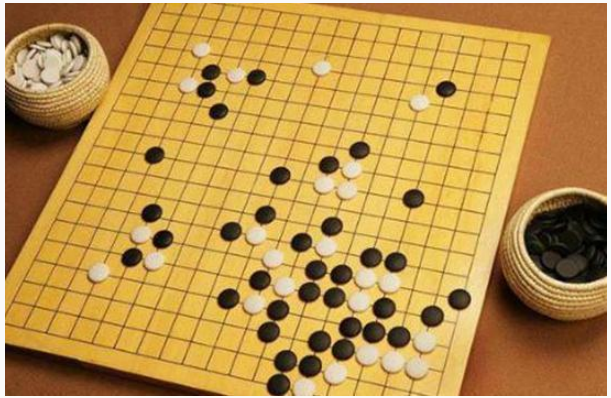
What would we change/expand...

1. **For Tic Tac Toe:**
   a. Heuristic Search Tree for computer/prediction
   b. A pre-existing train data as a starting point
   c. Another model: Q-learning
   d. Assess which strategy works/is adopted
2. **MORE COMPLICATED GAME**



Ultimate Tic Tac Toe

GoBang (Five-in-a-row)



Thank you for listening!

Any Questions?