### Guess My Passcode: Bonus Challenges

These (optional) challenges will be a good way to solidify your understanding of the AI concepts we learned in the first week (**features**, **predictions**, **backpropagation**).

AI touches many parts of society, so we’ve prepared 6 fun challenges under different themes:

**Data Scientist**, **Entrepreneur**, **Engineer**, **Mathematician**, **Inventor**, and **Teacher**.

For feedback, please email your solutions to your teacher!

#### **Data Scientist**

AI “chatbots” like ChatGPT have been described as everything from an agent of chaos in the classroom to the future of education. However, after everything you’ve learned in class today, you now know that ChatGPT’s behavior depends a **lot** on the data that has been used to train it. That data can be high quality, low quality, or even biased - either way, as of 2024 the public still doesn’t know.

One of the jobs of a **data scientist** is to cut past the hype or fear and to quantify, using scientific experiments, how well AI models actually perform. As a student, you are in a better position to understand how AI impacts students a whole lot better than people outside of the classroom.

**Hypothesizing**

1. What ways are you seeing chatbots being used in school? What have you experienced directly, and what have you heard about (from your peers, teachers, or parents)?
2. In what ways does the use of AI excite you? In what ways does the use of AI concern you?
3. Choose a use case that you brainstormed above. What’s one way that you might be able to evaluate how well chatbots would do at this use case?

**Example***:* let’s say that you want to see how good ChatGPT is at math. Can you come up with a set of math questions to ask it? How often does it get the answer right, or get it wrong, or fail to answer?

**Evaluating**

1. Let’s try to collect some data! “Running an experiment” sounds like a lot of work, but it’s something you can do on your laptop in 30 minutes.
	1. First, let’s come up with a set of at least 10 prompts you can think of that relate to your use case that you can ask ChatGPT.

**Important:** DO NOT share any sensitive information with ChatGPT, such as name, address, family members, or contact information for you or anyone.

* 1. For each prompt, what’s an example of a “good answer”? What would be an example of a “bad answer”?
	2. Out of the ten prompts, how well did ChatGPT perform? What percentage of the time did it meet your expectations, and what percentage of the time did it not?

**Bonus:** what if you asked each prompt several times, say 5 each? Do the percentages change, or stay the same?

1. Analysis and reflection: what patterns do you notice in the data you get back from ChatGPT? Is there anything that you didn’t expect, that you’re curious about?

#### **Entrepreneur**

The AI market is projected to become a $190B industry by 2025. 84% of all companies in a 2017 survey say that AI will give their business a competitive advantage. Can you come up with your own AI business idea to share with the class?

**1. What problem will you solve?**

Think back to our discussion in class - what is AI good at, compared to what humans are good at. Are there problems you’ve noticed or observed that AI could help with?

* Hint: if you are having trouble getting started, start with your own life and hobbies!

**2. What data will you need?**

Remember: a good AI model requires **features** and labeled **predictions**.

My AI will use these features:

My AI will predict:

**3. Let’s validate your idea!**

Try collecting a small dataset of 25 training examples based on your idea above. Do you notice any patterns in your features that your AI can learn from to make predictions?

**Engineer**

Are you excited to apply your skills learning computer science to build your own AI? Let’s try building an AI to play **Guess My Passcode** (our game from the lesson).

Only basic Python is required to try this challenge. You may also find it a good way to learn Python as you go.

**To get started, navigate to play** [**Guess My Passcode**](https://drive.google.com/file/d/1QfUBruKMoEIU74oUYXub8VB-Zym_ynYT/view?usp=sharing)**.** To run a cell, click the play button 

1. To refresh your understanding of the game, try playing the game on your own at least once, and comparing against the AI our team built. Do you notice any strategies that our AI is using?

2. In the section “Challenge: Build Your Own AI”, you'll find a playground below that will allow you to write your own Python code to play the game. Try to fill in the function calculate\_new\_guesses to perform backpropagation, and run the code to see your algorithm in action.

calculate\_new\_guess is called each time a passcode guess is submitted. It is given the following information from the attempt:

* current\_guess: a List of the current guess (setting each guess to 5 on the first attempt)
* multipliers: a List of all multipliers
* target\_number: an integer storing the target number returned by the phone lock
* n: the length of every sequence

Currently, calculate\_new\_guesses chooses a random number between 1-9 for each guess digit. Can you update it to solve the game more effectively?

**Hint 1**: Using print(), try printing out each of the parameters current\_guesses, multipliers, and target\_number to see how they work.

**Hint 2**: As a starter task: how would you use current\_guesses and multipliers to calculate the passcode guess from the last round?

**Hint 3**: There are many ways to choose learning\_rate in the backpropagation equation (and many strategies involve changing learning\_rate over time). Try experimenting!

**Mathematician**

Modern artificial intelligence is built on top of math. Let’s explore some interesting problems in solving the **backpropagation** algorithm, which lies at the heart of all artificial neural networks.

**Terminology**

The backpropagation algorithm we learned on day one can be expressed in the following form

$w\_{i} := w\_{i} + Δw\_{i}$

$Δw\_{i}=α⋅(y - g(x))⋅x\_{i}$

where := denotes an update made by the algorithm. Each variable above is defined as follows:

$w\_{i}$ - the ith passcode guess (i = 1, 2, 3, … n), also referred to as a **weight** in AI

$Δw\_{i}$ - how much to update the ith passcode guess during backpropagation

$α$ - the **learning rate**, or how big of an update to make

$y$ - the target number, also referred to a **label** in AI (aka. the correct prediction)

$x\_{i}$ - the ith multiplier, also referred to as a **feature** in AI

$g$ - the total, also referred to as a **prediction** in AI. In our game, g is defined as:

$g(x) =w\_{1}⋅x\_{1}+w\_{2}⋅x\_{2}+w\_{3}⋅x\_{3}+...+w\_{n}⋅x\_{n}$

Suppose we are playing the Guess My Passcode game with a sequence length of $n=3$, and we’ve received the following information on our first turn.

| $i$ | Guess ($w$) | Multiplier ($x$) |
| --- | --- | --- |
| 1 | 5 | - 2 |
| 2 | 5 | 2 |
| 3 | 5 | 4 |

**1. Forward Propagation**

Given our initial guesses and multipliers shown above, what is our total $g(x)$?

**2. Naive Backpropagation**

Now, suppose we’ve submitted our guess, and the lock returns an target number of $y=32$.

1. What is $y - g(x)$? This quantity is referred to as **error**
2. Let’s naively choose a learning rate of $α=1$. How much will we update each guess during backpropagation?

 $Δw\_{1}$ =

$Δw\_{2}$ =

 $Δw\_{3}$ =

1. After applying backpropagation in step (b), what are our new passcode guesses? (For sake of this exercise, assume that $w\_{i}$ can be larger than 9.

 $w\_{1}$ =

$w\_{2}$ =

 $w\_{3}$ =

1. Given these new passcode guesses, what is our updated total $g(x)$?
2. Does that updated guess seem reasonable? Why or why not?
3. What updated guess would we have arrived at if we had chosen $α=1/4$ in step (b)? How much did this change the error $y - g(x)$?

**3. Adaptive Learning Rate**

Clearly, our choice of the learning rate $α$ makes a big difference in how backpropagation behaves. Let’s see if we can come up with a better way to chose $α$ each turn.

1. **Target Number Matching**. A strategy we discovered in class is to update the guesses at the end of each turn so that our total matches the target number.

What learning rate $α$ should we set so that our updated total $g(x)$ would match the actual target number of $y=32$?

1. Can you find a way to express your learning rate from 3(a) in terms of $x\_{1}$, $x\_{2}$, and $x\_{3}$?

Once you’ve solved this problem, you’ll have derived the full backpropagation algorithm our teacher’s AI uses in the game. That’s all the “intelligence” there is :).

1. Can you come up with an intuitive explanation for the equation above?

**Inventor**

Part of what makes AI such a fast-growing field is that it is constantly reinventing itself. State-of-the-art algorithms are being developed almost every few months, and the next research breakthrough could come from your idea.

**Source Data**

These data points are taken from a 1948 study called *The Songs of Insects* that researched how temperature affects cricket behavior:

| Temperature (F) | Cricket Chirps (per second) |  |
| --- | --- | --- |
| 89 | 20 |
| 84 | 18 |
| 75 | 16 |
| 70 | 15 |
| 82 | 17 |

In this setting, we can build an AI model to perform **prediction**: that is, given any input temperature $x$, the AI will be able to predict a cricket chirp count $y$.

**Linear Regression**

Plotting the data above shows that it is roughly linear. This suggests that the AI model should produce an output equation of the form $y=m⋅x + b$. This problem is called **linear regression**.

Can you come up with your own procedure for estimating a formula $y=m⋅x + b$ that best fits the data above?

* It should take as input the five data points above, and produce parameters $m$ and $b$ to define the line $y=m⋅x + b$
* Aim for your procedure to be *repeatable*: that is, by following the steps in your procedure, any classmate should be able to arrive at the same answer. Being repeatable will make your procedure an **algorithm**.
* There is no single “correct” way to do this. Many methods exist that use math you’ve learned in school. Be creative!

**Teacher**

Artificial intelligence is a modern concept that is growing to touch many areas of our lives - from YouTube recommendations to ChatGPT. This rise in prevalence has also contributed to misconceptions and fake news about what AI is and what it is not.

Now that you’ve learned a bit about how AI actually works, you can help prevent misinformation and encourage debates that are grounded in facts!

**Reflection**

Think back to what we learned so far. How would you describe how AI works to a friend or family member?

How does modern artificial intelligence differ from human intelligence? Is the AI we’ve learned “conscious”?

How do your descriptions compare to what you might have read about AI in news or media?

**Teaching**

Try it out! See if you can explain how AI learns to a friend or family member who is not familiar with AI. As you discuss, you may also consider these questions for debate:

1. What are some examples of how AI has affected your life (or society)? Can you identify any others that we have not covered in our workshops?
2. How does AI technology work (at a fundamental level)?
3. What moral responsibilities should the scientists who are building AI have? Are there features and predictions that would be irresponsible to make?
4. What are some of the conversations that the public is having about AI? (For example, in recent presidential debates). What viewpoints do you agree with, and which do you disagree with?