NOTES AND TODOS

- Revisit timing from codemash to see if the exercises fit in the breakdown
- Less text on slides
- NLP
  - The structured language example is really weak (big bird as a semantic model)
  - Take *way* more time on sentence diagramming
- Correct Final Slide for CodeMash
- Publish to CodeMash branch in vcs
If You Didn’t See My Email...

- Install the following software / libraries
  - Python
  - scikit-learn
  - pytorch
  - vaderSentiment
  - nltk
  - pathfinding
  - gymnasium

- Clone the tutorial repository
  - git@github.com:sep/ots-ai-tutorial.git
  - https://github.com/sep/ots-ai-tutorial.git
Off the Shelf AI

Standing on the shoulders of giants
Who Are We?
What Are You All Looking For?

Give me a quick sense of who you are and why you're here.
What are we doing here?

"Simplicity--the art of maximizing the amount of work not done--is essential."

The Agile Manifesto
What are we doing here?

"Simplicity--the art of maximizing the amount of work not done--is essential."

The Agile Manifesto

Just as true of AI as anything else. We’re going to look at open source tools for AI today.
What Is AI Anyway?

Any program that seeks to accomplish tasks that are thought of as requiring human intelligence.
What Is AI Anyway?

Any program that seeks to accomplish tasks that are thought of as requiring human intelligence.

- Playing games
- Summarizing Books
- Writing Code
- Carrying on Conversations
- Designing Turbine Blades
- etc.
What Is AI Anyway?

Any program that seeks to accomplish tasks that are thought of as requiring human intelligence *that has yet to become sufficiently advanced to be its own thing.*

- Machine Learning
- Computer Vision
- Natural Language Processing
- Robotics
What Is AI Anyway?

Artificial Intelligence can:

- Sense its environment
- Plan for a desired outcome
- Either:
  - Execute that plan on its own
  - Present the plan to a human
What Is AI Anyway?

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The General Form of an AI Solution

Original Problem Domain → Problem Description in Formalism → Solution in Formalism → Solution in Domain Terms
The General Form of an AI Solution

Original Problem Domain → Problem Description in Formalism → Solution in Formalism

Original Problem Description

Solution in Domain Terms
What Is AI Anyway? Turns out, it’s math!
What Is AI Anyway? Turns out, it’s math!

“It was my understanding there would be no math”
What Is AI Anyway? Turns out, it’s math!
The General Form of an AI Solution
The General Form of an AI Solution

Original Problem Domain

Original Problem Description

Problem Description in Formalism

Solution in Formalism

Solution in Domain Terms
A Brief Sketch of AI Systems
A Brief Sketch of AI Systems
Where Do I Start?


by Stuart Russell and Peter Norvig

The authoritative, most-used AI textbook, adopted by over 1500 schools.

Table of Contents for the US Edition (or see the Global Edition)
Some Ground Rules

- We’re going to lean-coffee the exercises
  1. So we have time to cover everything if we want to
  2. We don’t have to move on if we don’t want to, we can always dedicate more time to a topic if there’s interest.

Please Ask Lots of Questions

- Material often sticks better (and is more entertaining) when this is less of a lecture and more of a dialogue.
What’s My Agenda

● A Brief Introduction to AI
● **Syllabus (hey, that’s this!)**
● Natural Language Processing
● Machine Learning
● Automated Planning and Optimization
● Potpourri
What’s My Agenda

● A Brief Introduction to AI
● **Syllabus (hey, that’s this!)**
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  ○ Generating Novel-ish Text
  ○ Is the user pleased?
  ○ What were they talking about?
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  ○ Recognizing patterns
  ○ That, but better using spatial relationships
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  ○ Pathfinding in video games
  ○ Controllers for robots
● Potpourri
  ○ Choose Your Own Adventure
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- A Brief Introduction to AI
- **Syllabus** (hey, that’s this!)
- Natural Language Processing
  - ChatGPT
  - Sentiment Analysis
  - Text Binning
- Machine Learning
  - Simple Neural Networks
  - Convolutional Neural Networks
- Automated Planning and Optimization
  - Deterministic Planning and Scheduling
  - Stochastic Planning and Scheduling
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  - Choose Your Own Adventure
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  - Deterministic Planning and Scheduling
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  - Choose Your Own Adventure
Do People Have Machines Configured For The Tutorial?

If not, let’s get that settled.

We can break into pairs / small groups.

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  - scikit-learn
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  - pathfinding
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  - git@github.com:sep/ots-ai-tutorial.git
  - https://github.com/sep/ots-ai-tutorial.git

I can help you get some things installed and cloning.
NAVI GATING AI

NLP
- Extraction
- Ingestion

Optimization
- Automation
- Recommendation
- Scheduling
- Planning

Generative
- GPT
- LLM
- Video
- Image
- Voice

Prediction
- Modeling Reality
- Machine Learning
- Classification

Recognition
- Vision
- Ingestion
- Extraction

@DrBass
ChatGPT: What it is and isn’t
Exercise 1a: Let’s Talk About Children’s Games

- How do I play hangman?
- What are effective strategies for playing hangman?
- From the perspective of X, explain the game of hangman.
  - Wikipedia
  - An elementary school teacher
  - A grandparent
  - A middle schooler
Exercise 1b: Let’s Try To Play a Game of Hangman
Why Was ChatGPT So Good at 1a But Not At 1b?
Garden Path Sentences

A garden-path sentence is a grammatically correct sentence that starts in such a way that a reader's most likely interpretation will be incorrect (per wikipedia)
Garden Path Sentences

A garden-path sentence is a grammatically correct sentence that starts in such a way that a reader's most likely interpretation will be incorrect (per wikipedia)

The old man the boat.
Garden Path Sentences

You
Can you give me an example of a garden path sentence?

ChatGPT
Certainly! A garden path sentence is a sentence that starts in such a way that a reader's most likely interpretation will be incorrect, leading them down the "wrong path" before they realize they need to reinterpret the sentence. Here's an example:

"The old man the boats."

At first glance, it may seem like a sentence with an old man as the subject, but as you read further, you realize that it is actually saying, "The old (people) man the boats." It's a play on words that creates a momentary confusion before the correct interpretation becomes clear.
Some Other Examples

Create a novel example of a garden path sentence

Sure! Here's a novel example of a garden path sentence:

"After taking a sip of her potion, the witch cast a spell with her broomstick, stirring the cauldron as she flew through the night sky."

In this sentence, the reader might initially interpret "After taking a sip of her potion" as the witch taking a sip of the potion before doing anything else. However, the sentence takes a twist as it continues, revealing that it was actually the broomstick she sipped from before casting a spell and stirring the cauldron while flying through the night sky. This structure can lead the reader down a "garden path" of misunderstanding before they grasp the intended meaning.
Some Other Examples

Create a novel example of a garden path sentence

Certainly! Here's a novel example of a garden path sentence:

"Running through the park, the tree branch reached out and grabbed my attention."

In this sentence, the phrase "Running through the park" could lead the reader to assume that the subject of the sentence is "Running" or perhaps a person who is running through the park. However, as the sentence progresses, it becomes clear that "the tree branch" is the actual subject, and the intended meaning is that the tree branch caught the speaker's attention while they were running through the park. This structure creates a momentary confusion or diversion from the expected interpretation, making it a garden path sentence.
Rewrite the Gettysburg Address with every fourth noun replaced with a random aquatic mammal:

"Fourscore and seven years ago, our fathers brought forth on this continent a new dolphin, conceived in liberty and dedicated to the proposition that all seals are created equal.

Now we are engaged in a great manatee, testing whether that nation, or any nation so conceived and so dedicated, can long endure. We are met on a great battlefield of that war. We have come to dedicate a portion of that field as a final resting place for those who here gave their lives that the otters might live. It is altogether fitting and proper that we should do this.

But, in a larger sense, we cannot dedicate, we cannot consecrate, we cannot hallow this ground. The brave walrus, living and dead, who struggled here have consecrated it far above our poor power to add or detract.

The world will little note nor long remember what we say here, but it can never forget what these whales have done. It is for us, the living, rather to be dedicated here to the unfinished work which they who fought here have thus far so nobly advanced. It is rather for us to be here dedicated to the great dolphin remaining before us—that from these honored sea lions we take increased devotion to that cause for which they gave the last full measure of devotion—that we here highly resolve that these sea otters shall not have died in vain—that this nation, under God, shall have a new birth of freedom—and that government of the dolphins, by the dolphins, for the dolphins, shall not perish from the earth."
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What ChatGPT Is And Isn’t

It Is:
- Able to generate things that looks like other things in its training corpus
- Part of larger systems that can do the things on the right

It Is Not:
- A Document Retrieval System
- Capable of Explicit State Models
- Capable of validating facts
- Capable of inference or modeling
What Generative Techniques ChatGPT Are And Aren’t

They are:
- Able to generate things that looks like other things in its training corpus
- Part of larger systems that can do the things on the right

They are not:
- A Document Retrieval System
- Capable of Explicit State Models
- Capable of validating facts
- Capable of inference or modeling
Be Mindful of ToS and Your Data
Some Suggestions

Do Use Generative Techniques:
- To provide a starting point to experts
- To fill in text for generic items in a game
- As a way of generating random text for test inputs
- To ideate a story
- To game out various potential client conversations

Do Not Use Generative Techniques:
- As a replacement for expert advice
- As a source of truth
- To try and break the writers’ guild strike
- To replace your help desk
Some Suggestions

Do Use Generative Techniques:
- To provide a starting point to experts
- To fill in text for generic items in a game
- As a way of generating random text for test inputs
- To ideate a story
- To game out various potential client conversations

Do Not Use Generative Techniques Alone:
- As a replacement for expert advice
- As a source of truth
- To try and break the writers’ guild strike
- To replace your help desk
Further Exercises

- RAG Model for Answering Rules Questions For Your Favorite Board Game
- Integrate ChatGPT With a Virtual Table Top (Roll20, Foundry, etc)
- Reddit / Twitter / Etc. Digest Generator
- Chat Bot for Mocking Your Friends / Serving Up Your Family Calendar / Etc
When We Return From Break, More NLP!

- A Brief Introduction to AI
- Syllabus (hey, that’s this!)
- **Natural Language Processing**
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Part 2: Natural Language Processing
Some Common NLP Use Cases

- Summarizing Bodies of Text
- Question Answering
- Extracting facts from news feeds as inputs for high frequency trading
- Cyber Security
- Phone Tree Systems
What’s the Common Underlying Problem?

Making largely unstructured data, namely text, machinable in a reliable, scalable way.
What’s the Common Underlying Problem?

Making largely unstructured data, namely text, machinable in a reliable, scalable way.

```prolog
((canary (is-a bird)
  (color yellow)
  (size small))
(bird (is-a vertebrate)
  (has-part wings)
  (reproduction egg-laying)))
```
What’s the Common Underlying Problem?

Making largely unstructured data, namely text, machinable in a reliable, scalable way.

A canary is a kind of bird.
Big bird is modeled on a canary.

```
((canary (is-a bird)
  (color yellow)
  (size small))

(bird (is-a vertebrate)
  (has-part wings)
  (reproduction egg-laying)))
```
NLP Is Almost Always A Means to an End

- Understand facts on wikipedia so that I can win at Jeopardy (Watson)
- Grab sentiment on tweets to use as a barometer of public opinion
- Summarize the content of an email to properly route customer inquiries
- Find posts violating terms of service to ease burden of forum moderators
- Identify interesting communiques to direct analyst attention
Common Problems in Natural Language Processing

- Language is *really* expressive
- Word-sense disambiguation
- Referential issues with pronouns and dropped words
- Non-verbal communication that accompanies language
- Nonliteral Expressions
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(You) Close the window.
Common Problems in Natural Language Processing

- Language is *really* expressive
- Word-sense disambiguation
- Referential issues with pronouns and dropped words
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- Nonliteral Expressions

(You) Close the window.

Sally is my mother. She sells seashells by the seashore.
Common Problems in Natural Language Processing

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- Referential issues with pronouns and dropped words
- Non-verbal communication that accompanies language
- Nonliteral Expressions
Common Problems in Natural Language Processing

- Language is *really* expressive
- Word-sense disambiguation
- Referential issues with pronouns and dropped words
- Non-verbal communication that accompanies language
- **Nonliteral Expressions**

The apple doesn’t fall far from the tree.
Common Problems in Natural Language Processing

- Language is *really* expressive
- Word-sense disambiguation
- Referential issues with pronouns and dropped words
- Non-verbal communication that accompanies language
- **Nonliteral Expressions**

The apple doesn’t fall far from the tree.

Yes, clearly that is a reasonable approach. Let’s do that.
The young boys really like video games.
The Two Kinds of NLP: Classic

The young boys really like video games.

The girls are pleased with the good news
The Two Kinds of NLP: Modern

John likes to watch movies. Mary likes movies too.
The Two Kinds of NLP: Modern

John likes to watch movies. Mary likes movies too.

BoW1 = {"John":1,"likes":2,"to":1,"watch":1,"movies":2,"Mary":1,"too":1}
How Classic NLP Works

- Ingest a bunch of text
- Tokenize that text
  - Remove “stop words”
- Part of speech tagging using statistics
- Induction of structure using sentence diagramming
- Word sense disambiguation
- Reduce structured text to desired machinable format
How Modern NLP Works

- Ingest a bunch of text
- Tokenize that text
  - Remove “Stop words”
- Embed tokens into a dictionary
- Use dictionary to vectorize source text
Token doesn’t have to mean one word (N-Grams)

- Ingest a bunch of text
- **Tokenize that text**
  - Remove “Stop words”
- Embed tokens into a dictionary
- Use dictionary to vectorize source text

John likes to watch movies. Mary likes movies too.

John likes watch movies . Mary likes movies too .

(John likes watch), (likes watch movies), (watch movies .),
(movies . Marry), (. Mary likes), (Mary likes movies),
(likes movies too), (movies too .)
Long Short-Term Memory as an Alternative

Legend:
- Layer
- Componentwise Copy
- Concatenate
Trade-offs Between The Two Major Approaches

Classic NLP:
- Labor Intensive
- Easy to tailor to a domain
- Works on small input sets
- Rich Semantic Understanding
- Easy to adapt to target output

Modern NLP:
- Single, well oiled ingestion path
- Little human intervention needed
- Extremely Data Hungry
- One size fits most representation
What’s a Large Language Model Anyway?

A large language model (LLM) is a language model characterized by its large size. Their size is enabled by AI accelerators, which are able to process vast amounts of text data, mostly scraped from the Internet.
What’s a Large Language Model Anyway?

Classic NLP:
- Labor Intensive
- Easy to tailor to a domain
- Works on small input sets
- Rich Semantic Understanding
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What’s a Large Language Model Anyway?

Modern NLP:
- Single, well oiled ingestion path
- Little human intervention needed
- Extremely Data Hungry
- One size fits most representation

- Ingest a bunch of text
- Tokenize that text
  - Stop word removal
- Embed tokens into a dictionary
- Use dictionary to vectorize source text

This step is likely done using advanced machine learning techniques.
We waited 20 minutes past our reservation for a table. Once our party was seated, the service was prompt and the food was delectable.
The Basics of Sentiment Analysis

We waited 20 minutes past our reservation for a table.

Once our party was seated the service was prompt.

The food was delectable.
The Basics of Sentiment Analysis

We waited 20 minutes past our reservation for a table

Once our party was seated the service was prompt

the food was delectable
The Basics of Sentiment Analysis

We waited 20 minutes past our reservation for a table.

Once our party was seated the service was prompt.

The food was delectable.
The Basics of Sentiment Analysis

We waited 20 minutes past our reservation for a table Neutral

Once our party was seated the service was prompt Positive

the food was delectable Positive
The Basics of Sentiment Analysis

We waited 20 minutes past our reservation for a table. Neutral

Once our party was seated the service was prompt. Positive

the food was delectable. Positive
Exercise 2a: Sentiment Analysis Using VADER
Importance of Stop Words and Domain-Aware Valence

In Some Domain Terms Have Different Connotations:

- Cable Termination
- Account Termination
- Program Termination
- The Terminator
Importance of Stop Words and Domain-Aware Valence

Some Domain Terms Have Different Connotations:
- Cable Termination
- Account Termination
- Program Termination
- The Terminator

Being negatively affected by Schindler’s List doesn’t make the movie bad; in fact, quite the opposite!
Exercise 2b: Sentiment Analysis With Bag of Words
Further Exercises

- Reddit / Twitter / Etc. Digest Generator
- Classify Novels / Films into Genre based on text
- Twitter / Reddit / Facebook post sentiment analysis
- Help Desk Ticket Classification
- MMO Log Parser and Shout Classifier
NAVGATING AI

NLP
- Extraction
- Ingestion

Optimization
- Automation
- Recommendation
- Scheduling
- Planning

Generative
- GPT
- LLM
- Image
- Video
- Voice

Prediction
- Modeling Reality
- Machine Learning
- Classification

Vision
- Recognition
- Ingestion
- Extraction
Part 3: Machine Learning
Some Common Business Cases in Machine Learning

- Reading text from a physical form
- Segmenting customers into related groups
- Recommending similar goods and services to users
- Credit Card Fraud Detection
- Just-in-time Manufacturing and Warehousing
- Predictive Text Completion
What is Machine Learning?
What is Machine Learning?

Data → Software Development → Expected Output (labels)

- Thing to execute (program)

Data → Machine Learning → Model (thing to execute)

- Labels (expected output)
What is Machine Learning?

“Let’s see who you really are!”
What is Machine Learning?

MACHINE LEARNING

“Let's see who you really are!”

PROBABILITY & STATISTICS
What Is Machine Learning?
What Is Machine Learning?
The Common Formalism

- Find a numeric representation of your problem
- Define an error metric you can minimize
- Learn a function that minimizes the error on your data
The Common Formalism

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- Define an error metric you can minimize
- Learn a function that minimizes the error on your data
The Common Formalism

- Find a numeric representation of your problem
- Define an error metric you can minimize
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NAVIGATING AI

NLP
- Extraction
- Ingestion

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- GPT
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- Image
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- Voice

Optimization
- Automation
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- Scheduling
- Planning

Prediction
- Modeling Reality
  - Machine Learning
  - Classification
- Recognition
  - Vision
  - Ingestion
  - Extraction
The Common Formalism

- Find a numeric representation of your problem
- Define an error metric you can minimize
- Learn a function that minimizes the error on your data
The Common Formalism
The Common Formalism

3

1 1 1 1 1
0 0 1 1 1
0 1 1 1 1
1 0 0 1 1
1 1 1 1 0

@DrBass
The Common Formalism
The Common Formalism
The Common Formalism
The Common Formalism

1 1 1 1 1
0 0 1 1 1
0 1 1 1 1
1 0 0 1 1
1 1 1 0

1 1 1 1 1 0 0 1 1 1 0 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0
The Common Formalism

- Find a numeric representation of your problem
- Define an error metric whose minimization also minimizes error in your desired outcome
- Learn a function that minimizes the error on your data
Some Terminology: Datapoint

Datapoint

Label  Features
Some Terminology: Datapoint

Datapoint

Label  Features

3 1 1 1 1 0 0 1 1 0 1 1 1 1 1 0 0 1 1 1 1 1 0
Some Terminology: Data Set

- Data Set
  - Datapoint
    - Label
    - Features
  - Datapoint
    - Label
    - Features
  - ...
  - Datapoint
    - Label
    - Features
How to Train Your Model

- Model Update
- Model Update
- Model Update

Datapoint
- Label
- Features

Datapoint
- Label
- Features

Datapoint
- Label
- Features
How to Train Your Model

Data Set

<table>
<thead>
<tr>
<th>Datapoint</th>
<th>Datapoint</th>
<th>Datapoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Label</td>
<td>Features</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Model Update
Model Update
Model Update
How to Train Your Model
How to Train Your Model
How to Train Your Model

But how do we evaluate the model?

Data Set
Datapoint
Label | Features
Datapoint
Label | Features
Datapoint
Label | Features

Label Label Label
Model
Machine Learning

Features
Features
Features
Some Terminology: Test and Training Set
How to Train Your Model
How to Train Your Model

Data Source → Data Ingestion → Data Validation → Data Preparation → Evaluation → Deployment

Training data → Machine Learning

Testing data
How To Evaluate Your Model
How To Evaluate Your Model

- True Positives
- False Negatives

- Labeled True
- False Positives
- Labeled False

- True Negative
How To Evaluate Your Model
How To Evaluate Your Model

![Diagram showing true positives, false negatives, true negatives, and labeled vs. false categorized items.]

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How To Evaluate Your Model

Accuracy

Precision

Recall
Types of Approaches

- K-Nearest Neighbors
- Decision Trees
- Linear Regression
- Neural Networks
  - Recurrent Neural Nets
  - Convolutional Neural Nets
  - Deep Learning
- Boosting
Types of Approaches

- K-Nearest Neighbors
- Decision Trees
- Linear Regression
- **Neural Networks**
  - Recurrent Neural Nets
  - **Convolutional Neural Nets**
  - Deep Learning
- Boosting
Exercise 3a: Digit Recognition with scikit-learn
Why Did the ML Model Make the Mistakes It Did?
What Does “Linear in the Features” Mean Anyway?

\[ y = f(x) \]
What Does “Linear in the Features” Mean Anyway?

y = f(x)
y = x^3 + 3x^2 - 2x + 1
What Does “Linear in the Features” Mean Anyway?

\[
y = f(x) = x^3 + 3x^2 - 2x + 1
\]
What Does “Linear in the Features” Mean Anyway?

\[ y = f(x) \]

\[ y = x^3 + 3x^2 - 2x + x^0 \]
Convolutions Let Us Model Relationships
Convolutions Let Us Model Relationships
Convolutions Let Us Model Relationships
Convolutions Let Us Model Relationships
Exercise 3b: Convolutional Neural Nets with PyTorch
It’s Not Just Spatial Relationships!

- Color Space (RGBA)
- Temporal Domains
- Semantic Distance
- Basically Anything You Can Compute On Inputs
Common Pitfalls and Gotchas

- Inadvertent Biases in Input Data
- Target Concepts Change Over Time
- The System Influences Its Own Inputs
- Socially Tone Deaf Applications of Technology
Common Pitfalls and Gotchas

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Common Pitfalls and Gotchas

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Common Pitfalls and Gotchas

- Inadvertent Biases in Input Data
- Target Concepts Change Over Time
- The System Influences Its Own Inputs
- Socially Tone Deaf Applications of Technology
More Complicated Isn’t Better

Why does explainability matter?

• User experience
• Lets us understand why a decision was made
• Accountability if something goes wrong
Further Exercises

- Object Detection and Tracking (Find the Cat, Dog, etc)
- Understanding Field of Play in Video Game
  - How many units of what types in an RTS
  - Identifying Rare Enemies in RPGs
- Computational Art
Part 4: Automated Planning and Scheduling
What is Optimization?

Combinatorial optimization is a subfield of mathematical optimization that consists of finding an optimal object from a finite set of objects, where the set of feasible solutions is discrete or can be reduced to a discrete set.
What is Optimization?

Combinatorial optimization is a subfield of mathematical optimization that consists of finding an optimal object from a countably infinite set of objects, where the set of feasible solutions is discrete or can be reduced to a discrete set.
What is Optimization?

- All Possible Plans
- All Feasible Plans
- Good Plans

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What are some common problems it addresses?

- Scheduling crew members to shifts at a restaurant or hospital
- Laying out patterns on material to maximize raw material usage
- GPS Navigation
- Moving characters around in video games
- Finding vulnerabilities in software using targeted static analysis
- Self driving cars, self flying planes, etc
- Playing Poker
The Underlying Formalism (Deterministic Planning)
The Underlying Formalism (Deterministic Planning)
The Underlying Formalism (Deterministic Planning)
The Underlying Formalism (Deterministic Planning)

Treewidth: How far away a graph is from being a tree
What is an optimization problem?

- Maximize this objective
- Subject to these constraints
What is an optimization problem?

- Maximize this objective
  - Some function of the paths in the tree or graph
- Subject to these constraints
  - The shape of the tree or graph itself
What is an optimization problem?

- Maximize this objective
  - Or minimize it by inverting some signs
- Subject to these constraints

Like everything else in life, minimization is just a primitive, degenerate form of maximization.
What is an optimization problem?

- Maximize multiple objectives
- Subject to these constraints
What is an optimization problem?

- Maximize **multiple** objectives
- Subject to these constraints

\[
\text{ordered}(a, b) = \begin{cases} 
  a.x < b.x || \\
  \quad (a.x == b.x && a.y < b.y)
\end{cases}
\]

*First One, Then The Other*
What is an optimization problem?

- Maximize **multiple** objectives
- Subject to these constraints

\[ \text{ordered}(a, b) = (a.x + a.y) < (b.x + b.y) \]

First One, Then The Other

Blend them together
What is an optimization problem?

- Maximize multiple objectives
- Subject to these constraints

Pareto, the solution frontier

First One, Then The Other

Blend them together

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Some Standard Approaches: A*

Open list: S

Diagram:
- S
- A
- B
- G
- C

Paths:
- S to A
- S to B
- S to C
- G to C
Some Standard Approaches: A*

Open list: SA, SB

Closed list: S

Diagram:
- S connected to A and B
- B connected to C
- C connected to G
Some Standard Approaches: A*

Open list: SA SB

Closed list: S
Some Standard Approaches: A*

Open list: SB SAS
Closed list: S SA

Diagram:
- Nodes: S, A, B, C, G
- Edges: SA, SB, S, A, B, G, C

Nodes highlighted in red indicate they are in the open list.
Nodes highlighted in green indicate they are in the closed list.
Some Standard Approaches: A*

Open list: SB  SAS

Closed list: S  SA
Some Standard Approaches: A*

Open list: SB

Closed list: S, SA

Diagram:
- S connected to A
- A connected to B
- B connected to C
- G connected to S
Some Standard Approaches: A*

Open list: SB
Closed list: S SA

Diagram:
- S
- A
- B
- G
- C

Connections:
- S to A
- S to B
- B to C
- C to G
Some Standard Approaches: A*

Open list: SBC

Closed list: S SA SB

Diagram of A* search with nodes S, A, B, G, and C.
Some Standard Approaches: A*

Open list: SBCG

Closed list: S, SA, SB, SBC

Diagram:

- Nodes: S, A, B, C, G
- Edges:
  - S to A
  - S to B
  - B to C
  - B to G

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Some Standard Approaches: A*

Open list: SBCG

Closed list: S SA SB SBC
Some Standard Approaches: Depth First Search

Open list

S
Some Standard Approaches: Depth First Search

Open list

B
A

Diagram:

- S
- A
- B
- G
- C
- D
- E

Nodes in the tree are explored in the order S -> A -> B -> G -> C -> D -> E.
Some Standard Approaches: Depth First Search

Open list

C
D
E
A

S
A
B
G
C
D
E
Some Standard Approaches: Depth First Search

Open list:
- D
- E
- A

Diagram:
- S
  - A
    - G
    - C
  - B
    - D
    - E
Some Standard Approaches: Depth First Search

Open list

- E
- A
Some Standard Approaches: Depth First Search

Open list

A
Some Standard Approaches: Depth First Search

Open list

G

G

C

D

E
Some Standard Approaches: Depth First Search

Open list

G
Exercise 4a: Video Game Pathfinding
Common Pitfalls and Gotchas

- Applying Tree Search to Graphs
- Inefficient Encodings
- Expensive Heuristics Reduce Overall Performance
- Perfect is the enemy of the good
Ok, But Where Does It Fall Down?
Sensing Is Key Here!
Wait, Those Sound Really Different!

Deterministic Planning (Planning with Certainty)
- Scheduling crew members to shifts
- Laying out patterns on material
- GPS Navigation
- Moving characters around in video games
- Finding vulnerabilities in software using targeted static analysis

Stochastic Planning (Planning Under Uncertainty)
- Self driving cars, self flying planes, etc
- Playing Poker
How Do We Handle Uncertainty?
How Do We Handle Uncertainty?
How Do We Handle Uncertainty?
How Do We Handle Uncertainty?
How Do We Handle Uncertainty?
How Do We Handle Uncertainty?
The Approach: Reinforcement Learning
The Approach: Reinforcement Learning
The Approach: Reinforcement Learning

Right: inf
Up: inf
Left: inf
Down: inf
The Approach: Reinforcement Learning

Right: -1
Up: inf
Left: inf
Down: inf
The Approach: Reinforcement Learning

Right: -1
Up: -2
Left: -4
Down: -4
The Approach: Reinforcement Learning

Right: -0.92  
Up: -1.5  
Left: -2.5  
Down: -2.5
The Approach: Reinforcement Learning
The Approach: Reinforcement Learning

Right: -0.92
Up: -1.5
Left: -2.5
Down: -2.5
The Approach: Reinforcement Learning

Right: -0.92  
Up: -1.5  
Left: -2.5  
Down: -2.5

Reward for the state + Expected value of best action in state
The Approach: Reinforcement Learning

Reward for the state + Expected value of best action in state
The Approach: Reinforcement Learning
What’s this Stick Balancing State Space Look Like?
How About This Hill Cart One?
Exercise 4b: Stochastic Planning (Controllers)
Things to Be Mindful Of

- Modeling is Expensive
- Representation Matters
- Trees Grow Really, Really Fast
- Long Lived Computations in the Cloud are Pricey!
Further Exercises

- Play a Turn Based Game
  - Chess
  - Go
  - Checkers
- Play a Card Game
  - Blackjack
  - Poker
- Play an Atari or Classic Arcade Game
- Convert an image into a lego portrait
Part 5: Things That Didn’t Fit In Elsewhere
Some Things We Didn’t Cover That Are Cool

- AI Systems We’ve Seen at Our Consultancy
- Historically Significant AI Systems
- AI Formalisms We Didn’t Cover Here
- Philosophical Problems in AI
- AI and The Product Life Cycle
- Why Do AI Projects Fail
AI For Highway Maintenance
Let’s Do Tree Search

1ST ST

2ND ST

3RD ST

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AI For Lumber Mills

Instance

Solver

Solution & Value

Laser
Camera
Useful Formalisms: Tree Search

- Rotate Board
- Place blade 1
- Place blade 2
- Place blade 3
Predicting Failure of Turbine Engines
In Home Physical Therapy Using Pose Estimation
Pre-Employment Candidate Assessments
Welcome to

EEEEEE    LL   IIII   ZZZZZZ   AAAAA
EE       LL   II    ZZ    AA    AA
EEEEEE    LL   II    ZZZ    AAAAAAA
EE       LL   II    ZZ    AA    AA
EEEEEEE   LLLLLL  IIII  ZZZZZZ    AA    AA

Eliza is a mock Rogerian psychotherapist. The original program was described by Joseph Weizenbaum in 1966. This implementation by Norbert Landsteiner 2005.

ELIZA: Is something troubling you?
YOU:    Men are all alike.
ELIZA: What is the connection, do you suppose?
YOU:    They're always bugging us about something or other.
ELIZA: Can you think of a specific example?
YOU:    Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here?
YOU:    He says I'm depressed much of the time.
ELIZA: I am sorry to hear that you are depressed.
YOU:    It's true. I am unhappy.
ELIZA: Can you explain what made you unhappy?
YOU:
Shaky and Blocks World

https://www.youtube.com/watch?v=qXdn6ynwpiI
Chinook (Jonathan Schaeffer)
Deep Blue
Alpha Go (and subsequently Deepmind)
AI means intelligence as humans understand it

A human comprehensively defeated a top-ranked Go AI, in a surprise reversal of the 2016 computer victory that was seen as a milestone in the rise of artificial intelligence.
AI understands context

What is Toronto?????
Information Theory
Constraint Satisfaction Problems

5 3
6 1 9 5
9 8 6
8 6 3 1
4 8 3 1
7 2 6
6 2 8
4 1 9 5
8 7 9

The Minisat Page
Knowledge Representation and Logics

There’s a lady who knows all that glitters is gold, and she’s buying a stairway to heaven.
The Turing Test
Searle’s Chinese Room
The Arithmetic Room
AI & the Product Life Cycle
What are we doing exactly?
Can it be done at all?
Can We Afford To Do It?
Is It Ready To Release?
AI Lifecycle
Can it be done at all?
Can we afford to do it?
Is it ready to release?
Ok, so why do AI projects fail?
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1. The scope of the project is too big
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any software project
Thanks For Attending!

Consider seeing us at the conference!

- Thursday, 4:45 PM in Salon E
  - What Does Security Look Like When Building AI?
  - Robert Herbig, AI Practice Lead
- Thursday, 4:45 PM in Salon G
  - AI for Highway Maintenance
  - Jordan Thayer, AI Practice Lead
- Friday, 8:30 AM in Salon D
  - Can We Learn to Manage Uncertainty? Probably!
  - Robert Herbig, AI Practice Lead
- Friday, 9:45 AM in Cypress
  - How to answer "When will it be done?" using probabilistic forecasting.
  - Chris Shinkle, Director of Innovation

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