AI For Highway Maintenance
Who Am I

- B.S. CS from RHIT, 2006
- PhD in AI from UNH, 2012
- 5 years in Defense Research
- 3 years in Static Analysis
- 4 years as AI Practice Lead with SEP
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How did we get here?
How did we get here?
The Road Ahead

- The Problem Domain
- Using AI for Planning
- Some Initial Roadblocks
  - Understanding the domain
  - Problematic Models
  - Performance Hurdles
- Meeting the users where they are
  - Understanding needs
  - Adapting the solver
Some Terminology

- Segment - A section of road with a stop and end point
- Road Network - A collection of segments
- Agency - Some group charged with taking care of a road network
- PASER - the visual inspection scale for grading roads in Indiana
  - PAvement Surface Evaluation and Rating
The Maintenance Process
The Maintenance Process
The Maintenance Process

@DrBass
The Maintenance Process
Where’s Software?
Where’s Software?
There’s a Problem Though
How Is It Done Today?

<table>
<thead>
<tr>
<th>Roadway</th>
<th>From</th>
<th>To</th>
<th>Rating</th>
<th>2020 Treatment</th>
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<tbody>
<tr>
<td>1ST ST</td>
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<td>Cape Seal</td>
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<td>Chip Seal - Double</td>
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How Is It Done Today?
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How Is It Done Today?
Let’s Do That

1ST ST
2ND ST
3RD ST
4TH ST

10M
Let's Do That

1ST ST

2ND ST
3RD ST
4TH ST

@DrBass
Let’s Do That

1ST ST

2ND ST
3RD ST
4TH ST

10M

Nothing

10M

@DrBass
Let's Do That

1ST ST

2ND ST
3RD ST
4TH ST
Let’s Do That

1ST ST

2ND ST
3RD ST
4TH ST

10M
~
NR

10M

5M
Let’s Do That

1ST ST

2ND ST
3RD ST
4TH ST

10M

~

NR

10M

5M

... etc
Let’s Do That

1ST ST

2ND ST

3RD ST

4TH ST
Let's Do That

1ST ST

2ND ST

3RD ST

10M

5M

0M

NR

@DrBass

~

… etc

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… etc
Let’s Do **Tree Search**
Let’s Do Tree Search
Why Is This So Hard?

- Programmers Are Not Civil Engineers
- Our Input Data Wasn’t Pristine
- Tree Search at These Scales is Inherently Difficult
Building Tree Search with SMEs

1. Build a model of applying treatments to segments
2. Run the optimizer for a limited amount of time to make the best treatment plan
3. Client evaluates the quality of the treatment plan
4. We talk about how to improve the model & treatment plan
Building Tree Search with SMEs

Build a model of applying treatments to segments.

Client evaluates the quality of the treatment plan.

We talk about how to improve the model & treatment plan.

Run the optimizer for a limited amount of time to make the best treatment plan.

@DrBass
Our Plans Underperformed Expert Expectations
Real World Data and Official Model Don’t Align
These Curves Were Made Using Other AI Techniques
Why Is Tree Search Hard?

"Space is big. Really big. You just won't believe how vastly hugely mind-bogglingly big it is. I mean, you may think it's a long way down the road to the chemist, but that's just peanuts to space."

Hitchhiker’s Guide to the Galaxy
So, Why Is Finding Good Goals Hard?

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Atoms in the Observable Universe = \[10^{82}\]
Work Smarter, Not Harder
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Work Smarter, Not Harder
Work Smarter, Not Harder
Also, Work Faster
Also, Work Faster

~ 1,000,000 nodes a second
Use a Profiler
Also, Work Faster
Write Down Expensive Computations in Tables

I wrote them down in my Diary so that I wouldn't have to remember.
Trick 2: Gotta Go Fast
Avoid Conditionals Where Possible

@DrBass
Trick 2: Gotta Go Fast

Diagram showing the flow of operations in a computer architecture, including cache, decode, and instruction dispatch units.
Trick 2: Gotta Go Fast

7.5
7500
Trick 2: Gotta Go Fast
Trick 2: Gotta Go Fast
Integer Math is Often Faster Than Floating Point

I don't know the difference between 7.5 and 7500.

And at this point I'm afraid to ask.
How Much Did Tuning Matter?
How Much Did Tuning Matter?

13.84 sec
5 hrs
How Were The Solutions Over All?

![Graph showing the average (network) Paser score over years for two approaches: Old Approach and Optimizer. The graph indicates a decrease in score over time, with the Old Approach showing a more pronounced decline.]
How Do You Win Hearts and Minds?
The Maintenance Process
Is Iterative, Not Comparative
The Users Iterated in Two Major Ways

- Don’t do this part, and use the money on something else
- Do this, and find budget for it
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The Development Process Is Iterative Too!

1. User study
2. Build prototype
3. AI team makes Optimizer changes
4. Product team makes Design changes

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@DrBass
If I Knew Then What I Know Now

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Takeaways

- Al crops up in unexpected places
- It can (and must) be built using the same sorts of agile techniques that are best practice everywhere
- What users will accept is more important than finding the best solution

- 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

@DrBass