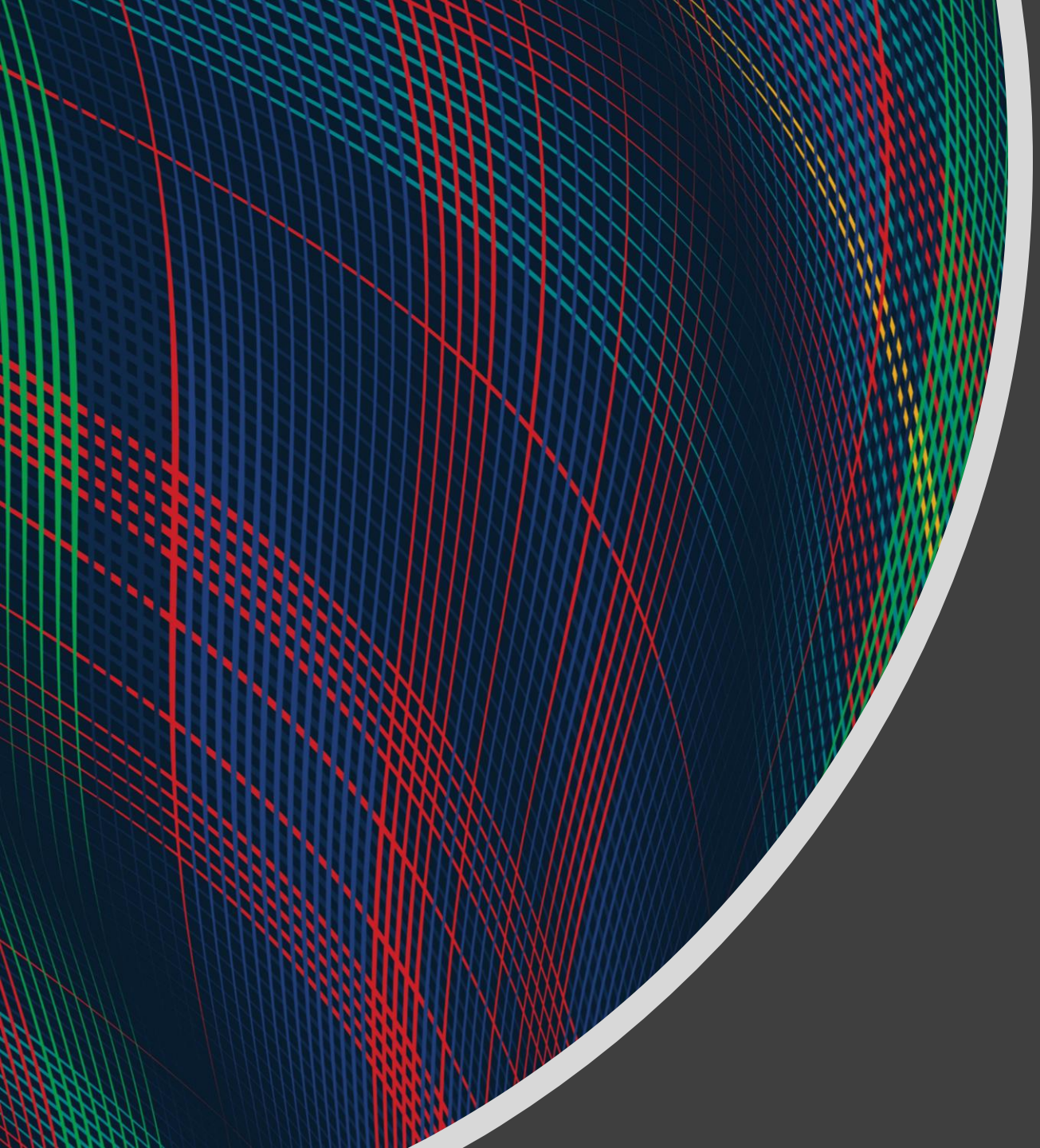


10-607 Computational Foundations for Machine Learning

Data Structures

Instructor: Pat Virtue

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

- Dense vs sparse structures
- Trees
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Dynamic Programming

Previous lecture slides

Abstractions vs. Data Structures

Abstractions

- List
- Set
- Map (Dictionary)
- Tree
- Queue (FIFO)
- Stack (LIFO)
- Priority Queue
- Graph

Data Structures

- Array (fixed size)
- Array (variable size)
- Linked List
- Doubly-Linked List
- Multidimensional Array
- Tensor
- Hash Map
- Binary Search Tree
- Balanced Tree
- Trie
- Stack
- Heap
- Graph
- Bipartite Graph
- Sparse Vector
- Sparse Matrix

Data Structures for ML

Examples…

Data:

- Dense feature vector (array)
- Sparse feature vector (sparse vector)
- Design matrix (multidimensional array)

Models:

- Decision Trees (tree)
- Bayesian Network (directed acyclic graph)
- Factor Graph (bipartite graph)

Algorithms:

- Greedy Search (weighted graph)
- A* Search (priority queue/heap)
- Forward-backward for HMM (trellis)

Tree to Predict C-Section Risk

Learned from medical records of 1000 women (Sims et al., 2000)

Negative examples are C-sections

```
[833+,167-] .83+ .17-
Fetal_Presentation = 1: [822+,116-] .88+ .12-
| Previous_Csection = 0: [767+,81-] .90+ .10-
| | Primiparous = 0: [399+,13-] .97+ .03-
| | Primiparous = 1: [368+,68-] .84+ .16-
| | | Fetal_Distress = 0: [334+,47-] .88+ .12-
| | | | Birth_Weight < 3349: [201+,10.6-] .95+ .(
| | | | Birth_Weight >= 3349: [133+,36.4-] .78+
| | | Fetal_Distress = 1: [34+,21-] .62+ .38-
| Previous_Csection = 1: [55+,35-] .61+ .39-
Fetal_Presentation = 2: [3+,29-] .11+ .89-
Fetal_Presentation = 3: [8+,22-] .27+ .73-
```

Figure from Tom Mitchell

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

- Dense vs sparse structures
- Trees
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Dense vs sparse structures

Vector dot product example

- Linear regression model $y = \mathbf{w}^T\mathbf{x} + b$
- Where $\mathbf{x}$ represents the contents of text data, e.g., e-mail or book review

Dense vs sparse structures

Matrix multiplication with special structure

- Example: diagonal matrices

Plan

Dynamic Programming

- Overlapping subproblems
- Examples

Data Structures

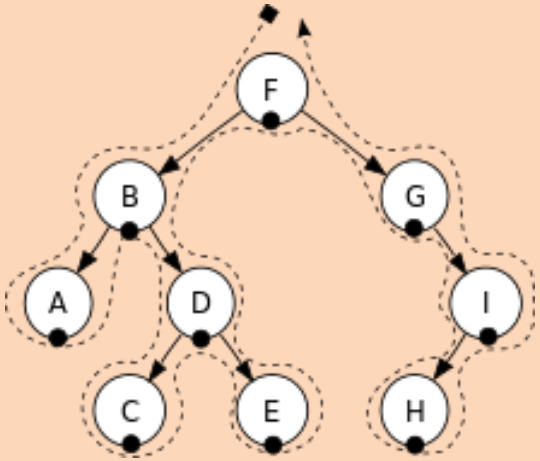
- Dense vs sparse structures
- Trees
- BFS and DFS
- Stacks and Queues
- Other tree implementations
- Graphs (next time)

Trees

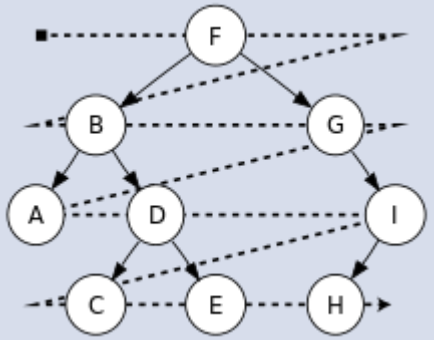
Notebook

Tree Traversals

Depth First Search



Breadth First Search



Figures from Wikipedia