# Analyzing Software using Deep Learning

## Lecture 5:
## Introduction to Course Project

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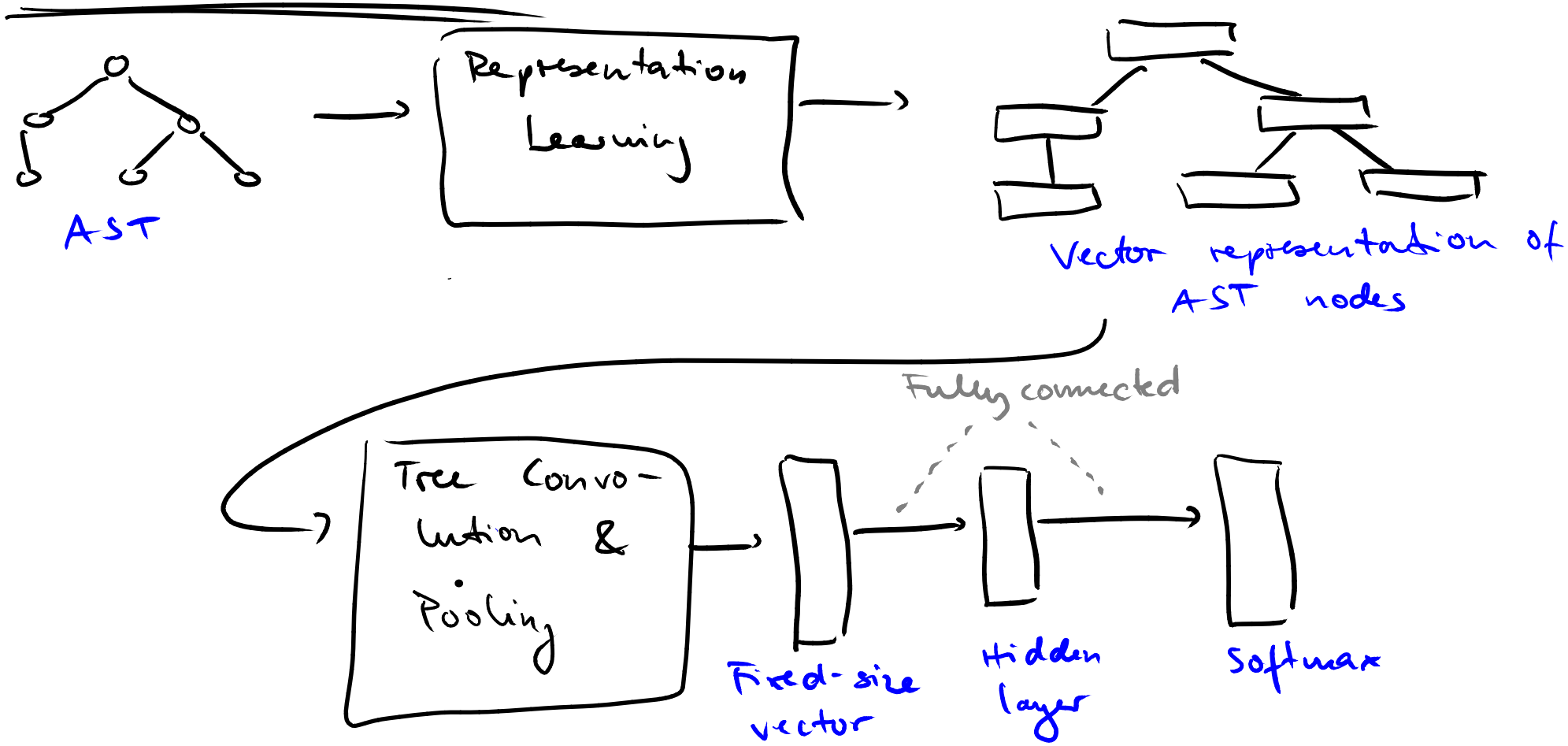
# Plan for Today (Part 1)

- **Convolutional networks**
  - Motivation and basics
  - Properties
  - Pooling
- **Tree convolution for program classification** ←

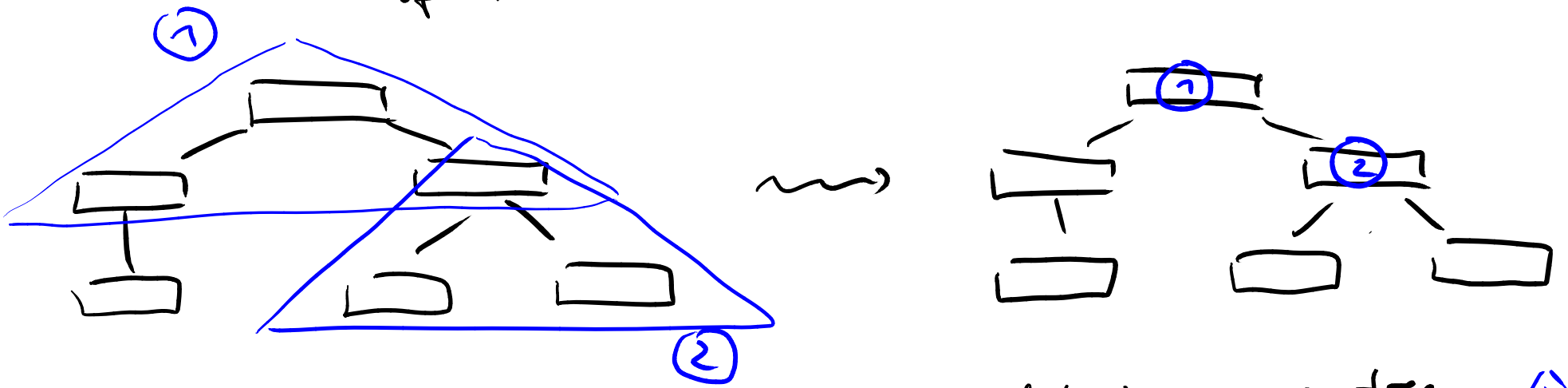
  Based on ”Convolutional Neural Networks over Tree Structures for Programming Language Processing” by Mou et al., 2016

# Detailed Overview



# Tree-based Convolution

- Input: Tree of vectors where nodes represent AST nodes
- Output: Tree of vectors where nodes summarize features of their children




- Idea: "Move" fixed-depth feature detector over tree

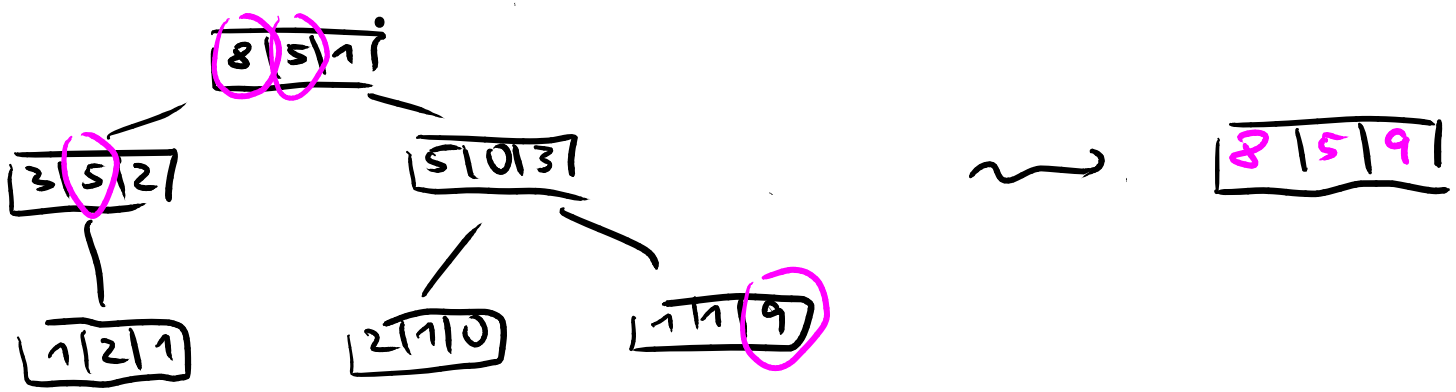

- Convolution: $y = \tanh(W_{conv} \cdot x_{top} + W_{left} \cdot x_{left} + W_{right} \cdot x_{right} + b_{conv})$

Weights of kernel

## Pooling

- Before pooling: Tree of fixed-sized vectors but with a varying of nodes
- Want: Single fixed-sized vector
- Here: Fixed-size pooling
  ↳ Use maximum value of each dimension

**Example:**



# Applications

**Identify functionality of a given program**

**Scenario 1: One out of N**

- Which of 104 programming tasks has been solved?

**Scenario 2: Binary classification**

- Does the code contain bubble sort?

# Scenario 1: One out of N

- Data: Solutions submitted to online programming education platform
- 104 problems, 500 solutions for each
- Split by 3:1:1 for training, validation, and testing
- Overall result: 94% accuracy

# Scenario 2: Binary classification

- Assumption: Bubble sort is inefficient and should be avoided
- Goal: Find instances of bubble sort in given code
- Training
  - 109 programs that implement bubble sort
  - 109 programs that implement something else
- Evaluation
  - Inject bubble sort code snippet into 4,000 other programs
  - 8,000 programs in total
- Overall result: 89% accuracy

# Summary

## Convolutional neural networks

- Train kernel to exploit hierarchical structure of input data
- Sparse interactions
- Parameter sharing
- Equivariant representations

## Application

- Tree-based convolution
- Classification of programs