# Analyzing Software using Deep Learning

## Lecture 3:

## RNN-based Code Completion and Repair Sequence-to-Sequence Networks

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# Plan for Today

- **Deep learning basics**
  - Finish up last lecture
- **Recurrent neural networks (RNNs)**
- **Code completion with statistical language models**

  Based on PLDI 2014 paper by Raychev et al.
- **Repair of syntax errors** 

  Based on ”Automated correction for syntax errors in programming assignments using recurrent neural networks” by Bhatia & Singh, 2016

# Motivation

- Given: Program with syntax error
- Goal: Find a fix that removes syntax error
- Possible application context: MOOCs with automated feedback on programming tasks

# Example (1)

```
def recPower (base , exp):
  if exp <= 0:
    return 1
  return base * recPower (base , exp - 1
```

# Example (1)

```
def recPower (base , exp):
  if exp <= 0:
    return 1
  return base * recPower (base , exp - 1)
```

# Example (2)

```
def recurPower (base , exp):
  if exp == 0:
    return = exp + 1
  else:
    return (base * recurPower (base ,exp - 1))
```

# Example (2)

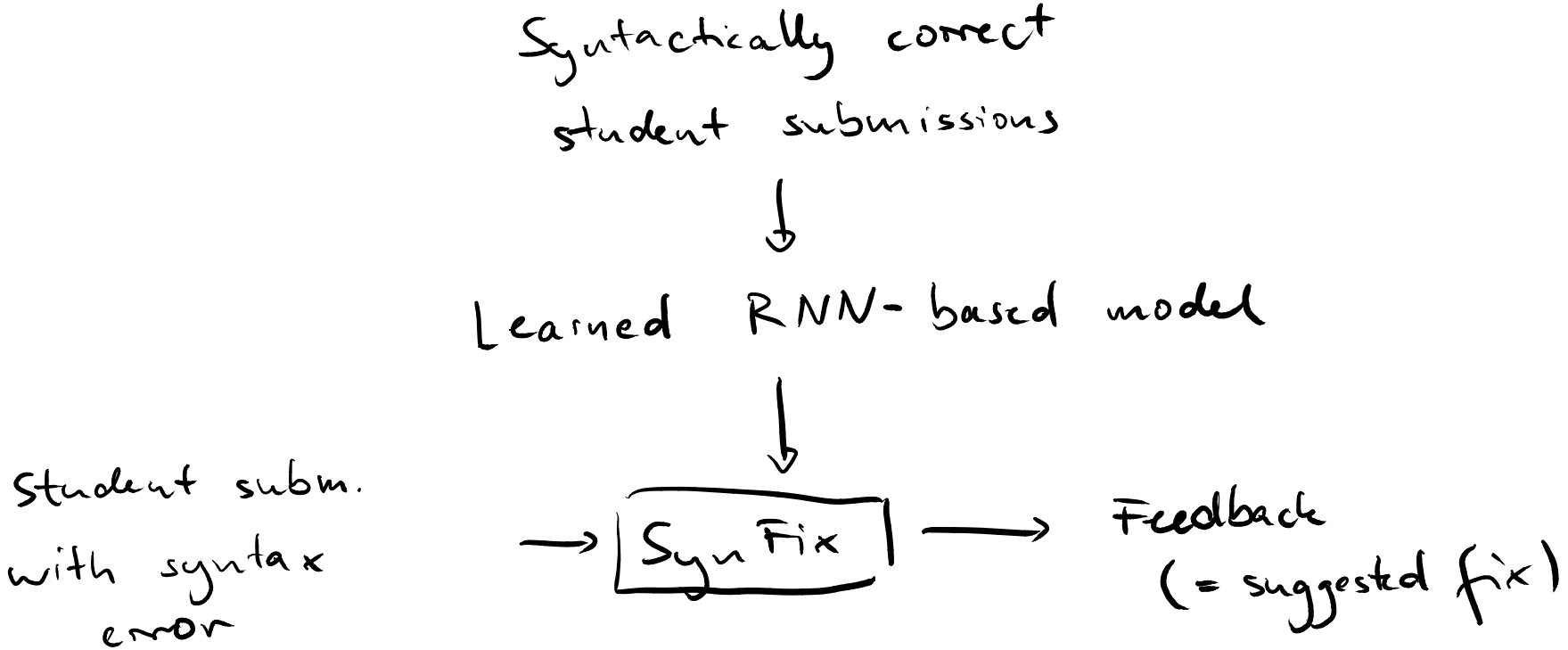
```
def recurPower (base , exp):
  if exp == 0:
    return base
  else:
    return (base * recurPower (base ,exp - 1))
```

# Example (2)

```
def recurPower (base , exp):
  if exp == 0:
    return base
  else:
    return (base * recurPower (base ,exp - 1))
```

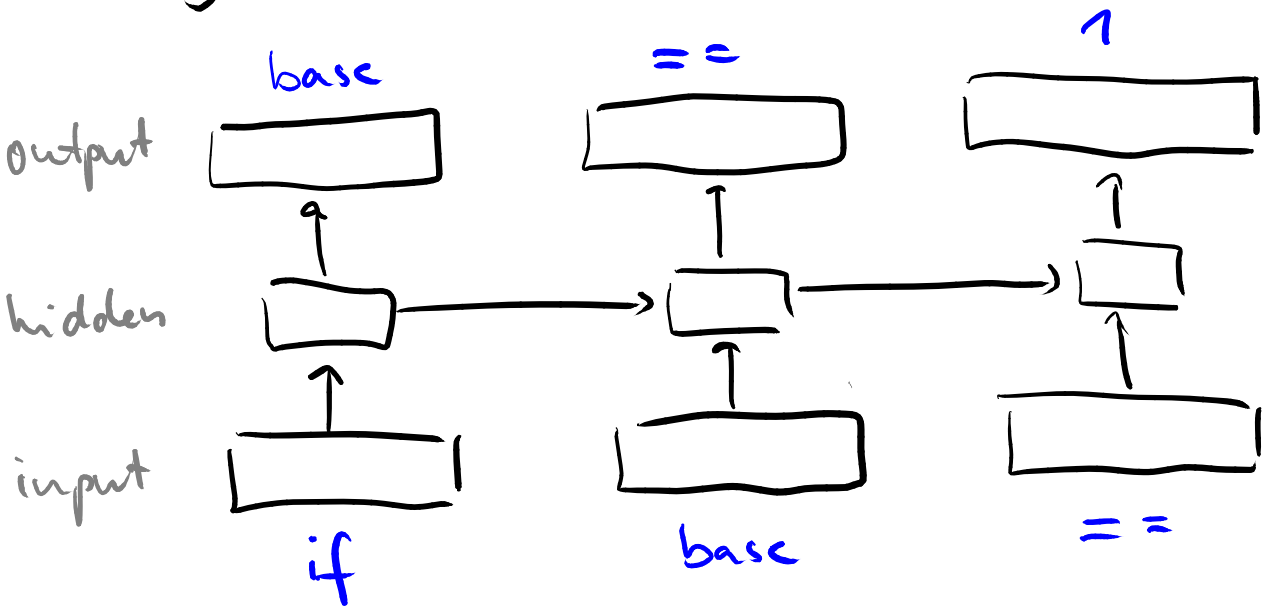
**Beware: Fix of syntax error may not be the semantically correct fix**

# SynFix : Overview



# RNN-based Model

- Program = Sequence of tokens




- Training:
  Expected output sequence = Input sequence shifted by one
- Prediction:
  Provide partial program until error location & generate next token(s)

# SynFix Algorithm

Given: Program with syntax error + error location

Steps:

- Parse and tokenize program
- Query network with prefix of tokens until error location
- Try if inserting or replacing one or more tokens fixes the error
- If not: Delete line with error and query network with prefix until the error line
- Try if inserting predicted tokens fixes the error

# Summary

- Recurrent Neural Networks (RNNs)
  - Powerful class of neural networks
  - Most effective for inputs (and outputs) that are sequences
- Two applications
  - Code completion:
    Predict next calls based on previous calls
  - Repair of syntax errors:
    Predict correct tokens based on previous tokens