CS11-737 Multilingual NLP

Text Classification and Sequence Labeling

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https://lileicc.github.io/course/11737mnlp23fa/

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Text Classification

- Given an input text X, predict an output label y

Topic Classification

I like peaches and → food / politics / music

I like peaches and herb → food / politics / music

...

Language Identification

I like peaches and pears → English / Japanese / German

桃と梨が好き → English / Japanese / German

...

Sentiment Analysis (sentence/document-level)

I like peaches and pears → positive / neutral / negative

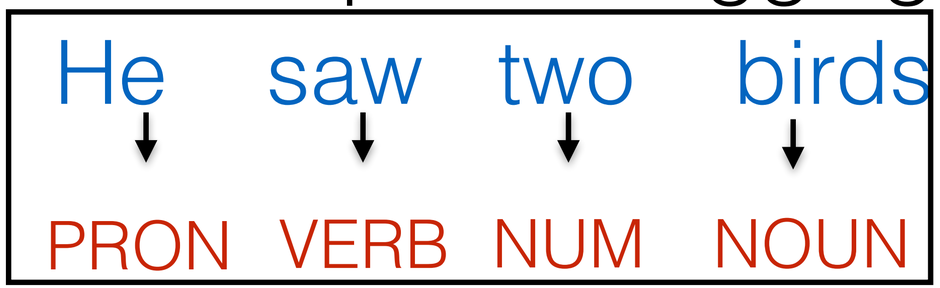
I hate peaches and pears → positive / neutral / negative

... and many many more!

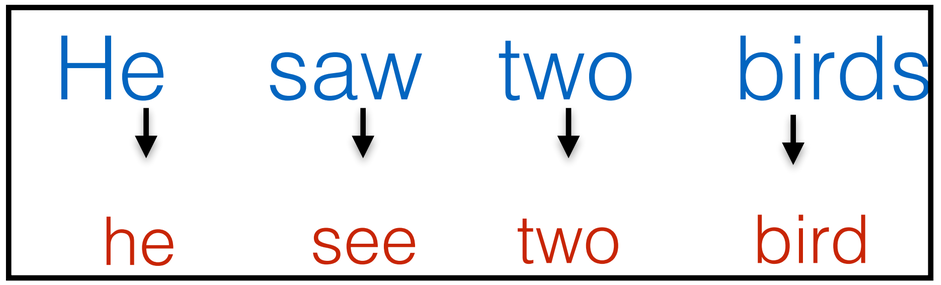
Sequence Labeling

- Given an input text *X*, predict an output label sequence *Y* *of equal length!*

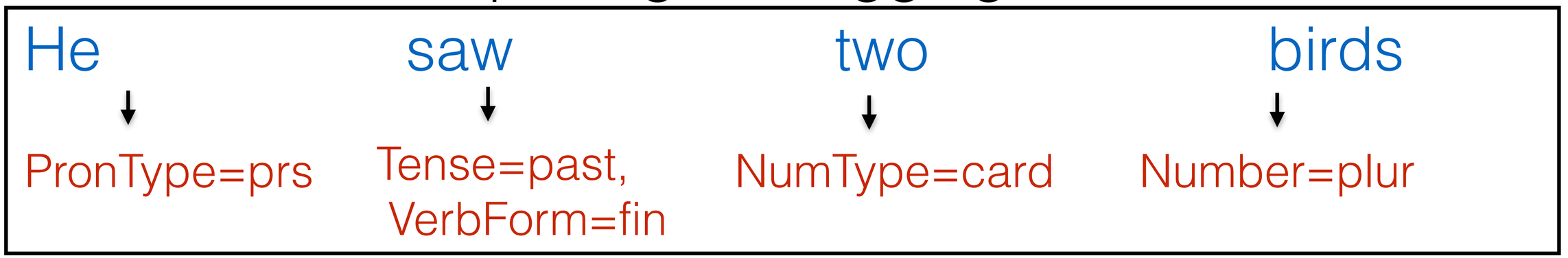
Part of Speech Tagging



Lemmatization



Morphological Tagging



... and more!

Span Labeling

- Given an input text *X*, predict an output spans and labels *Y*.

Named Entity Recognition

Leo Messi plays for Inter Miami CF
PER ORG

Syntactic Chunking

Leo Messi plays for Inter Miami CF
NP VP NP

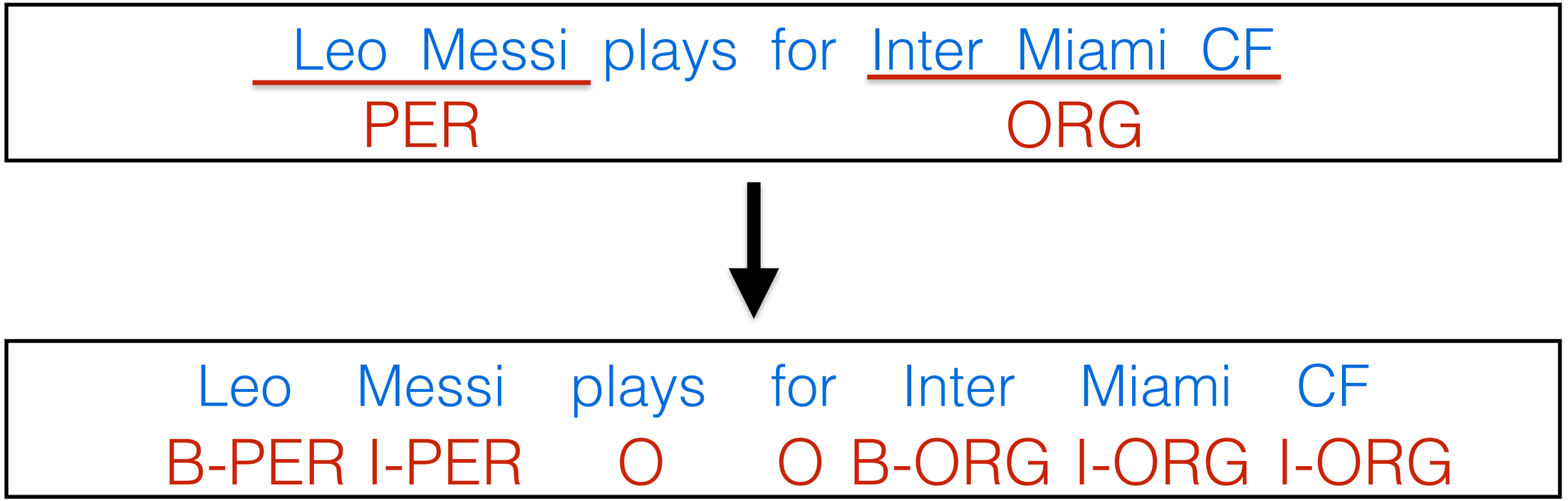
Semantic Role Labeling

Leo Messi plays for Inter Miami CF
Agent Predicate Theme

… and more!

Span Labeling as Sequence Labeling

- Predict **B**eginning, **I**n, and **O**ut tags for each word in a span



Text Segmentation

- Given an input text *X*, split it into segmented text *Y*.

Tokenization

A well-conceived "thought exercise."

A well - conceived " thought exercise . "

Word Segmentation (very important for web search)

南京市长江大桥

南京市 长江 大桥

Nanjing Yangtze River bridge

南京 市长 江大桥

Nanjing mayor Jiang Da Qiao

Morphological Segmentation

Köpekler

Köpek ler

dog Number=Plural

Köpekle r

dog_paddle Tense=Aorist

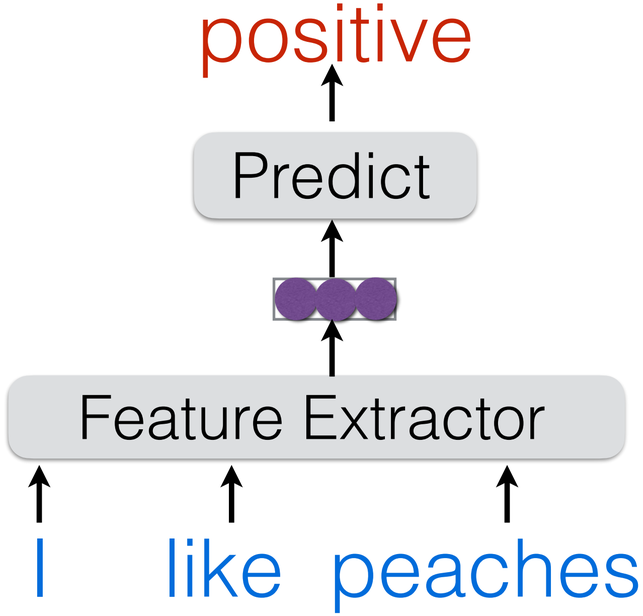
- Rule-based (statistical), or span labeling models

Modeling for Sequence Labeling/ Classification

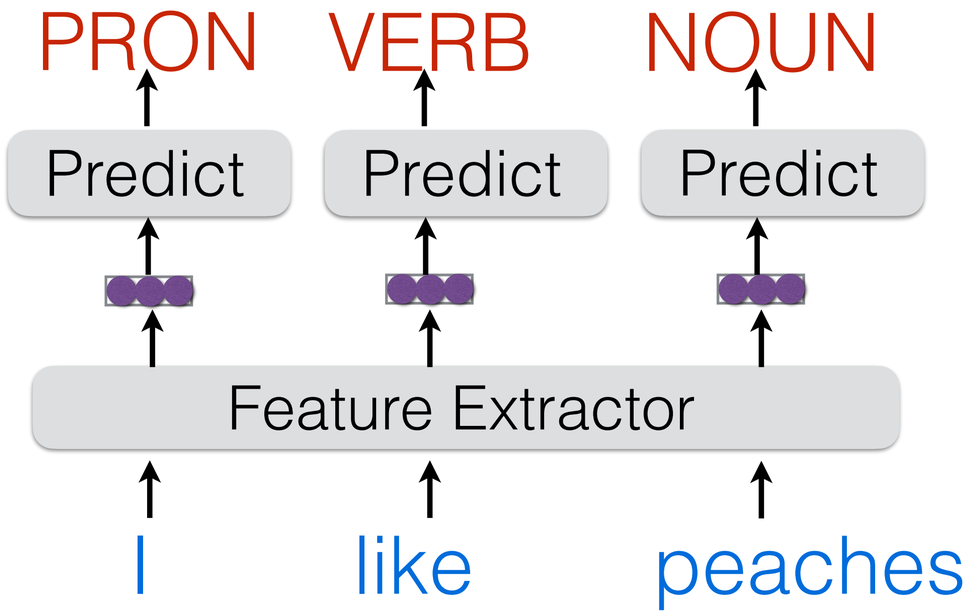
How do we Make Predictions?

- Given an input text *X*
- Extract features *H*
- Predict labels *Y*

Text Classification

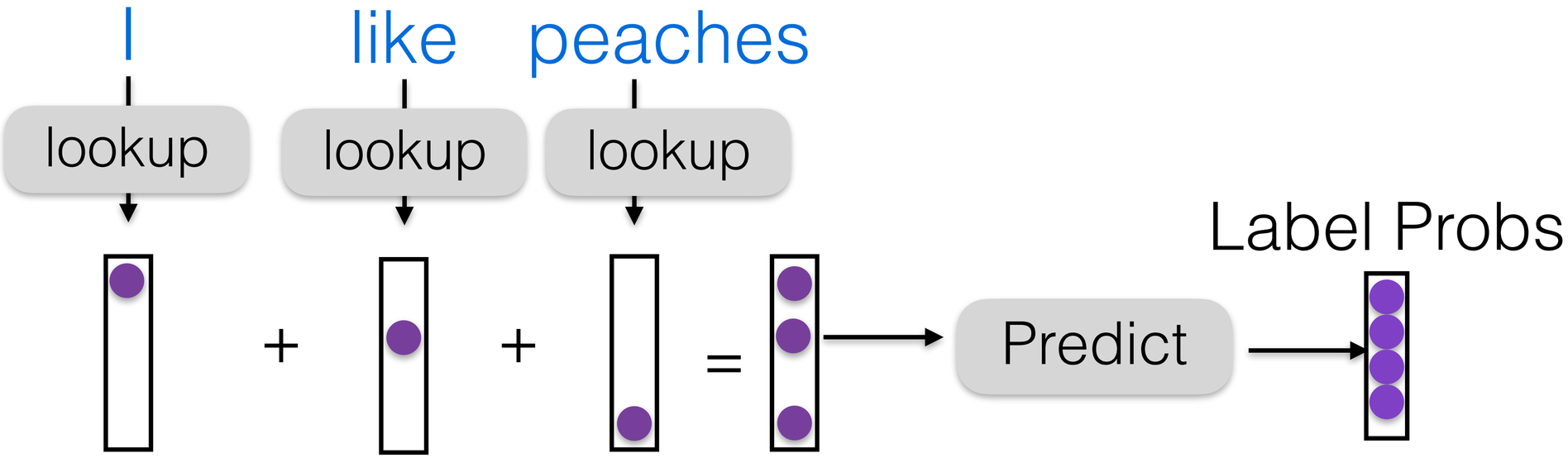


Sequence Labeling



A Simple Feature Extractor: Bag of Words (BOW)

- Each word has a vector of weights for each tag



A Simple Predictor: Linear Transform+Softmax

p = softmax(W * **h** + b)

Softmax converts arbitrary scores into probabilities

$$p_i = \frac{e^{s_i}}{\sum_j e^{s_j}}$$

$$s = \begin{pmatrix} -3.2 \\ -2.9 \\ 1.0 \\ 2.2 \\ 0.6 \\ \dots \end{pmatrix} \longrightarrow p = \begin{pmatrix} 0.002 \\ 0.003 \\ 0.329 \\ 0.444 \\ 0.090 \\ \dots \end{pmatrix}$$

Problem: Language is not a Bag of Words!

I don’t love pears

There’s nothing I don’t love about pears

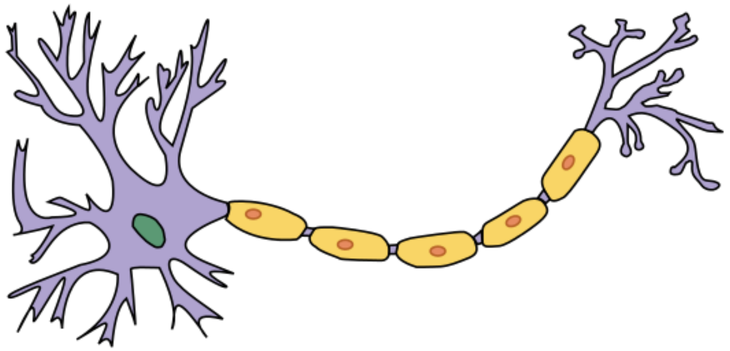
Better Featurizers

- Bag of n-grams
- Syntax-based features (e.g. subject-object pairs)
- Neural networks
  - Recurrent neural networks
  - Convolutional networks
  - Self attention

What is a Neural Net?: Computation Graphs

“Neural” Nets

- Original Motivation: The Neurons in Brain



- Neural Network is a Computational graph

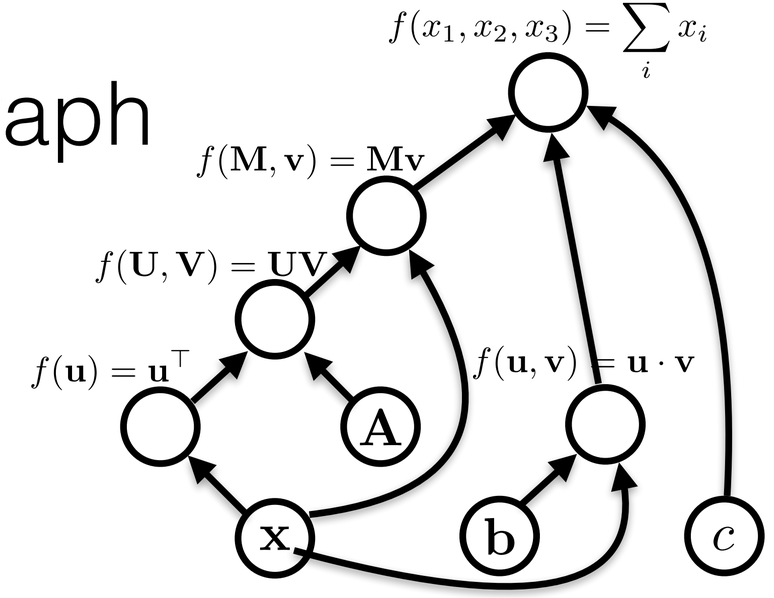


Image credit: Wikipedia

expression:

$\mathbf{x}$

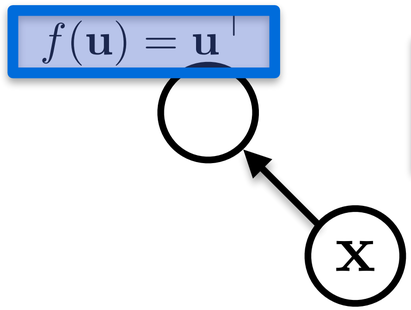
graph:

A **node** is a {tensor, matrix, vector, scalar} value

An **edge** represents a function argument.

A **node** with an incoming **edge** is a **function** of that edge's tail node.

A **node** knows how to compute its value and the *value of its derivative w.r.t each argument (edge) times a derivative of an arbitrary input* $\frac{\partial \mathcal{F}}{\partial f(\mathbf{u})}$.



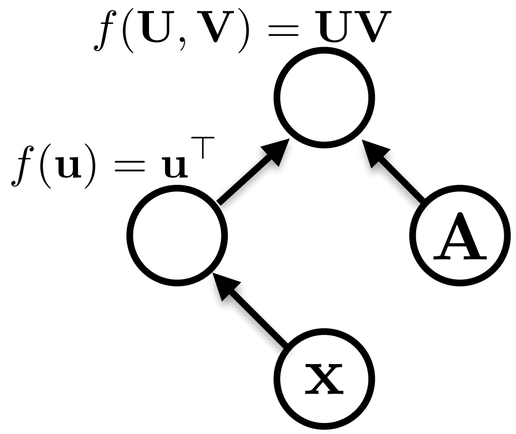
$$\frac{\partial f(\mathbf{u})}{\partial \mathbf{u}} \frac{\partial \mathcal{F}}{\partial f(\mathbf{u})} = \left(\frac{\partial \mathcal{F}}{\partial f(\mathbf{u})} \right)^\top$$

expression:

$$\mathbf{x}^\top \mathbf{A}$$

graph:

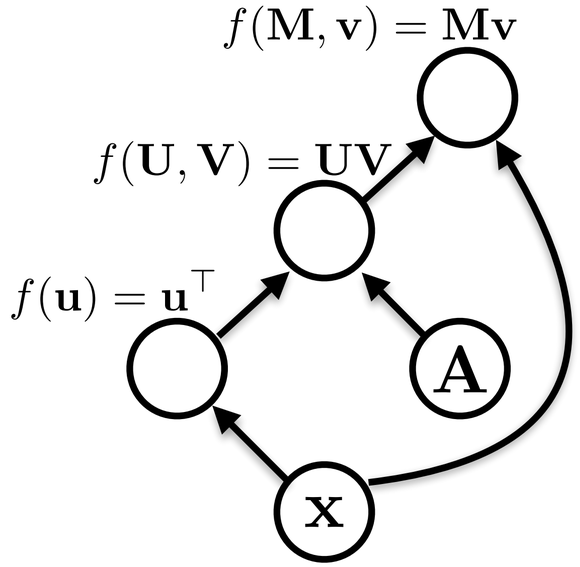
Functions can be nullary, unary, binary, … *n*-ary. Often they are unary or binary.



expression:

$$\mathbf{x}^\top \mathbf{A} \mathbf{x}$$

graph:

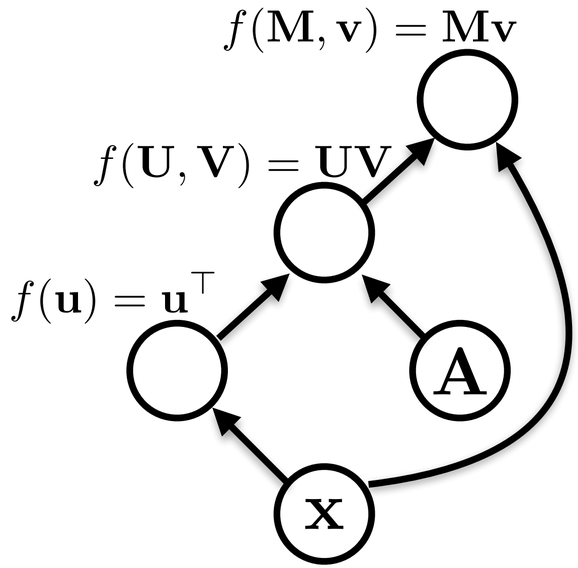


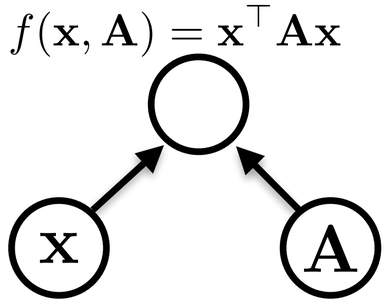
Computation graphs are generally directed and acyclic

expression:

$$\mathbf{x}^\top \mathbf{A}\mathbf{x}$$

graph:





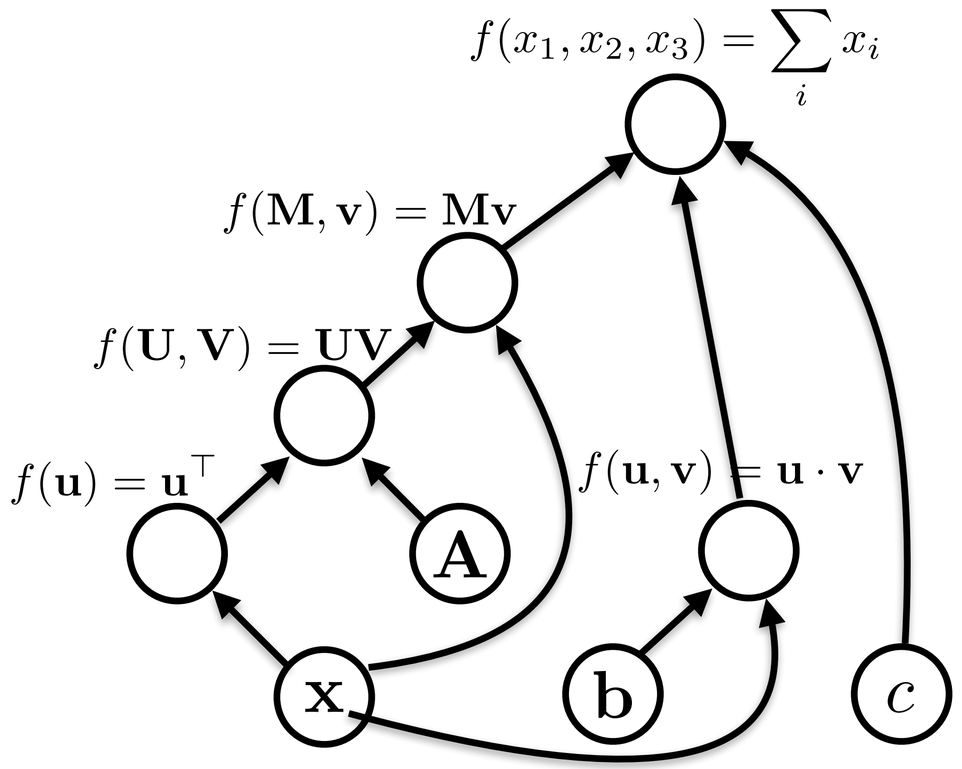
$$\frac{\partial f(\mathbf{x}, \mathbf{A})}{\partial \mathbf{x}} = (\mathbf{A}^\top + \mathbf{A})\mathbf{x}$$

$$\frac{\partial f(\mathbf{x}, \mathbf{A})}{\partial \mathbf{A}} = \mathbf{x}\mathbf{x}^\top$$

expression:

$$\mathbf{x}^\top \mathbf{A}\mathbf{x} + \mathbf{b} \cdot \mathbf{x} + c$$

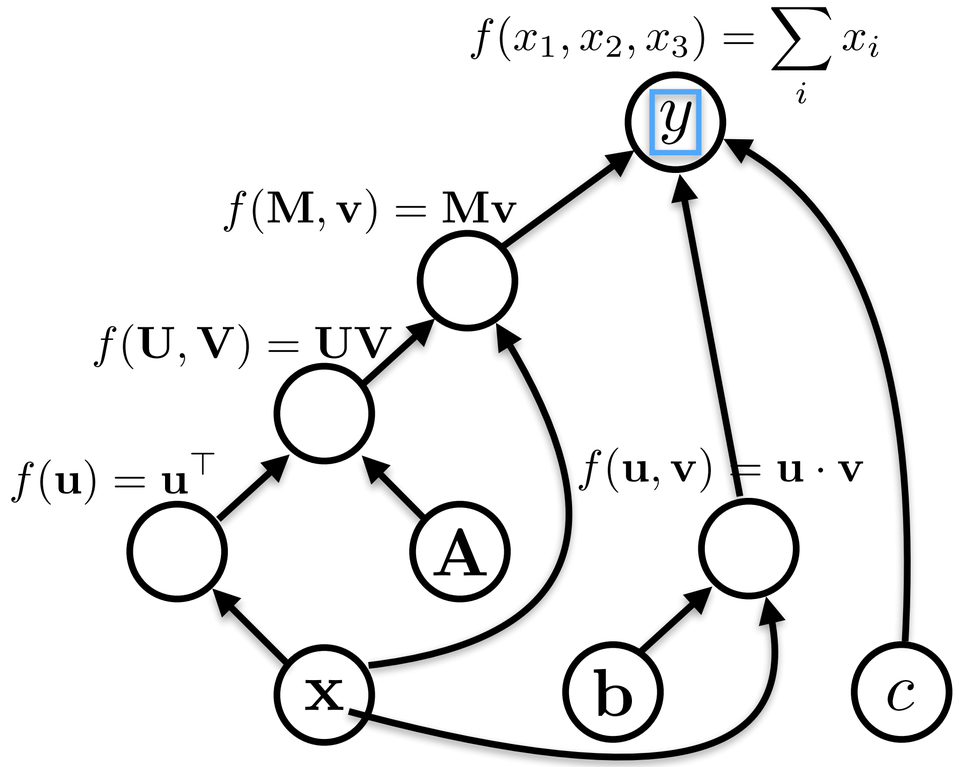
graph:



expression:

$$y = \mathbf{x}^\top \mathbf{A}\mathbf{x} + \mathbf{b} \cdot \mathbf{x} + c$$

graph:



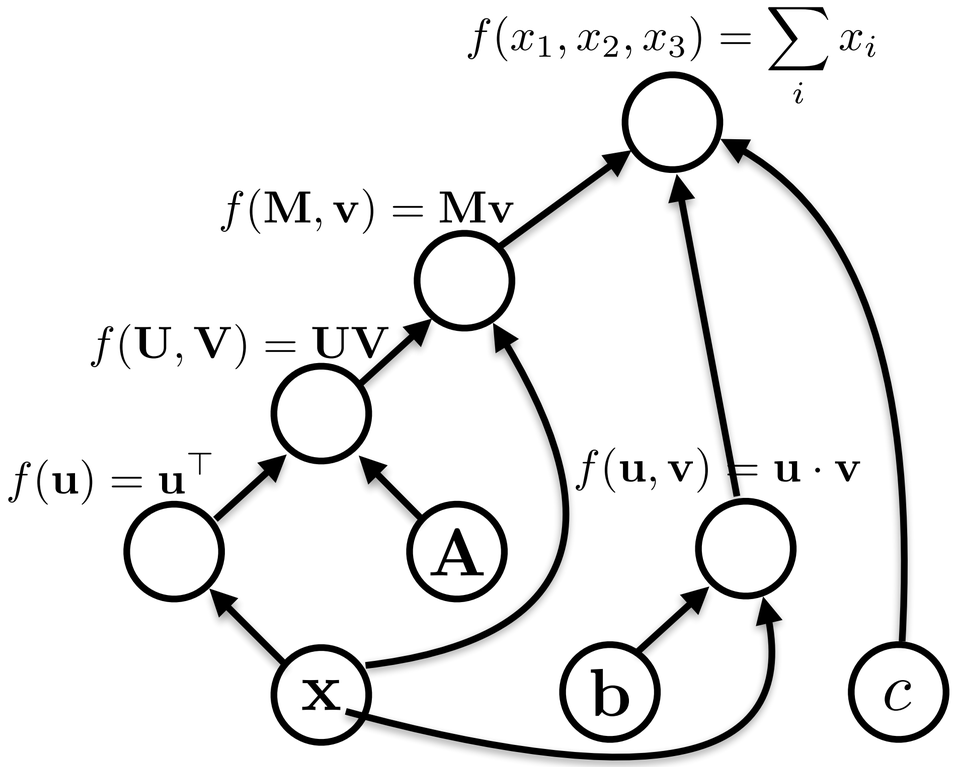
variable names are just labelings of nodes.

Algorithms (1)

- Graph construction
- Forward propagation
  - In topological order, compute the value of the node given its inputs

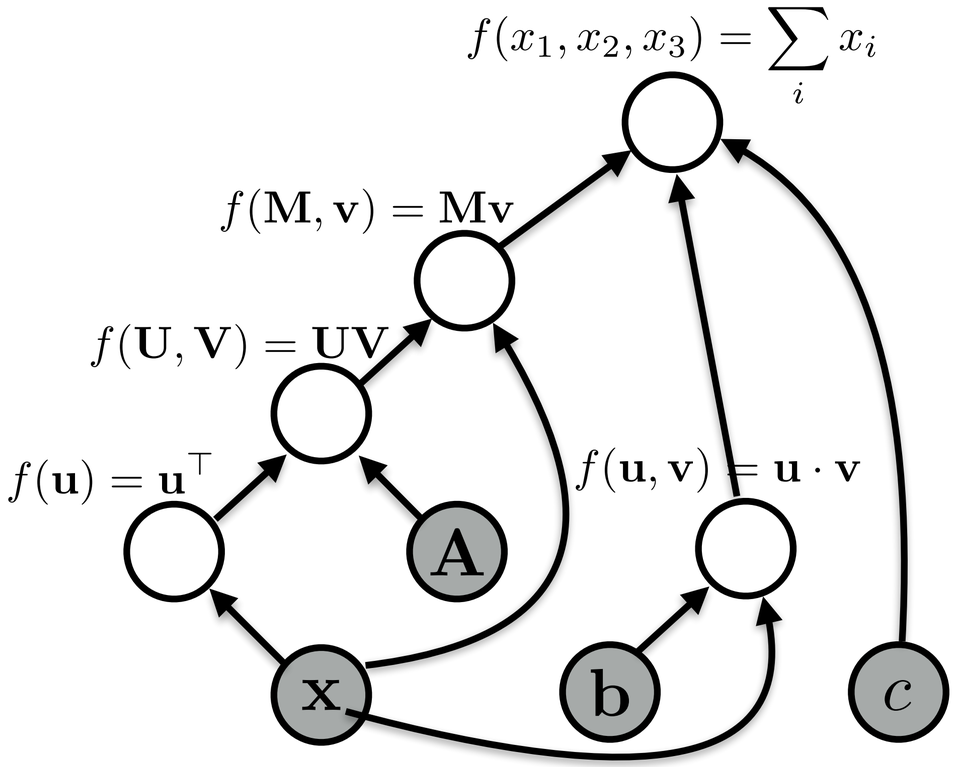
Forward Propagation

graph:



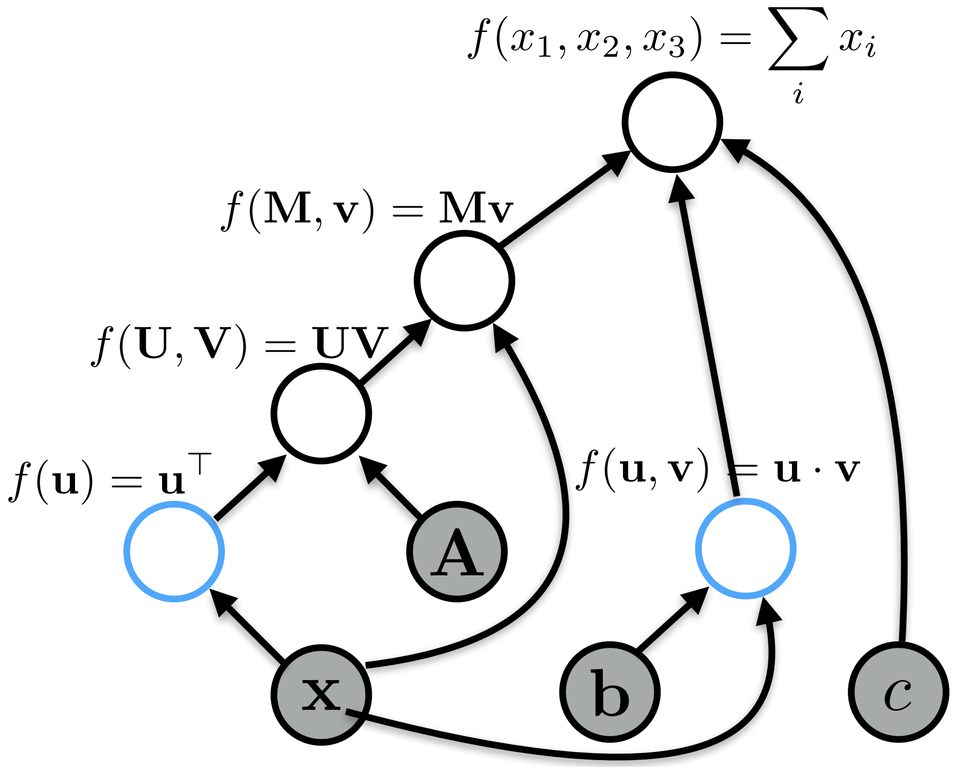
Forward Propagation

graph:



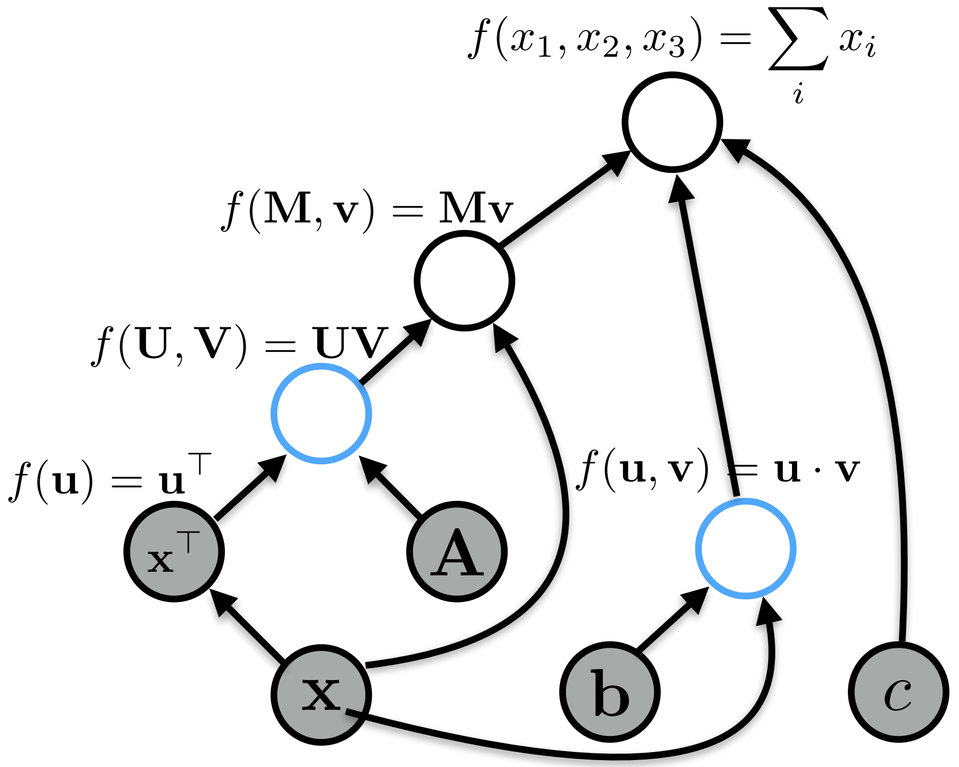
Forward Propagation

graph:



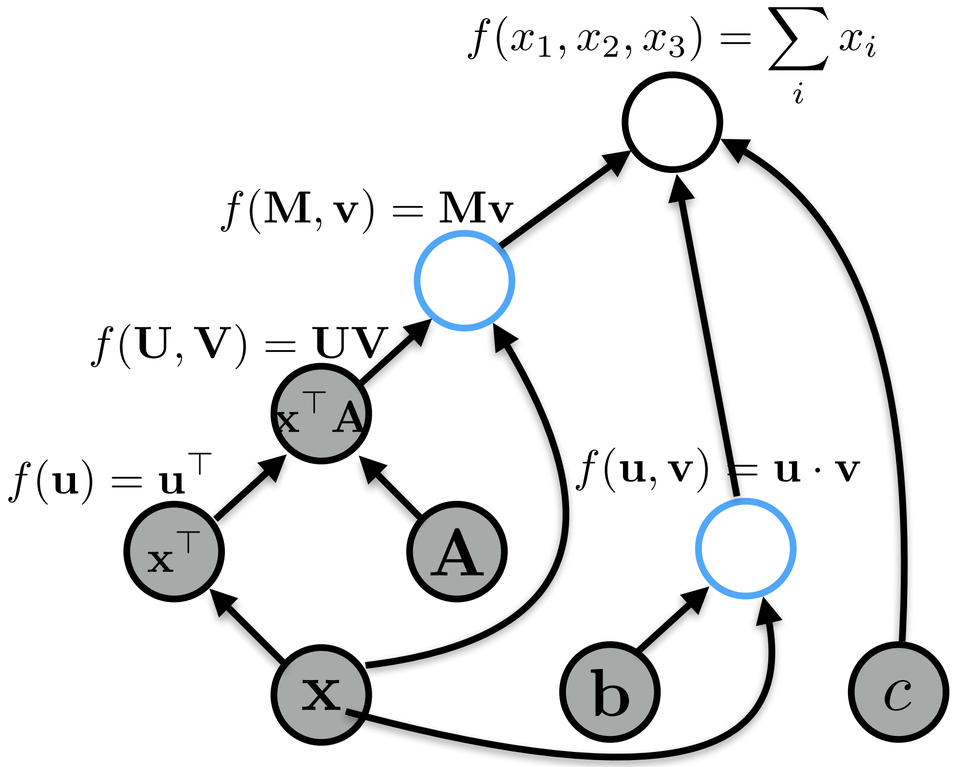
Forward Propagation

graph:



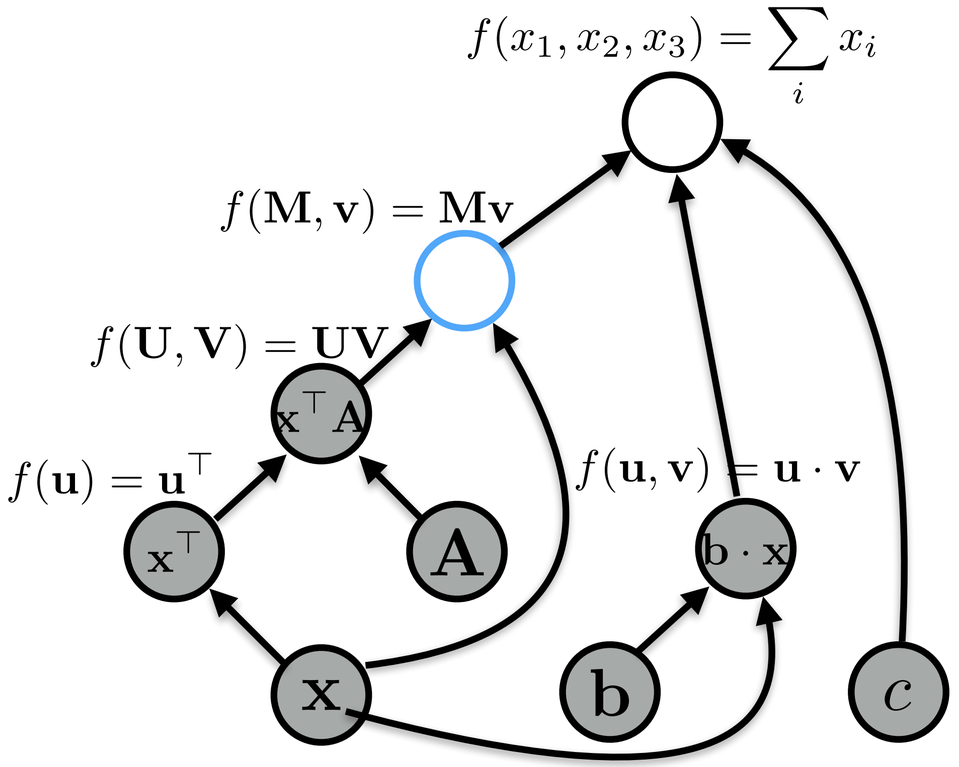
Forward Propagation

graph:



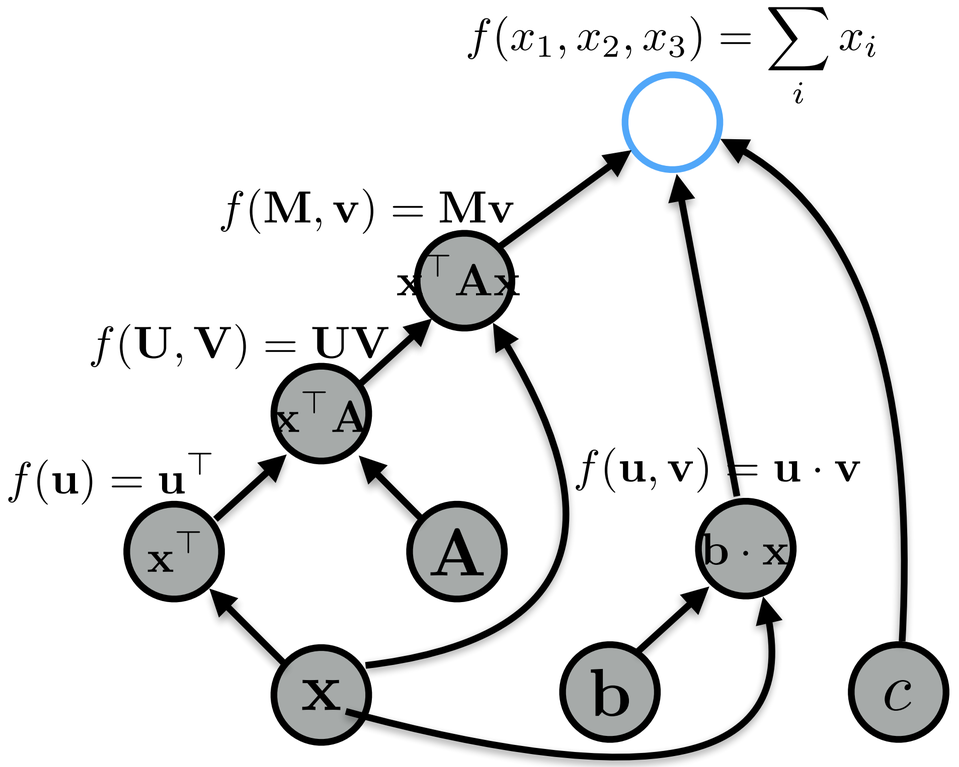
Forward Propagation

graph:



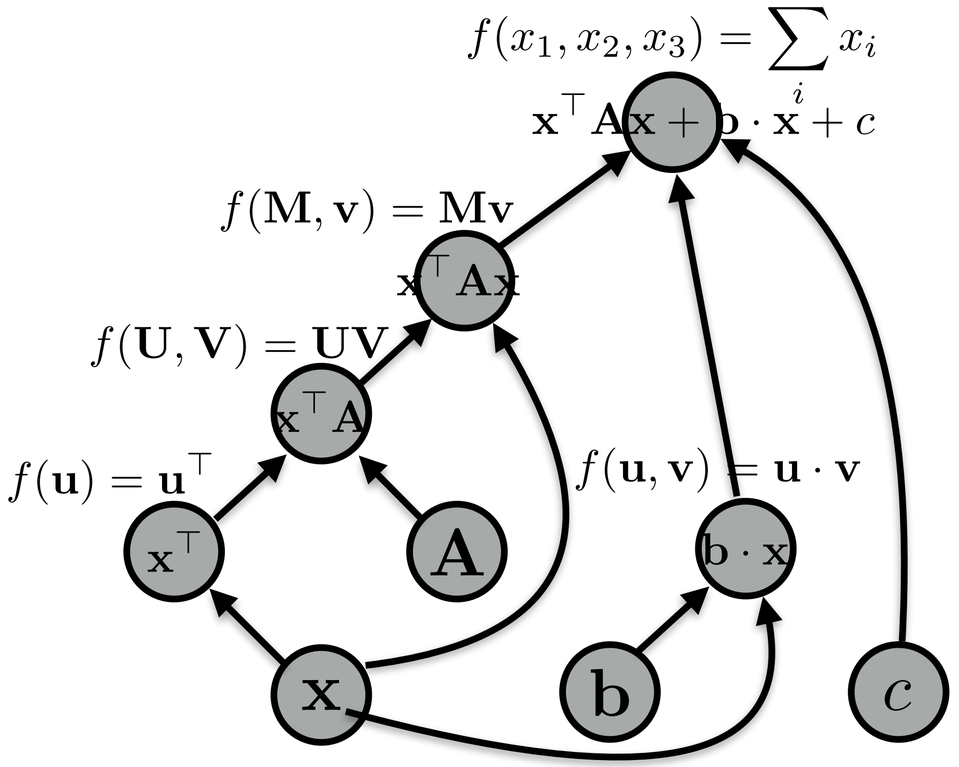
Forward Propagation

graph:



Forward Propagation

graph:

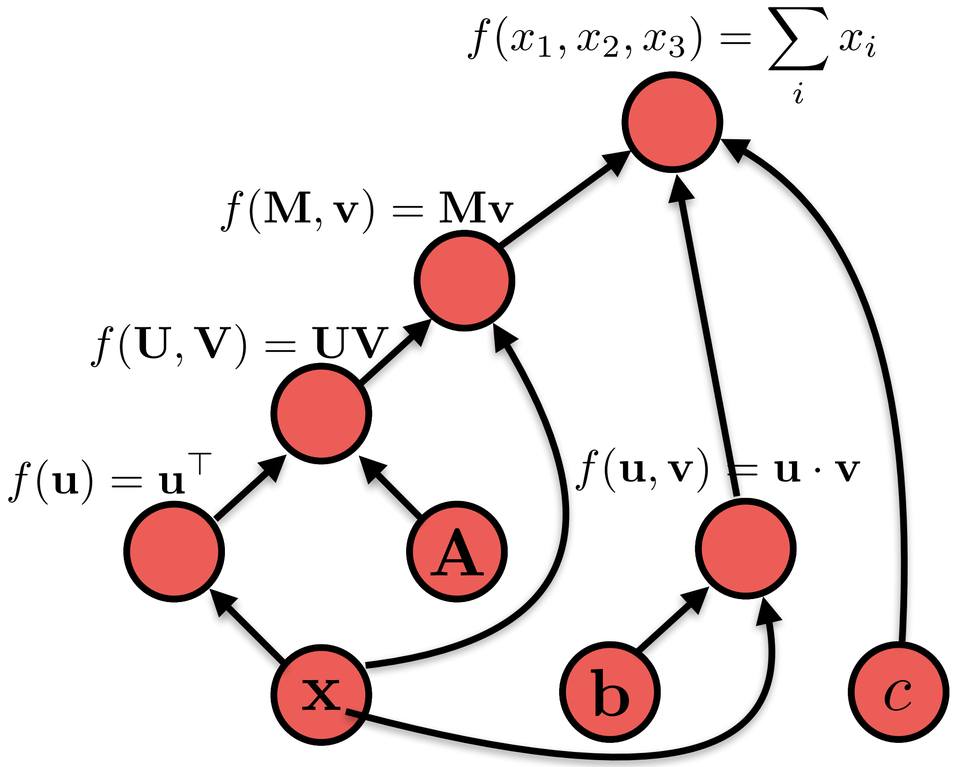


Algorithms (2)

- Back-propagation:
  - Process examples in reverse topological order
  - Calculate the derivatives of the parameters with respect to the final value
    (This is usually a “loss function”, a value we want to minimize)
- Parameter update:
  - Move the parameters in the direction of this derivative
    $W \mathrel{-}= \alpha * dl/dW$

Back Propagation

graph:



Neural Network Frameworks

Examples in this class

JAX

Autograd and XLA with numpy

Basic Process in (Dynamic) Neural Network Frameworks

- Create a model
- For each example
  - **create a graph** that represents the computation you want
  - **calculate the result** of that computation
  - if training, perform **back propagation and update**

Pytorch Quick Tutorial

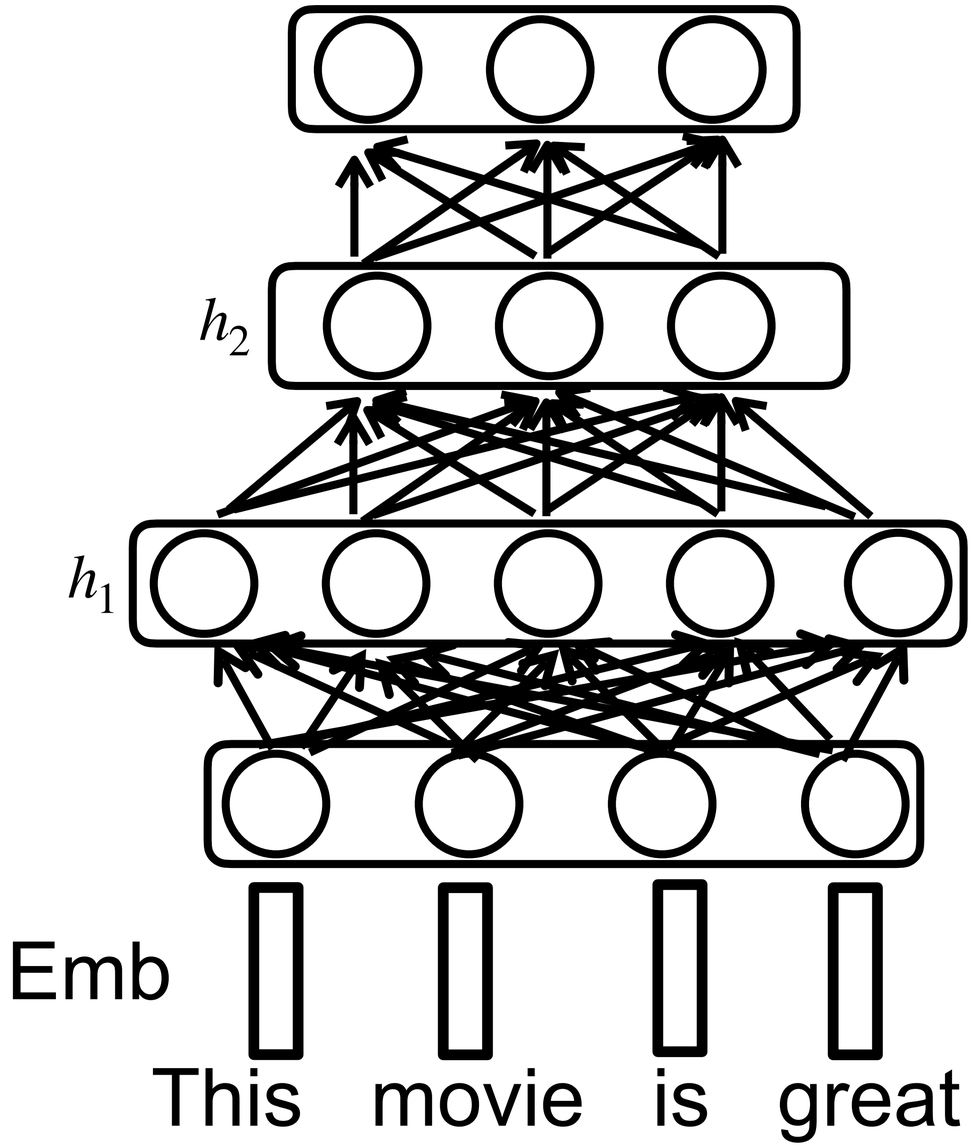
https://pytorch.org/tutorials/beginner/basics/intro.html

Feedforward Neural Net (FFN)

- also known as multilayer perceptron (MLP)
- Layers are connected sequentially
- Each layer has full-connection (each unit is connected to all units of next layer)
  - Linear project followed by
  - an element-wise nonlinear activation function

$$h = \sigma(w \cdot x + b)$$

- There is no connection from output to input



Recurrent Neural Networks

Long-distance Dependencies in Language

- Agreement in number, gender, etc.

He does not have very much confidence in **himself**.

She does not have very much confidence in **herself**.

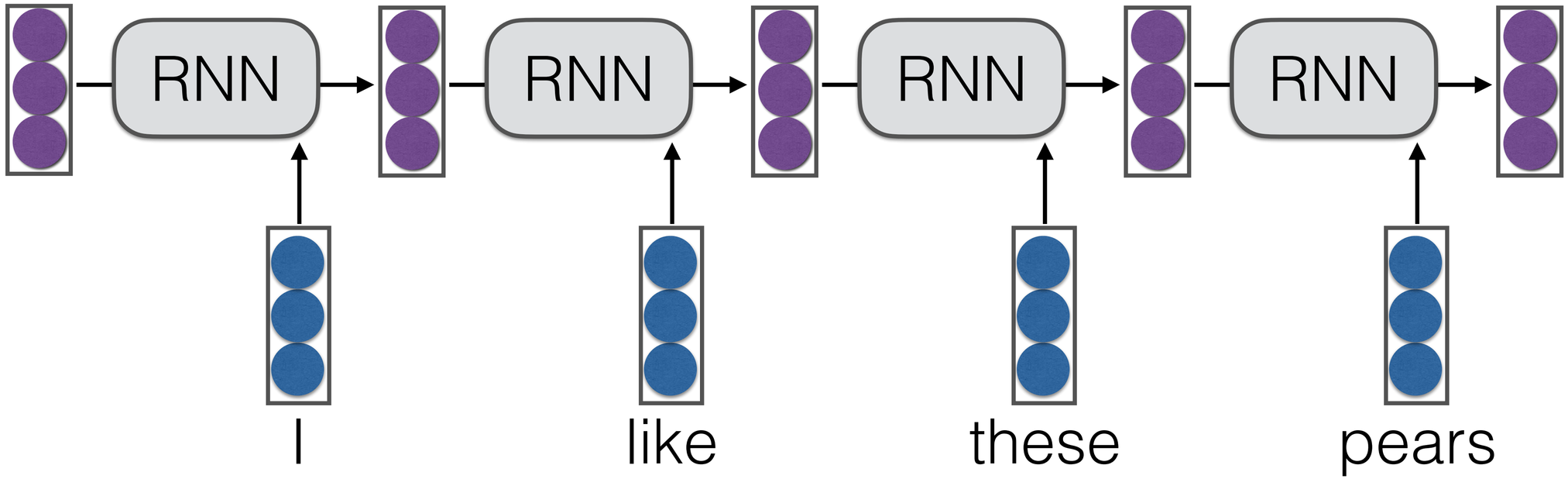
- Selectional preference

The **reign** has lasted as long as the life of the **queen**.

The **rain** has lasted as long as the life of the **clouds**.

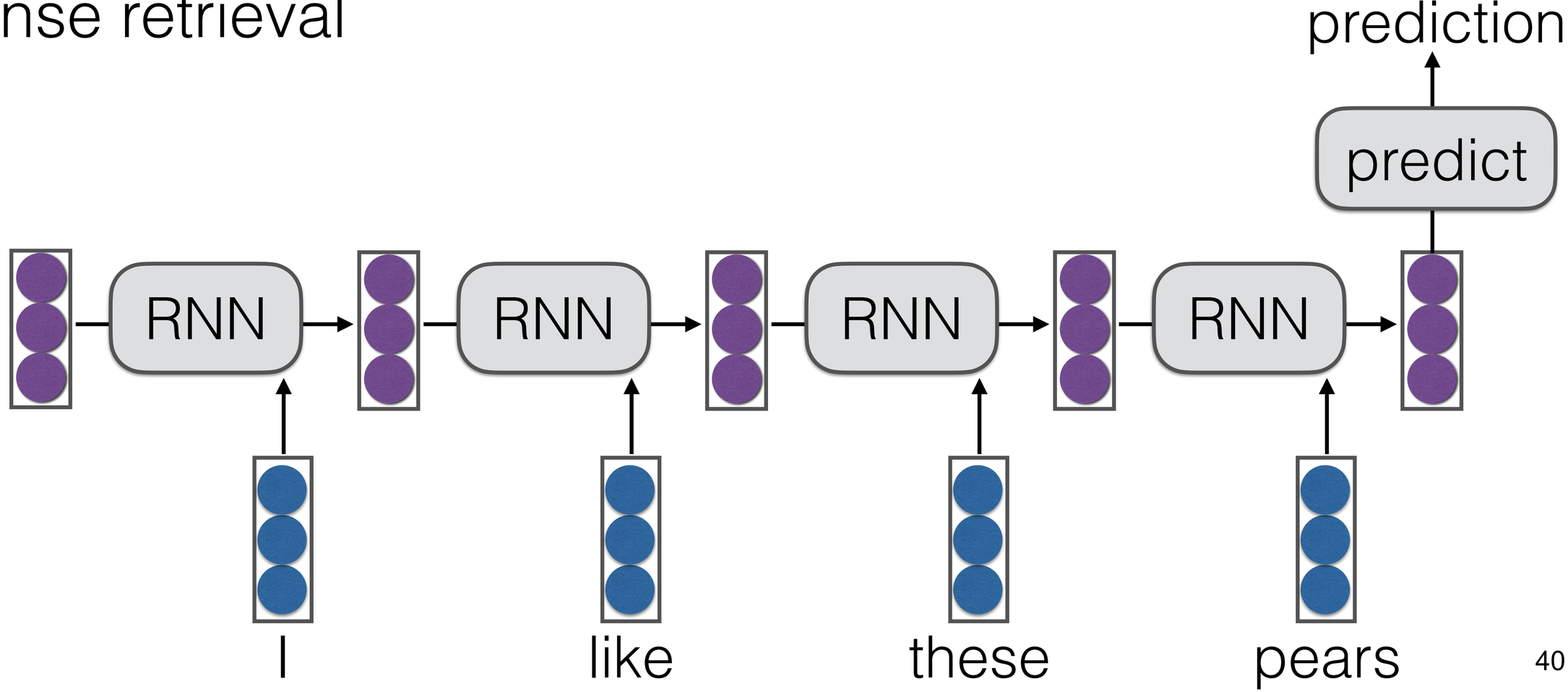
Recurrent Neural Networks (Elman 1990)

- Tools to “remember” information



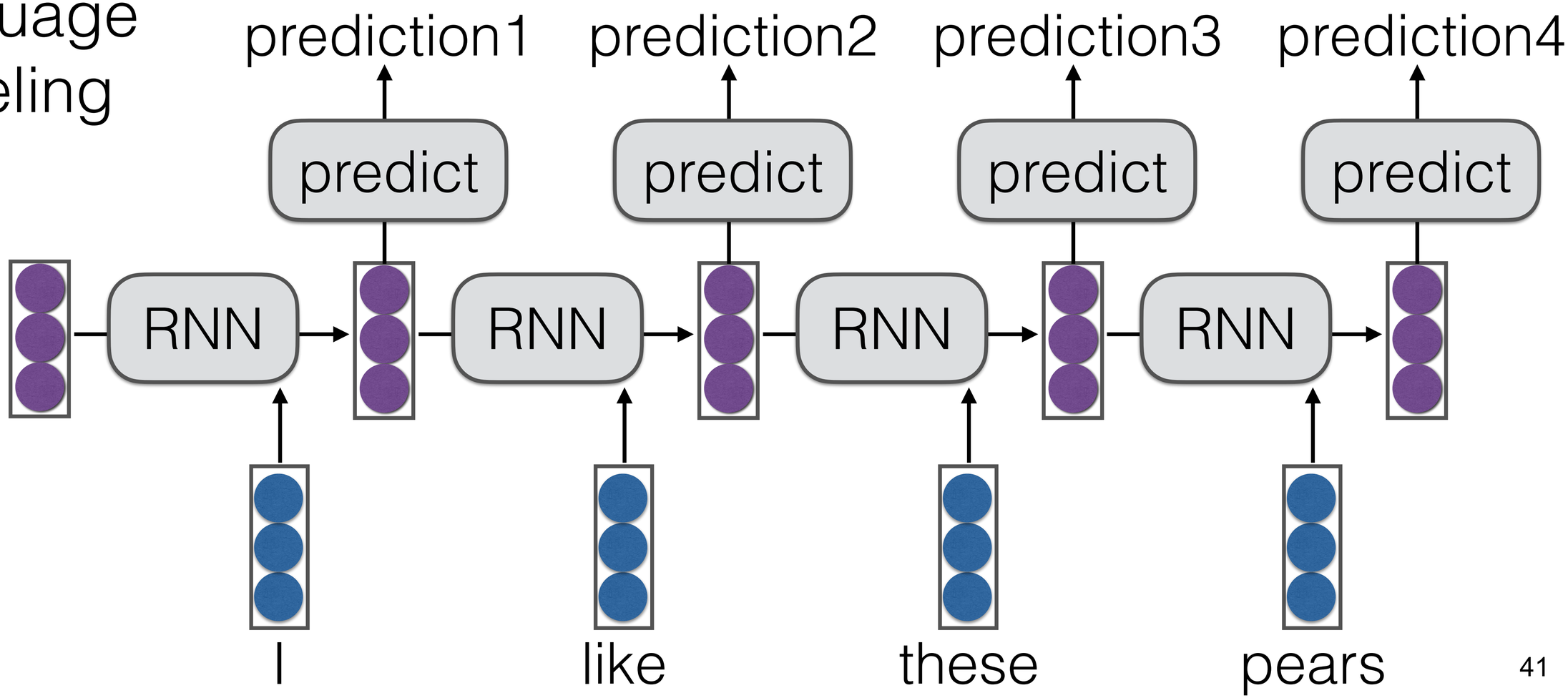
Sentence Representation for Downstream Tasks

- Text classification
- Conditional generation
- Sentense retrieval



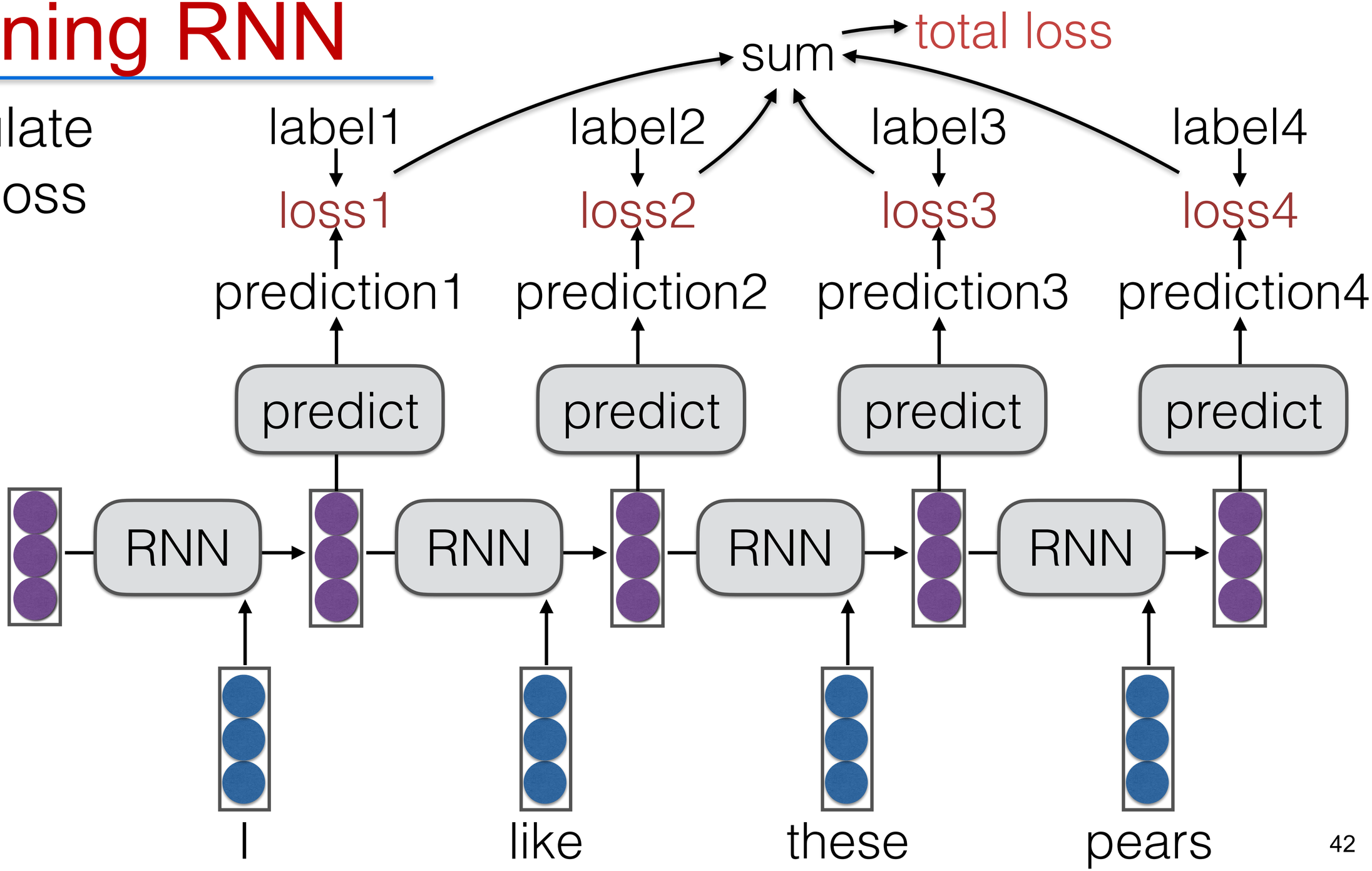
Representing Words

- Sequence Labeling
- Language Modeling



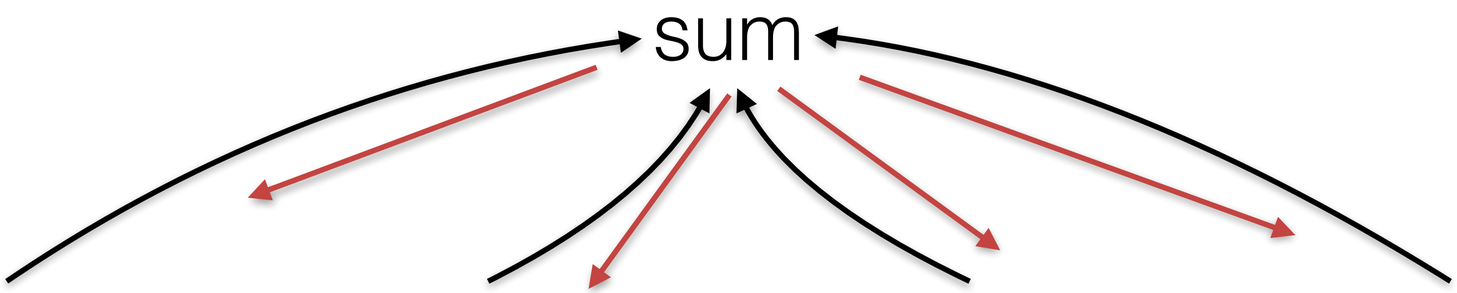
Training RNN

- calculate total loss



RNN Training

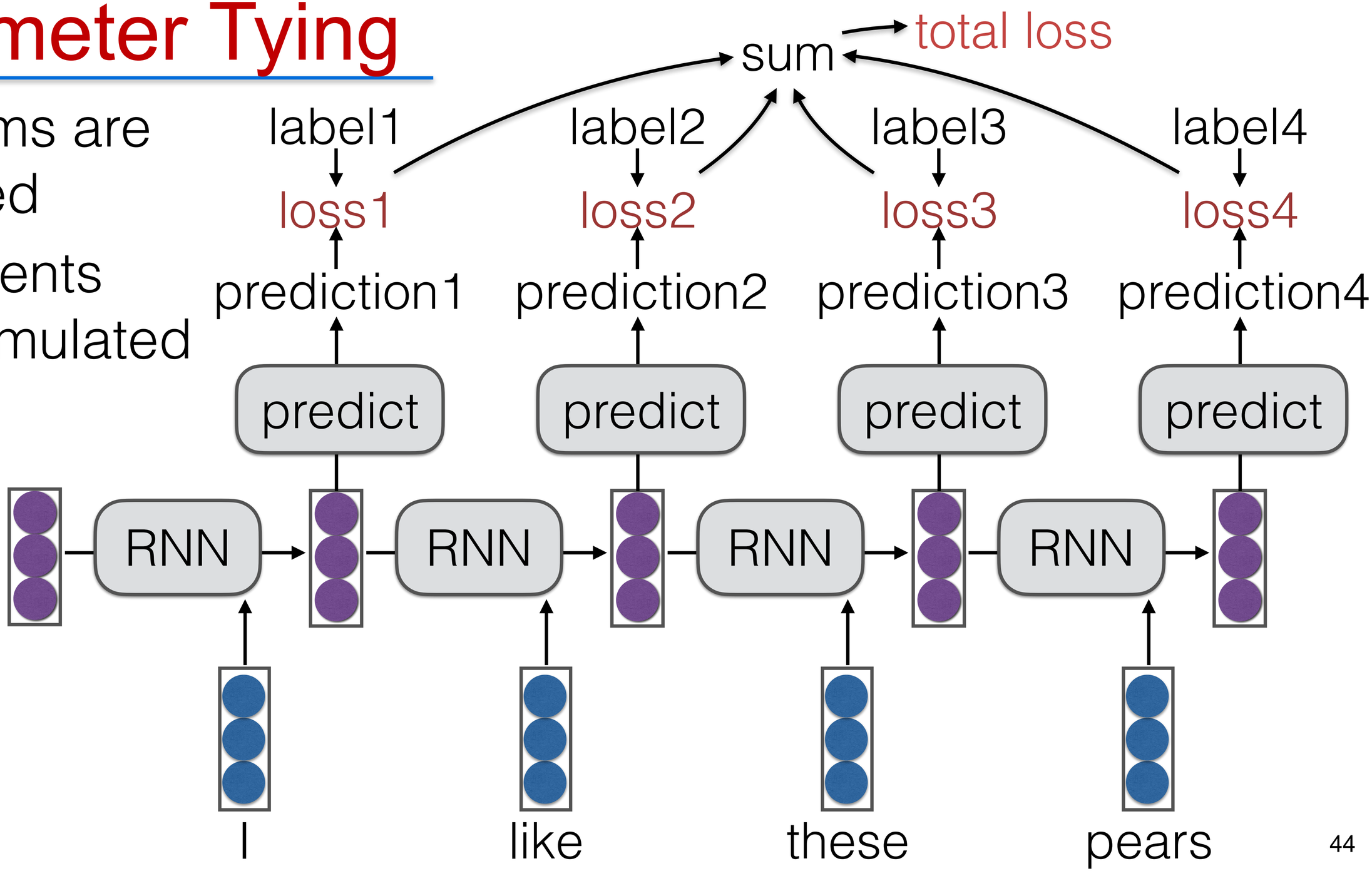
- The unrolled graph is a well-formed (DAG) computation graph—we can run backprop



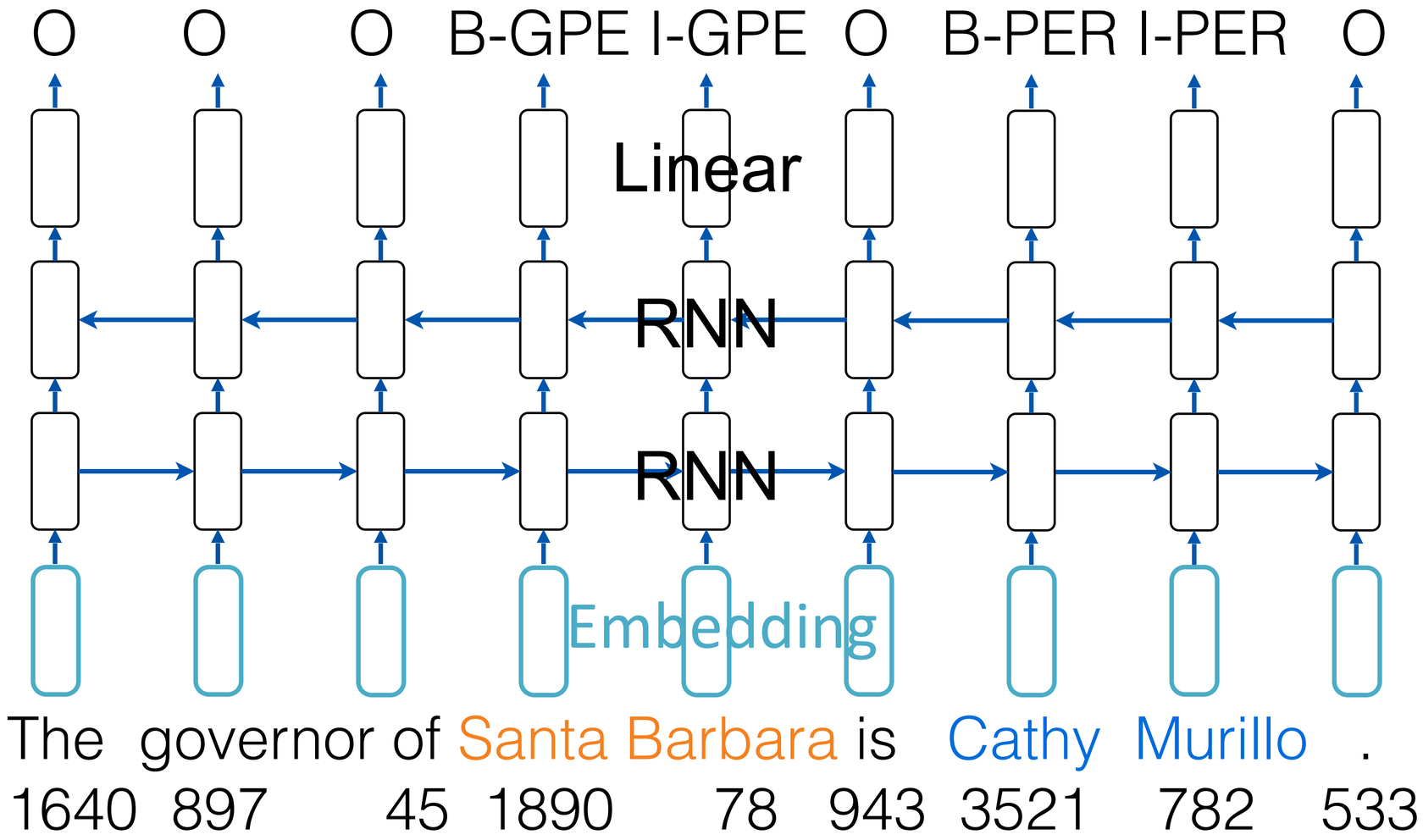
  - Parameters are tied across time, derivatives are aggregated across all time steps
  - This is historically called “backpropagation through time” (BPTT)

Parameter Tying

- Params are shared
- gradients accumulated



Bi-directional RNN



Multilingual Labeling/Classification Data and Models

Language Identification

LTI Language Identification Corpus
http://www.cs.cmu.edu/~ralf/langid.html
Benchmark on 1152 languages from a variety of free sources

langid.py
https://github.com/saffsd/langid.py
Off-the-shelf language ID system for 90+ languages

Automatic Language Identification in Texts: A Survey
https://arxiv.org/pdf/1804.08186.pdf

Text Classification

- Very broad field, many different datasets

MLDoc: A Corpus for Multilingual Document Classification in Eight Languages
https://github.com/facebookresearch/MLDoc
Topic classification, eight languages

PAWS-X: Paraphrase Adversaries from
https://github.com/google-research-datasets/paws/tree/
Paraphrase detection (sentence *pair* classification)

Cross-lingual Natural Language Inference (XNLI) corpus
https://cims.nyu.edu/~sbowman/
Textual entailment prediction (sentence *pair* classification)

Cross-lingual Sentiment Classification
Available from: https://github.com/ccsasuke/
Chinese-English cross-lingual sentiment dataset

Part of Speech/Morphological Tagging

- Part of universal dependencies treebank https://universaldependencies.org/
- Contains parts of speech and morphological features for 90 languages
- Standardized "Universal POS" and "Universal Morphology" tag sets make things consistent
- Several pre-trained models on these datasets:
  - *Udify:* https://github.com/Hyperparticle/udify
  - *Stanza:* https://stanfordnlp.github.io/stanza/

Named Entity Recognition

- “Gold standard” data
  - CoNLL 2002/2003 Language Independent Named Entity Recognition
  - https://www.clips.uantwerpen.be/conll2003/ner/
  - English, German, Spanish, Dutch human annotated data
- “Silver Standard”
  - WikiAnn Entity Recognition/Linking in 282 Languages
  - https://www.aclweb.org/anthology/P17-1178/
  - Available from: https://github.com/google-research/xtreme
  - Data automatically extracted from Wikipedia using inter-page links

Composite Benchmarks

- Benchmarks that aggregate many different sequence labeling/classification tasks
- XTREME: A Massively Multilingual Multi-task Benchmark for Evaluating Cross-lingual Generalization
  - 10 different tasks, 40 different languages
  - https://github.com/google-research/xtreme
- XGLUE: A New Benchmark Dataset for Cross-lingual Pre-training, Understanding and Generation
  - https://microsoft.github.io/XGLUE/
  - 11 tasks over 19 languages (including generation)

Discussion Today

Assignment 1 Introduction