CMU CS11-737: Multilingual NLP

Text Classification and Sequence Labeling

Graham Neubig

Carnegie Mellon University
Language Technologies Institute

Text Classification

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

Topic Classification

I like peaches and pears → 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

He	saw	two	birds
↓	↓	↓	↓
PRON	VERB	NUM	NOUN

Lemmatization

He	saw	two	birds
↓	↓	↓	↓
he	see	two	bird

Morphological Tagging

He	saw	two	birds
↓	↓	↓	↓
PronType=prs	Tense=past, VerbForm=fin	NumType=card	Number=plur

... and more!

Span Labeling

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

Named Entity Recognition

Graham Neubig	is teaching at	Carnegie Mellon University
PER		ORG

Syntactic Chunking

Graham Neubig	is teaching	at Carnegie Mellon University
NP	VP	NP

Semantic Role Labeling

Graham Neubig	is	teaching	at	Carnegie Mellon University
Actor		Predicate		Location

... and more!

Span Labeling as Sequence Labeling

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

Graham Neubig is teaching at Carnegie Mellon University

PER ORG

Graham Neubig is teaching at Carnegie Mellon University

B-PER I-PER O O O B-ORG I-ORG I-ORG

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

外国人参政権	
外国 人 参政 権	外国 人参 政権
foreign people voting rights	foreign carrot government

Morphological Segmentation

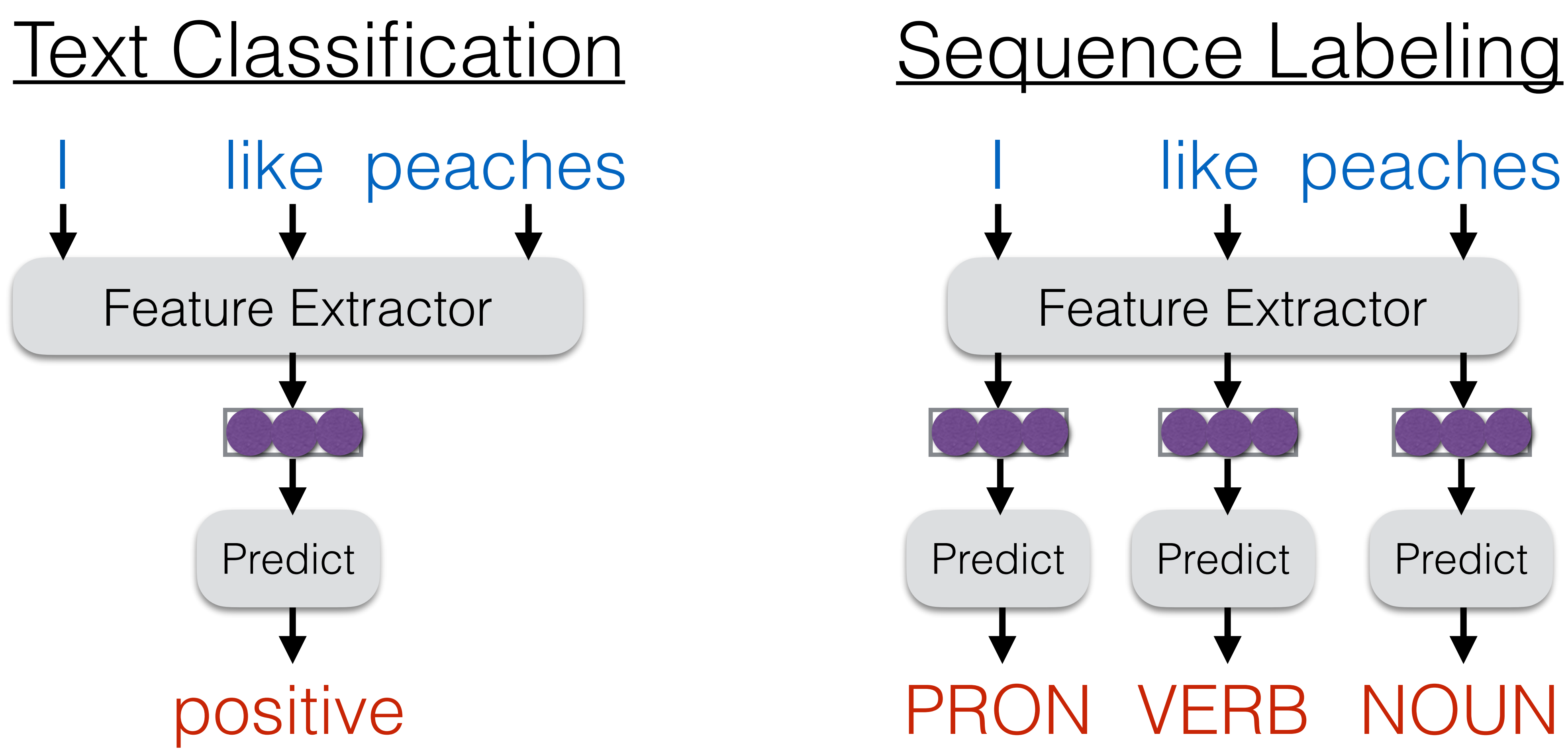
Köpekler	
Köpek ler	Köpekle r
dog Number=Plural	dog_paddle Tense=Aorist

- Rule-based, or span labeling models

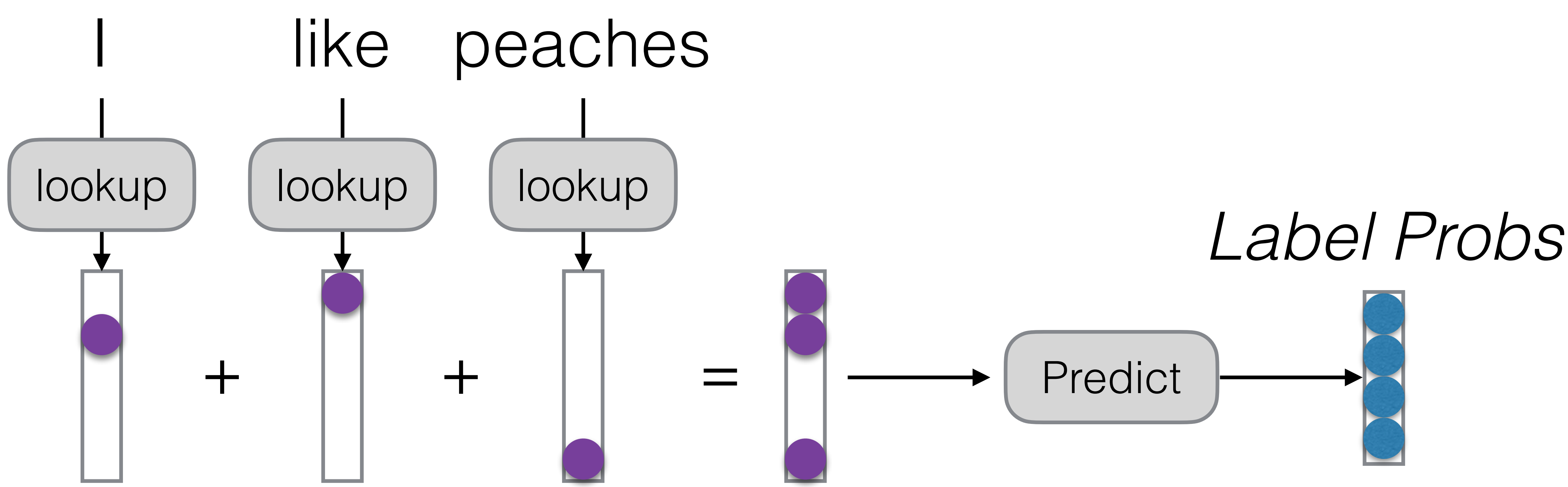
Modeling for Sequence Labeling/Classification

How do we Make Predictions?

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



A Simple Extractor: Bag of Words (BOW)



A Simple Predictor: Linear Transform+Softmax

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

- Softmax converts arbitrary scores into probabilities

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

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

Problem: Language is not a Bag of Words!

I don’t love pears

There’s nothing I don’t love about pears

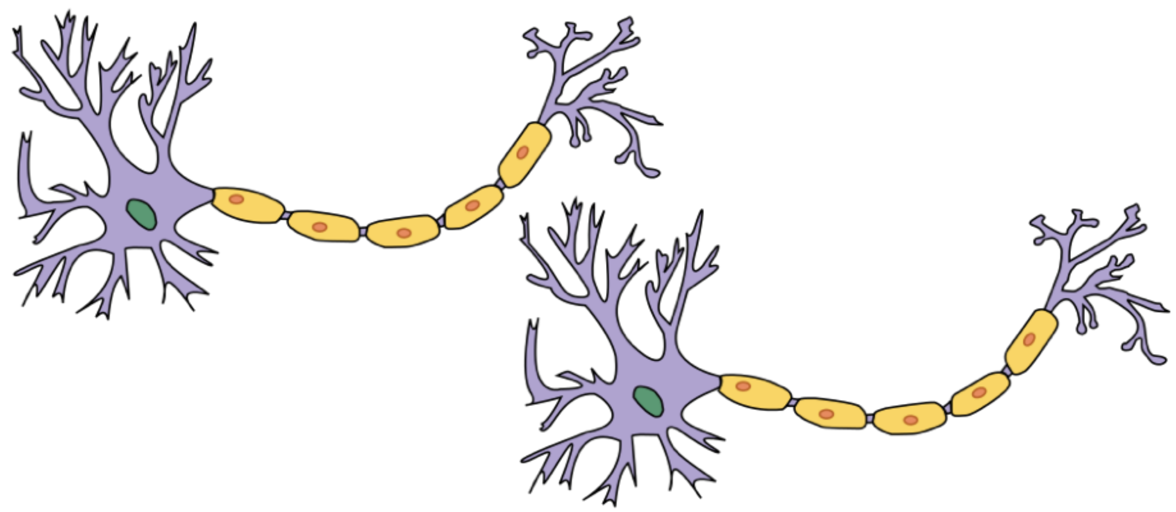
Better Featurizers

- 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: Neurons in the Brain



Current Conception: Computation Graphs

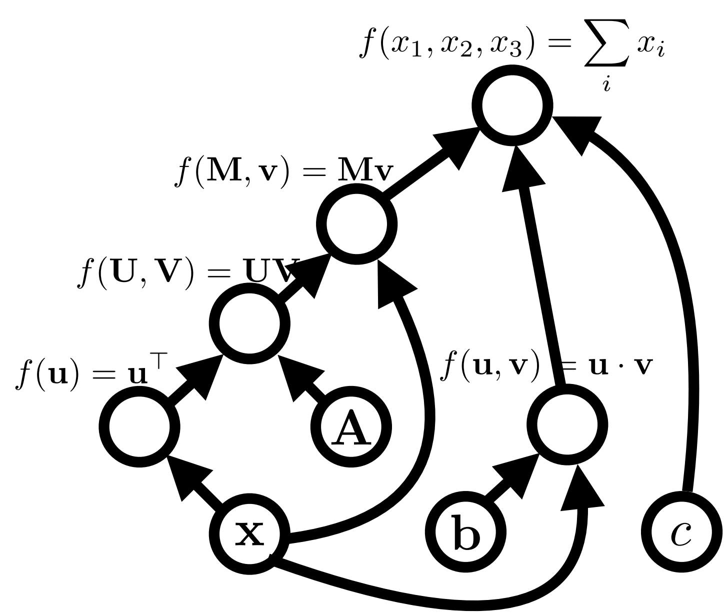


Image credit: Wikipedia

expression:

$$\mathbf{x}$$

graph:

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

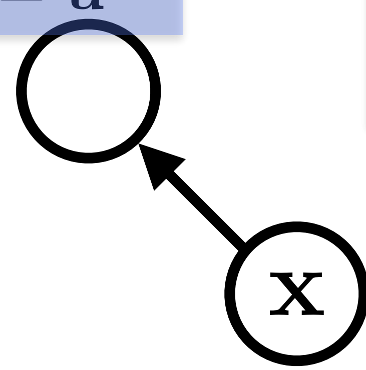
$$\mathbf{x}$$

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* $\frac{\partial \mathcal{F}}{\partial f(\mathbf{u})}$.

$f(\mathbf{u}) = \mathbf{u}^\top$



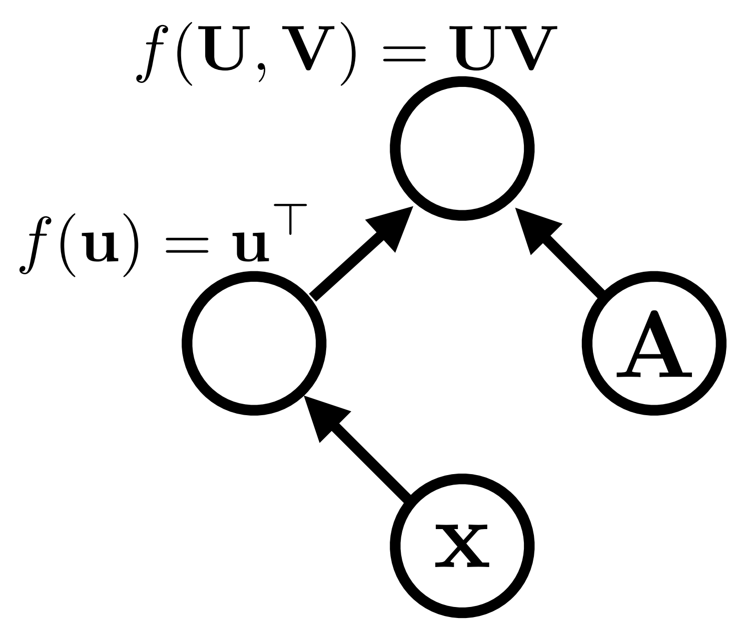
$$\frac{\partial f(\mathbf{u})}{\partial \mathbf{u}} \frac{\partial \mathcal{F}}{\partial f(\mathbf{u})} = \left(\frac{\partial \mathcal{F}}{\partial f(\mathbf{u})} \right)^\top$$

expression:

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

graph:

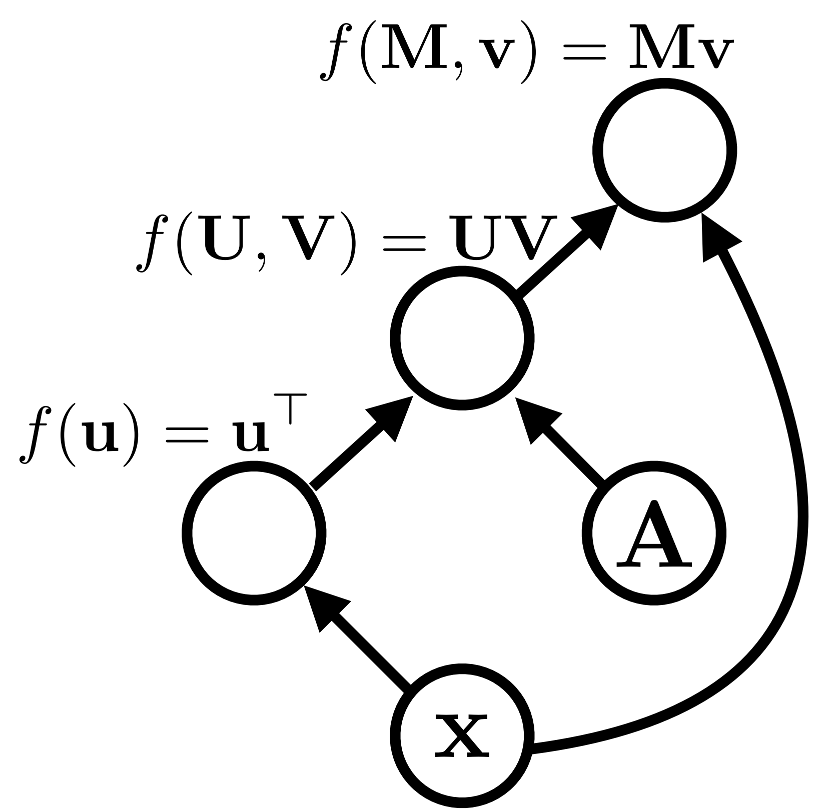
Functions can be nullary, unary, binary, … *n*-ary. Often they are unary or binary.



expression:

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

graph:

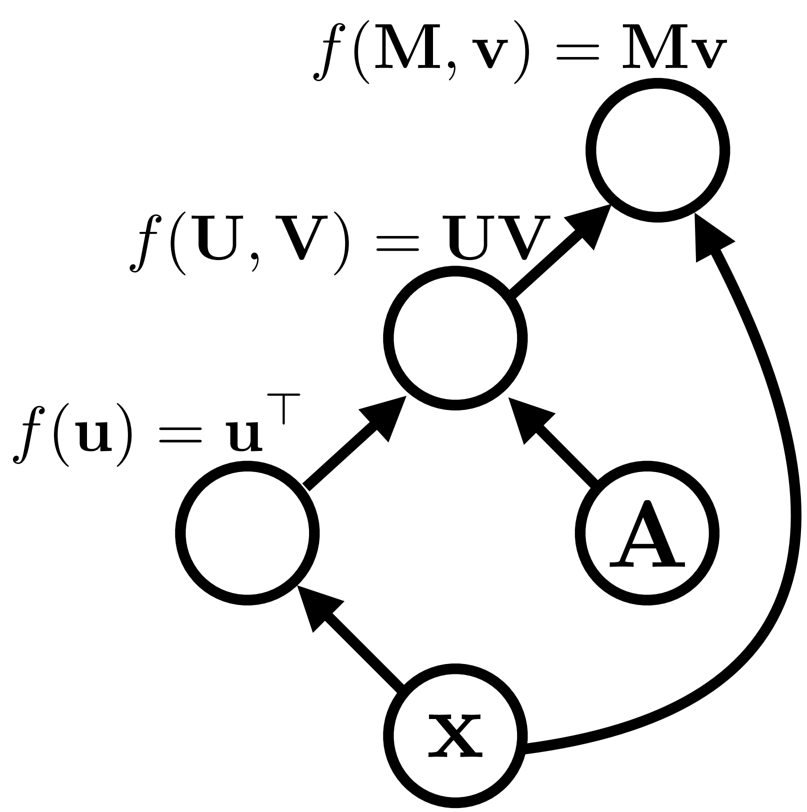


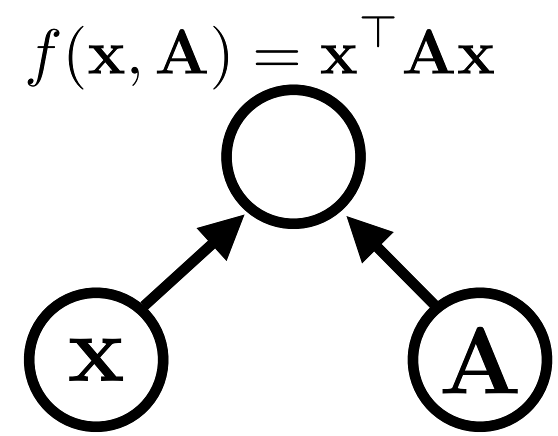
Computation graphs are generally directed and acyclic

expression:

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

graph:





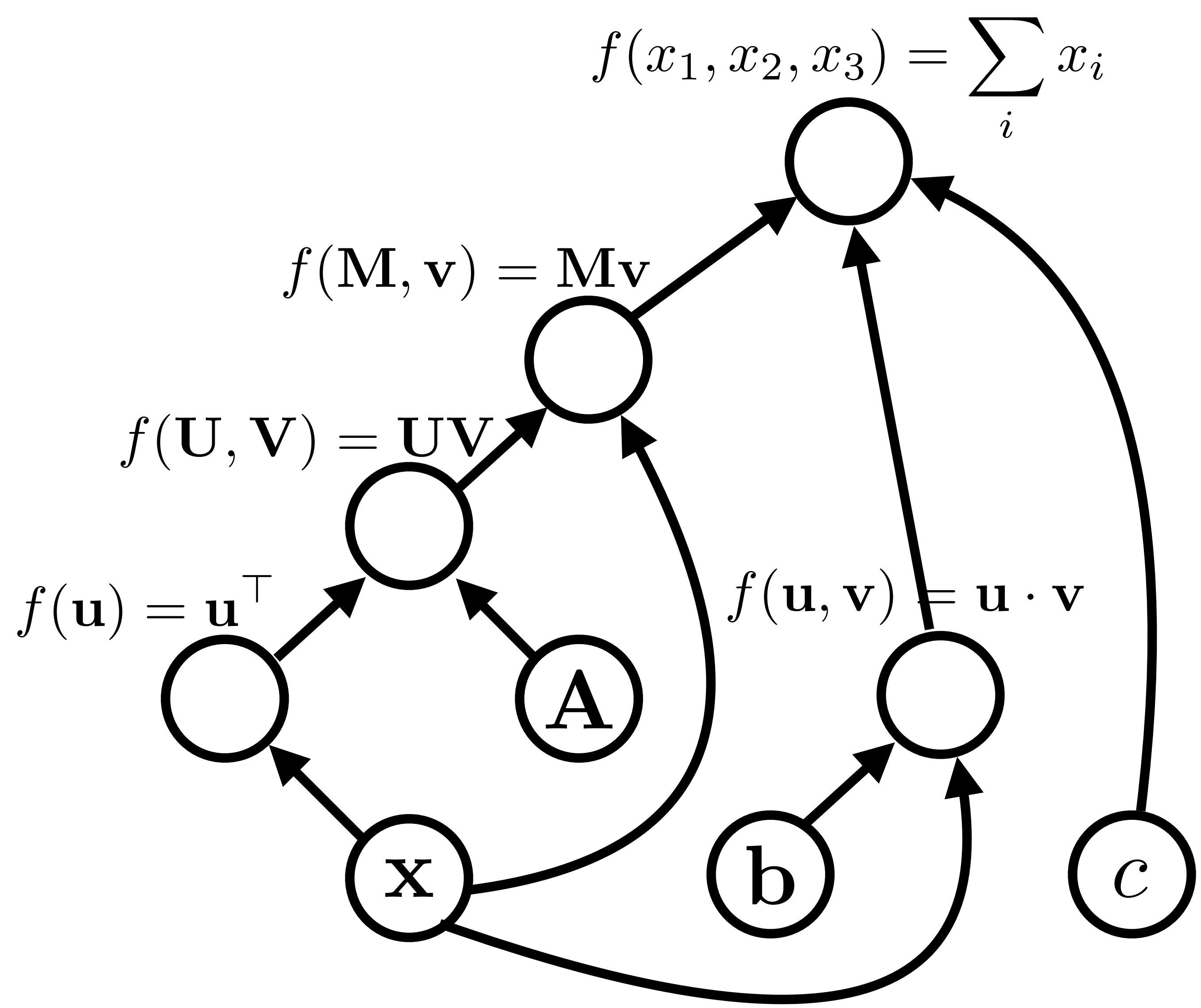
$$\frac{\partial f(\mathbf{x}, \mathbf{A})}{\partial \mathbf{x}} = (\mathbf{A}^\top + \mathbf{A})\mathbf{x}$$

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

expression:

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

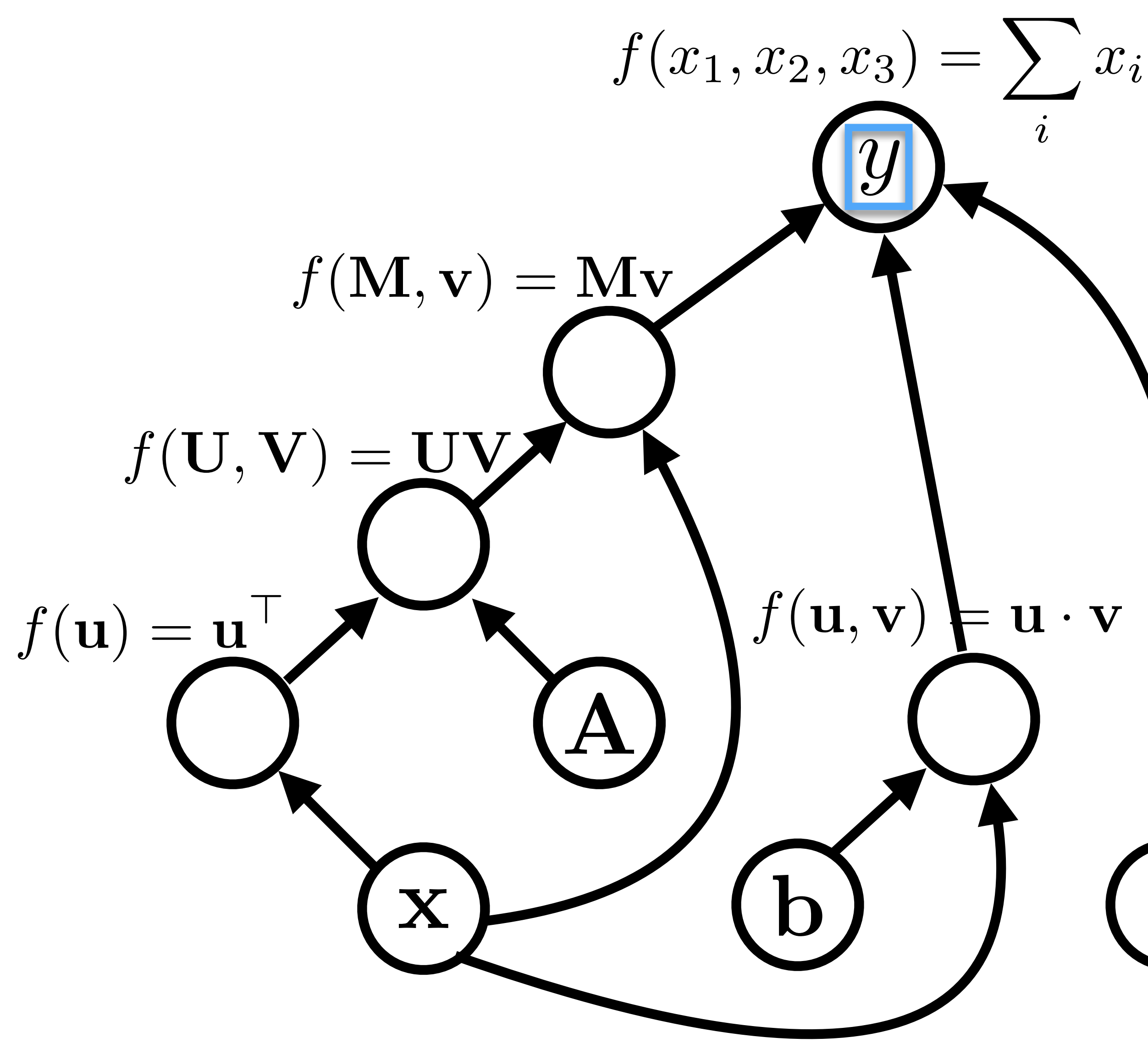
graph:



expression:

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

graph:



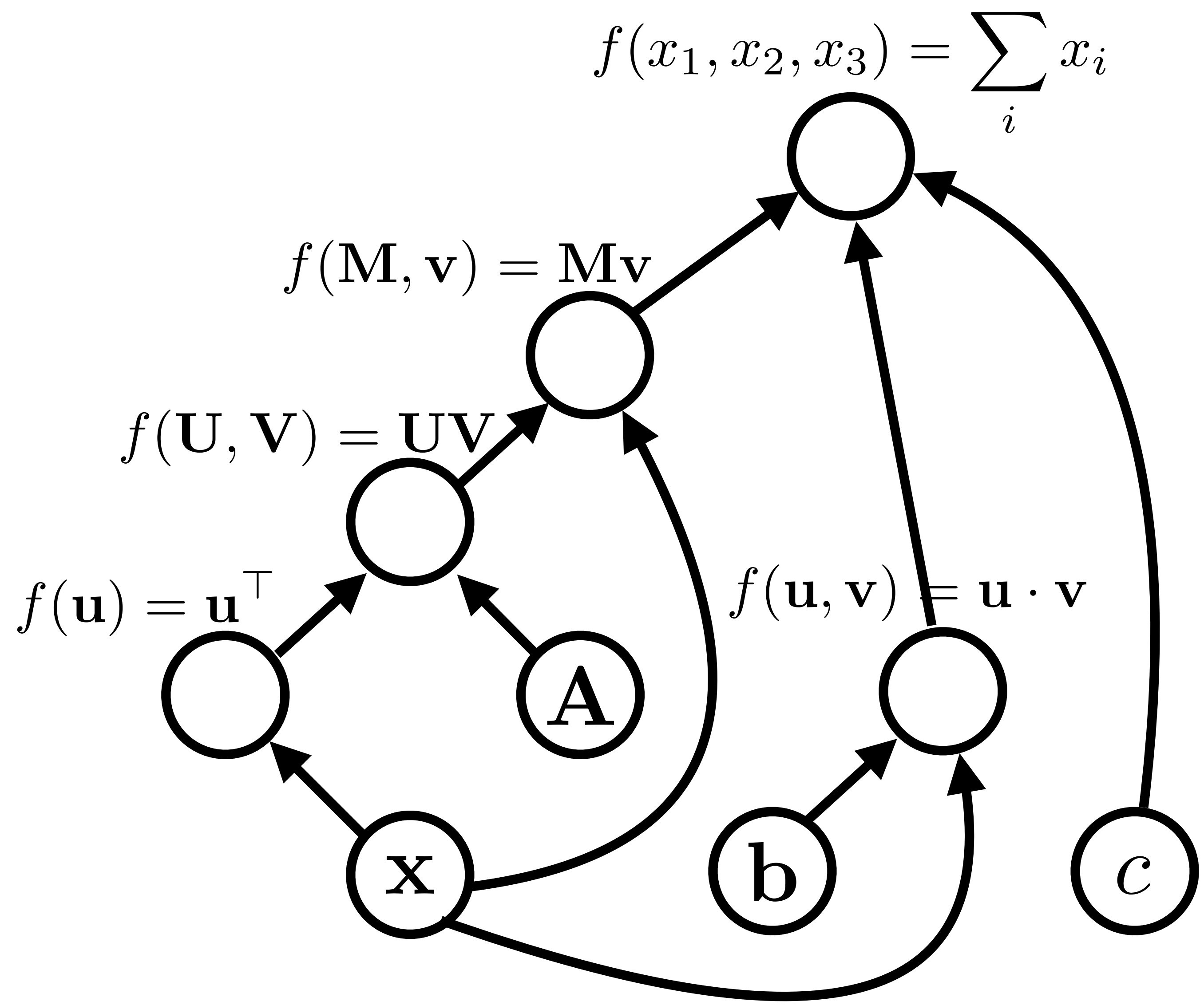
variable names are just labelings of nodes.

Algorithms (1)

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

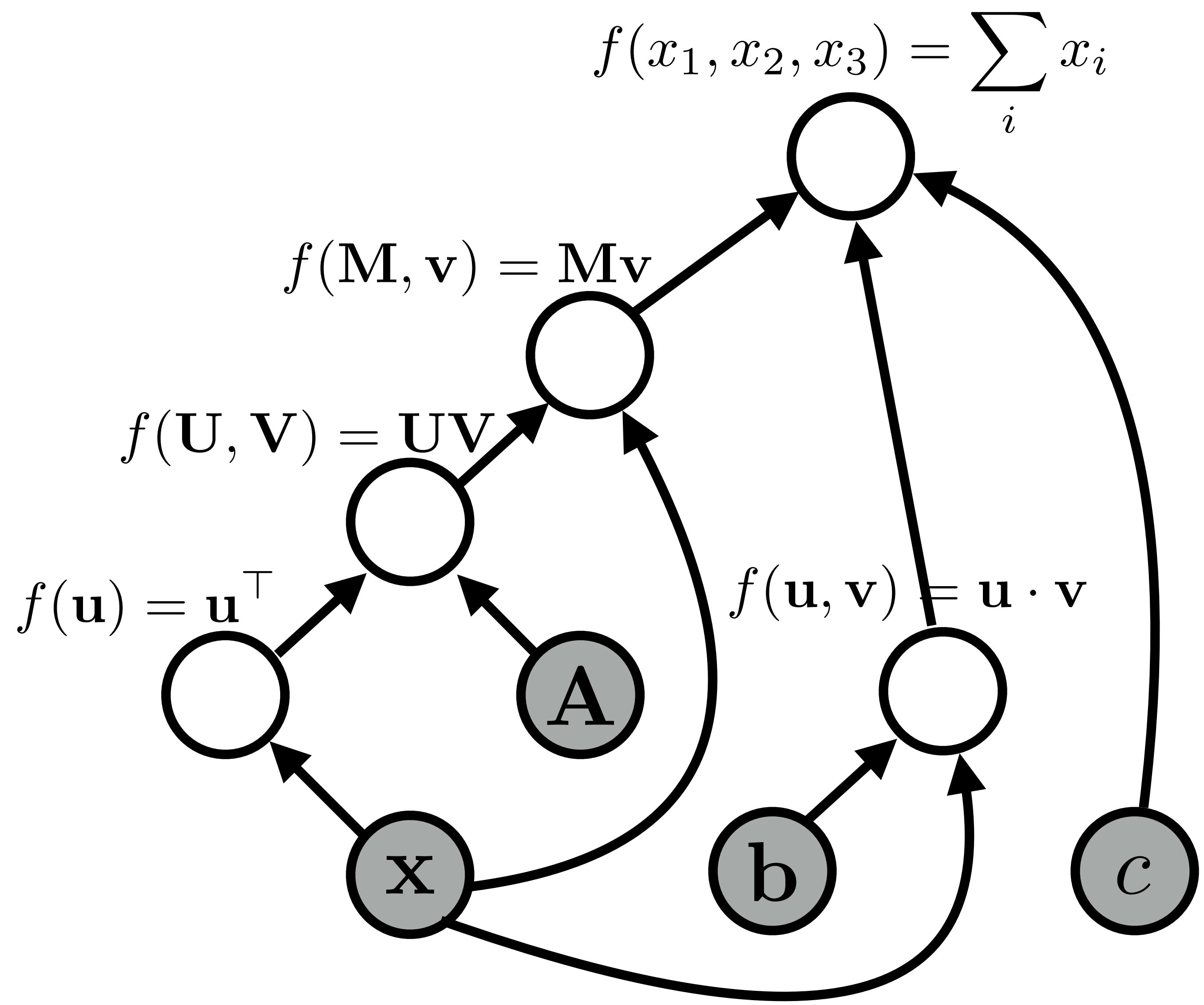
Forward Propagation

graph:



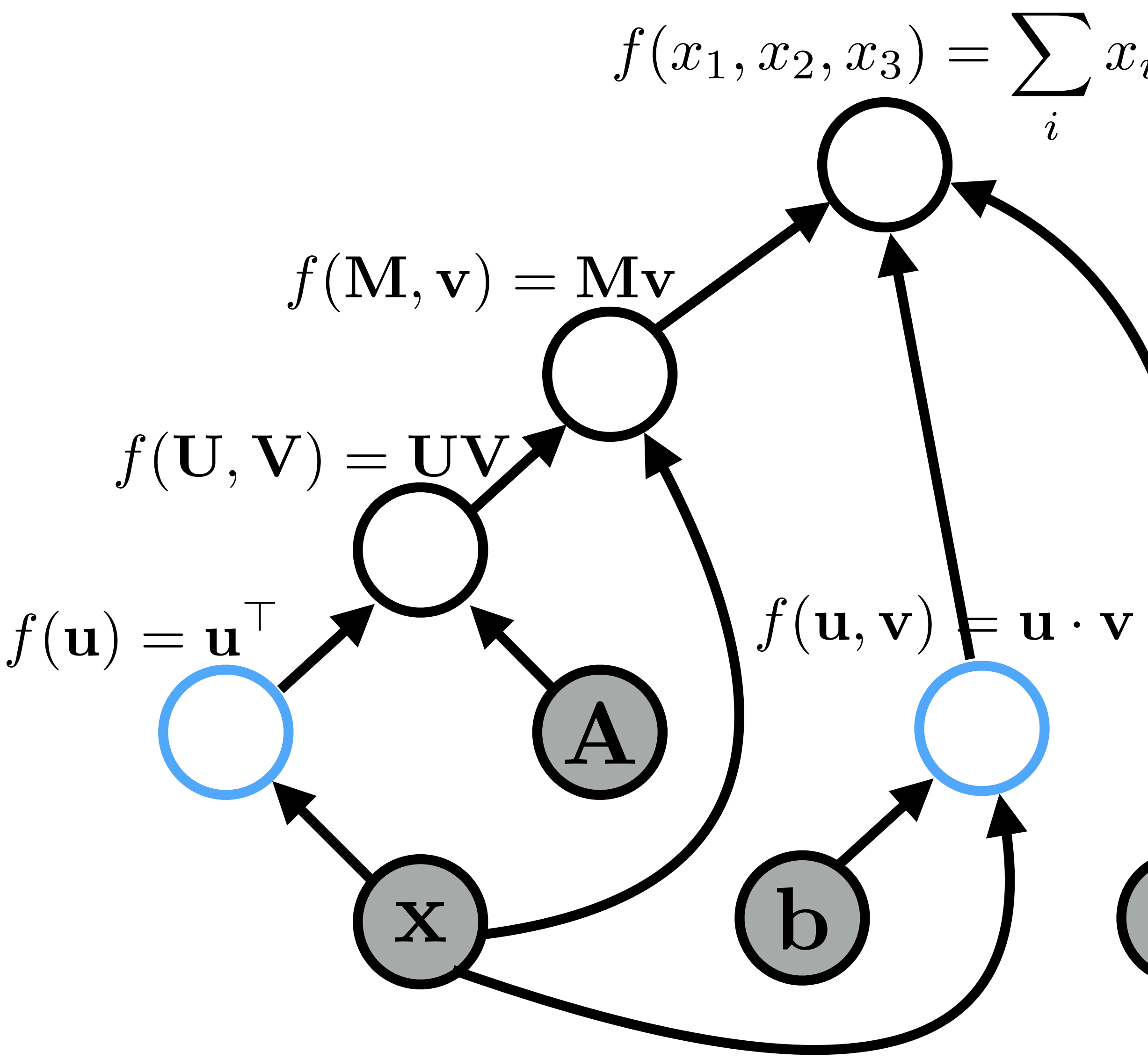
Forward Propagation

graph:



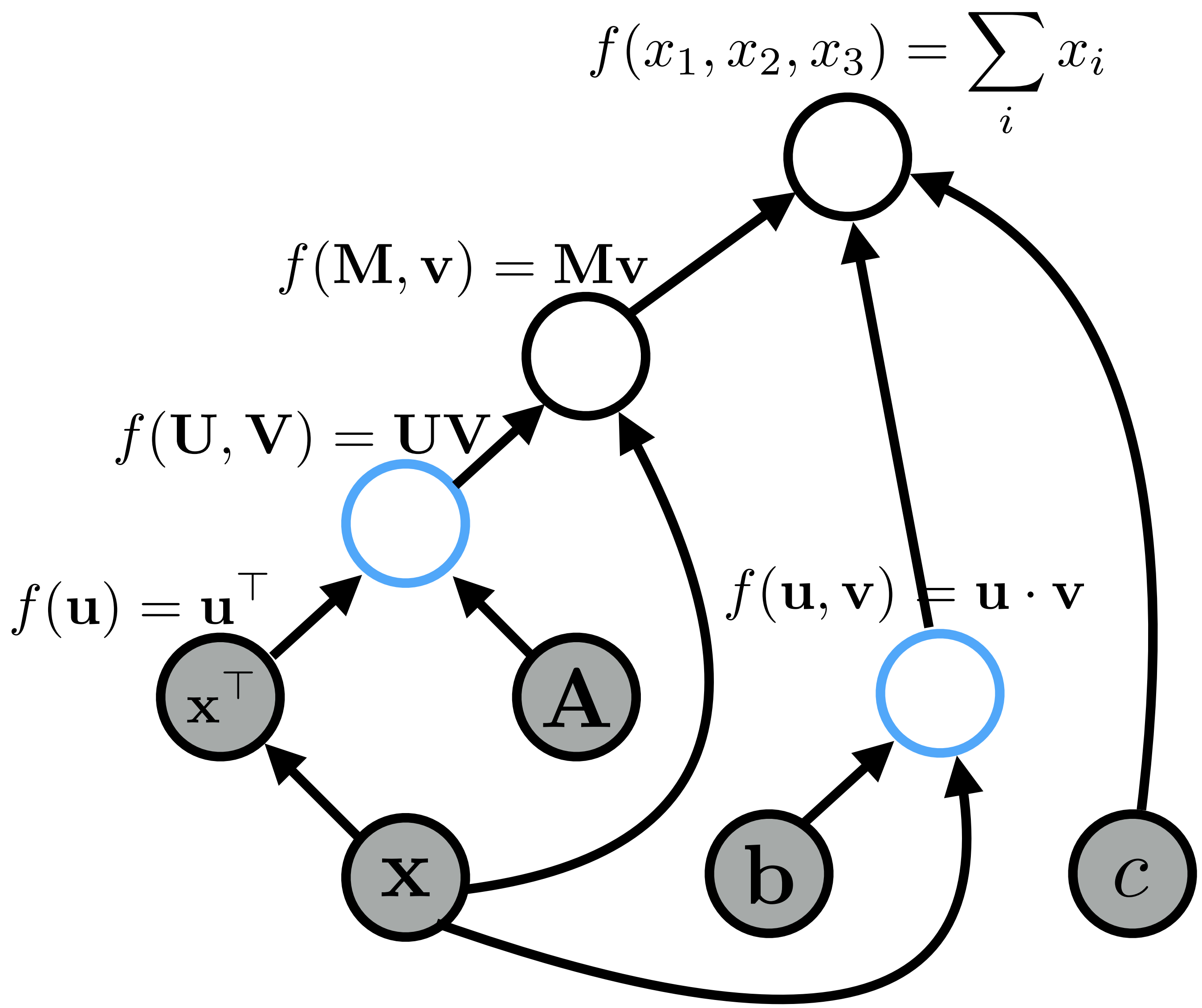
Forward Propagation

graph:



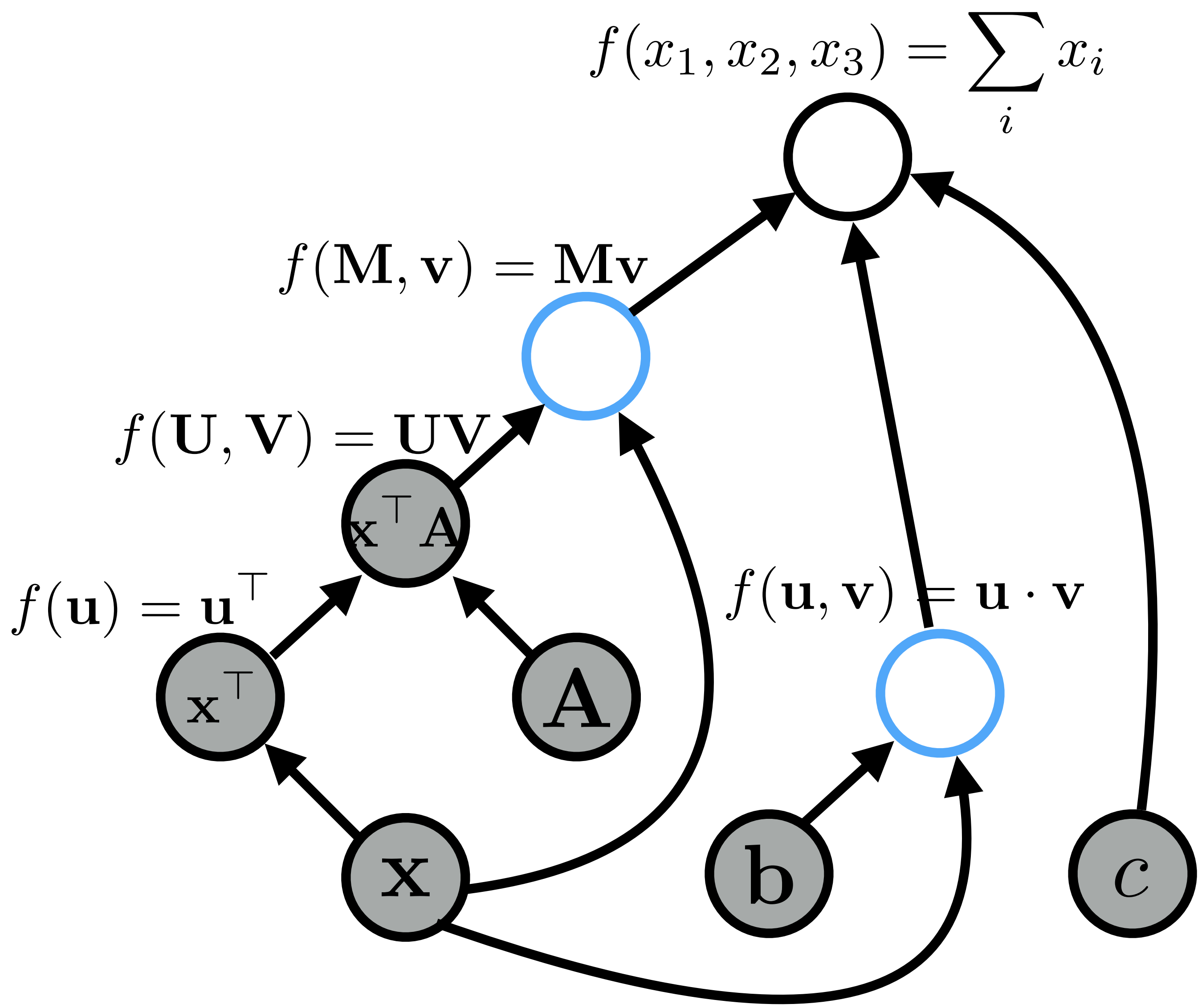
Forward Propagation

graph:



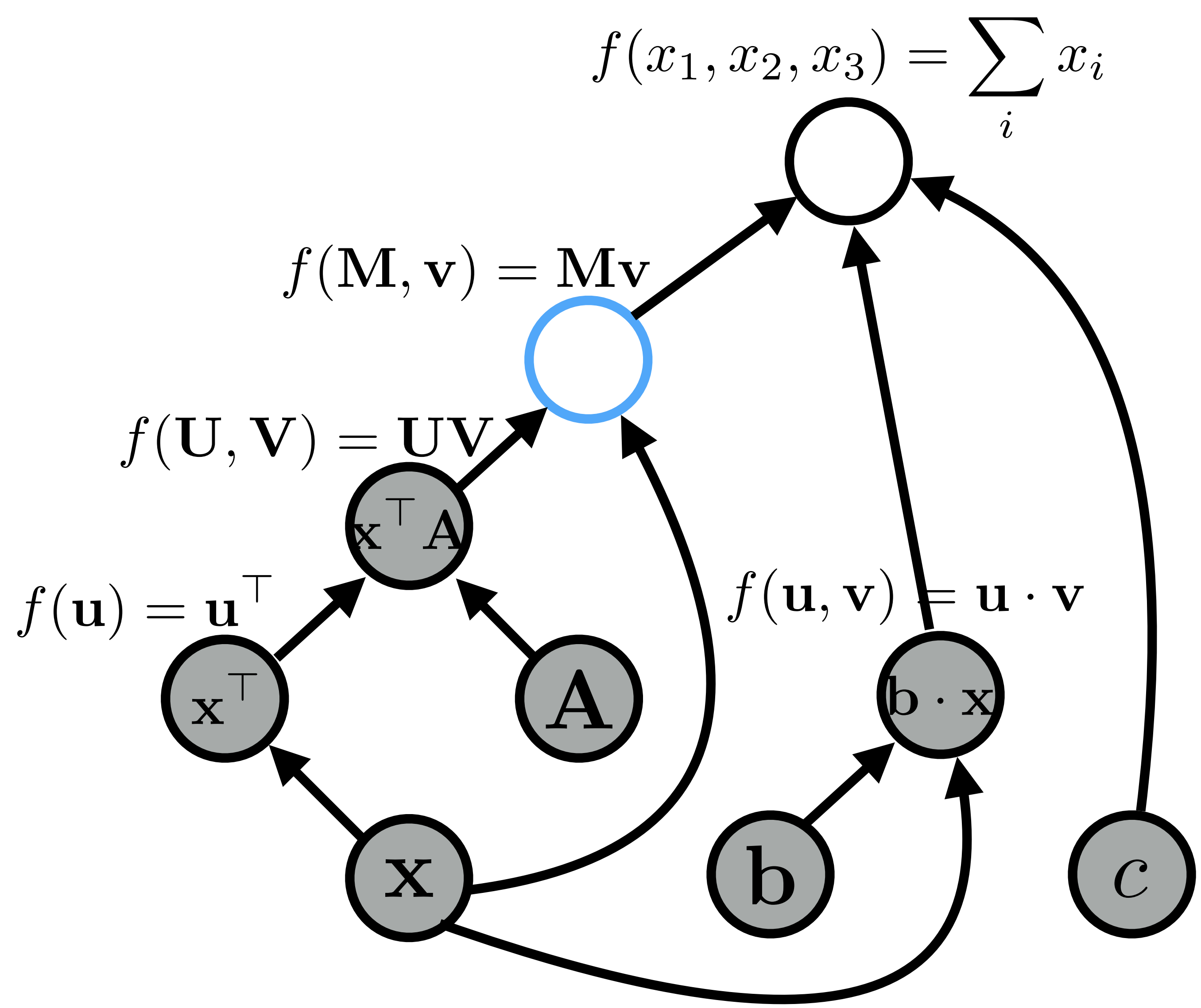
Forward Propagation

graph:



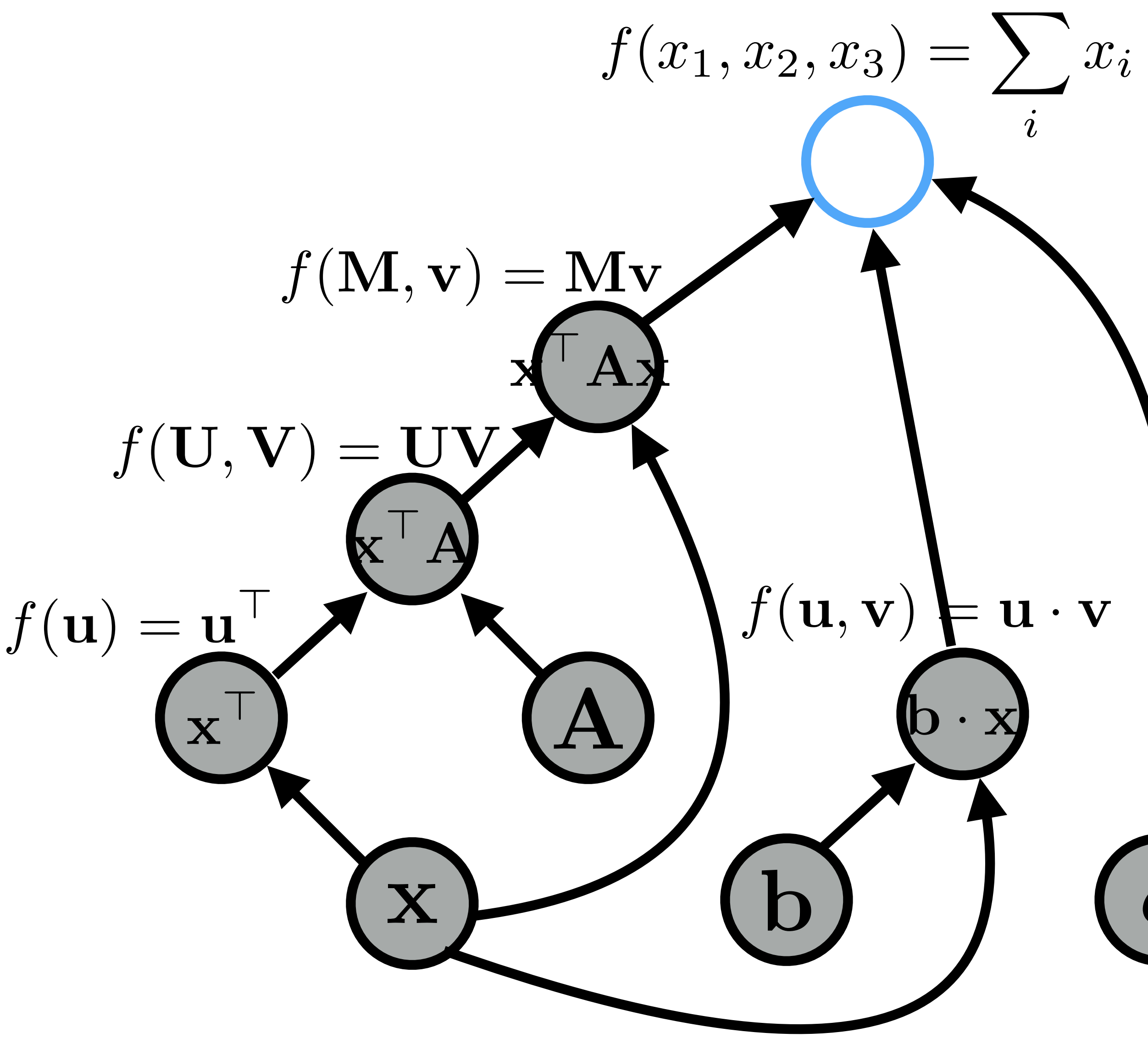
Forward Propagation

graph:



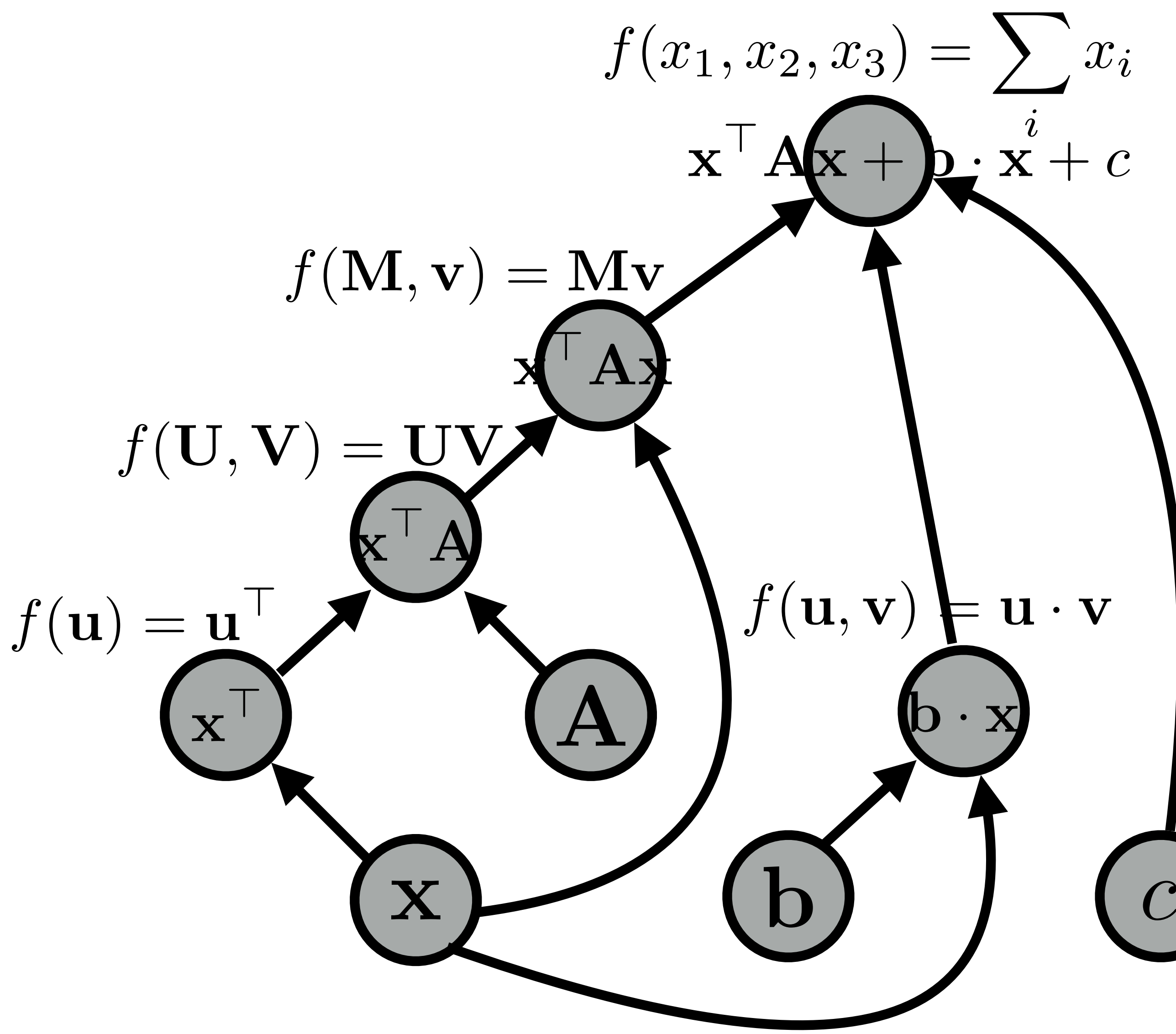
Forward Propagation

graph:



Forward Propagation

graph:

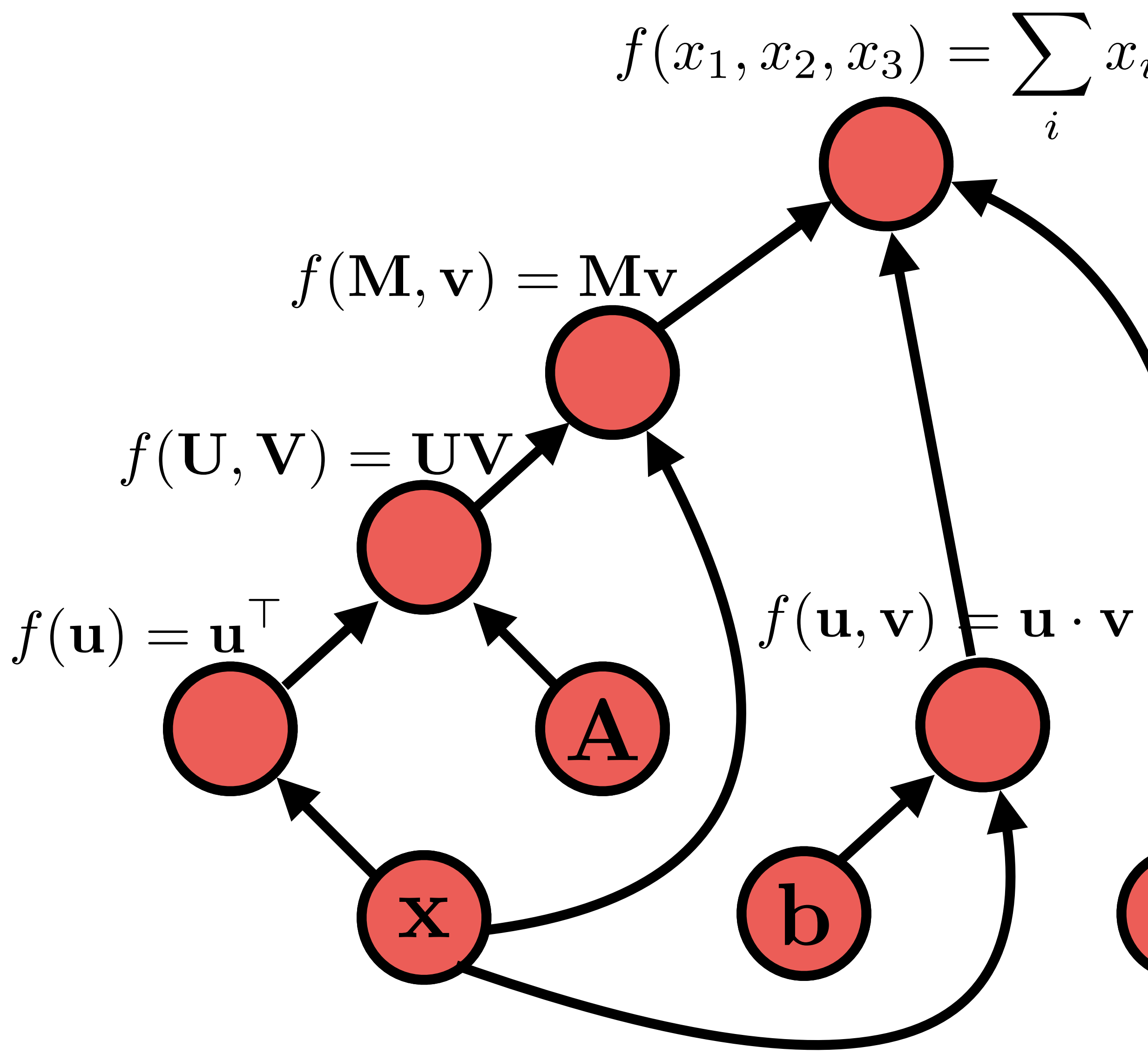


Algorithms (2)

- **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 -= $\alpha * dl/dW$

Back Propagation

graph:



Neural Network Frameworks

mxnet

dynet

TensorFlow

PYTORCH

Examples in this class

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**

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**.

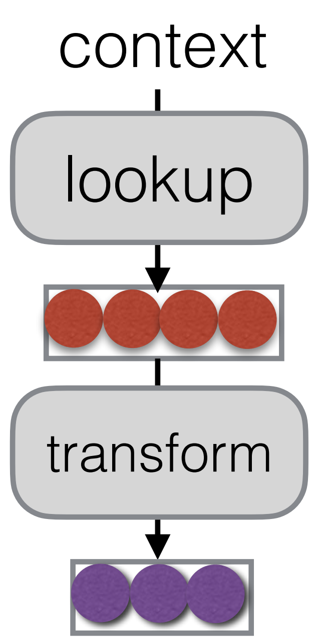
- Selectional preference

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

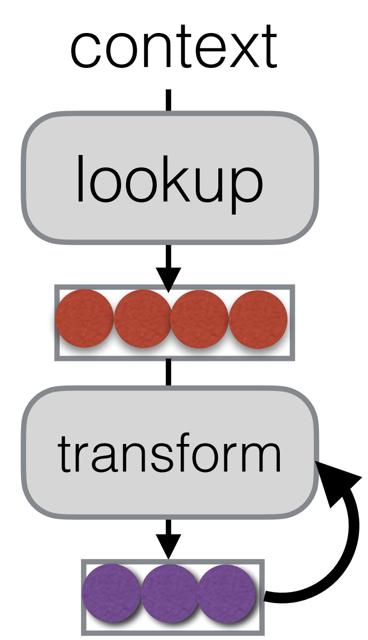
Recurrent Neural Networks
(Elman 1990)

- Tools to "remember" information

Feed-forward NN

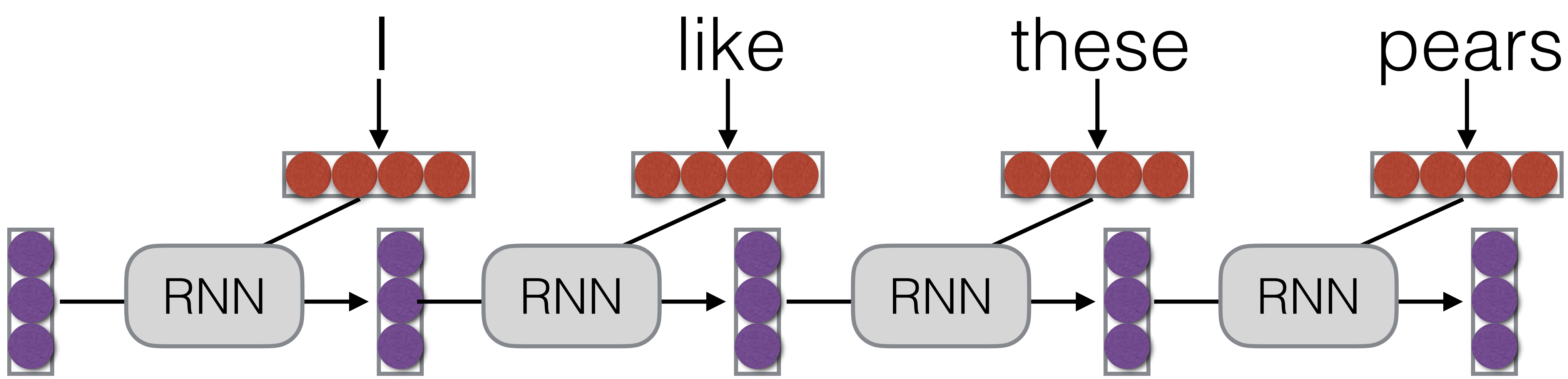


Recurrent NN

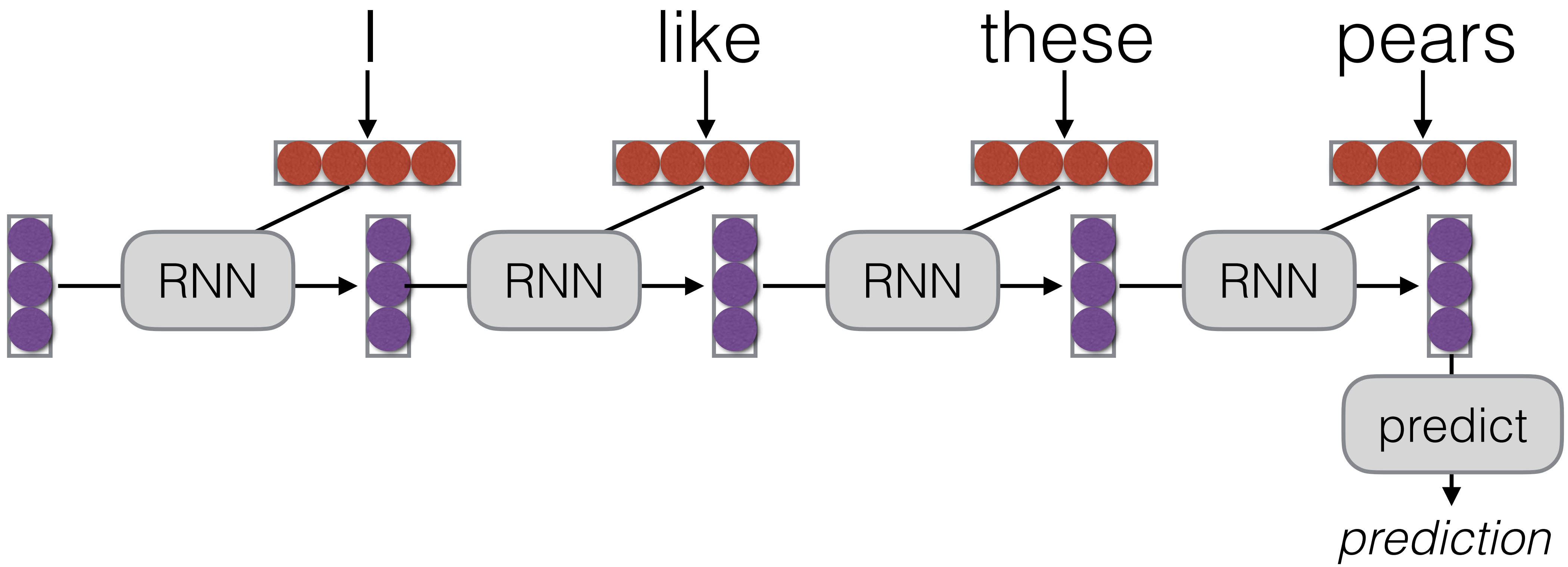


Unrolling in Time

- What does featurizing a sequence look like?

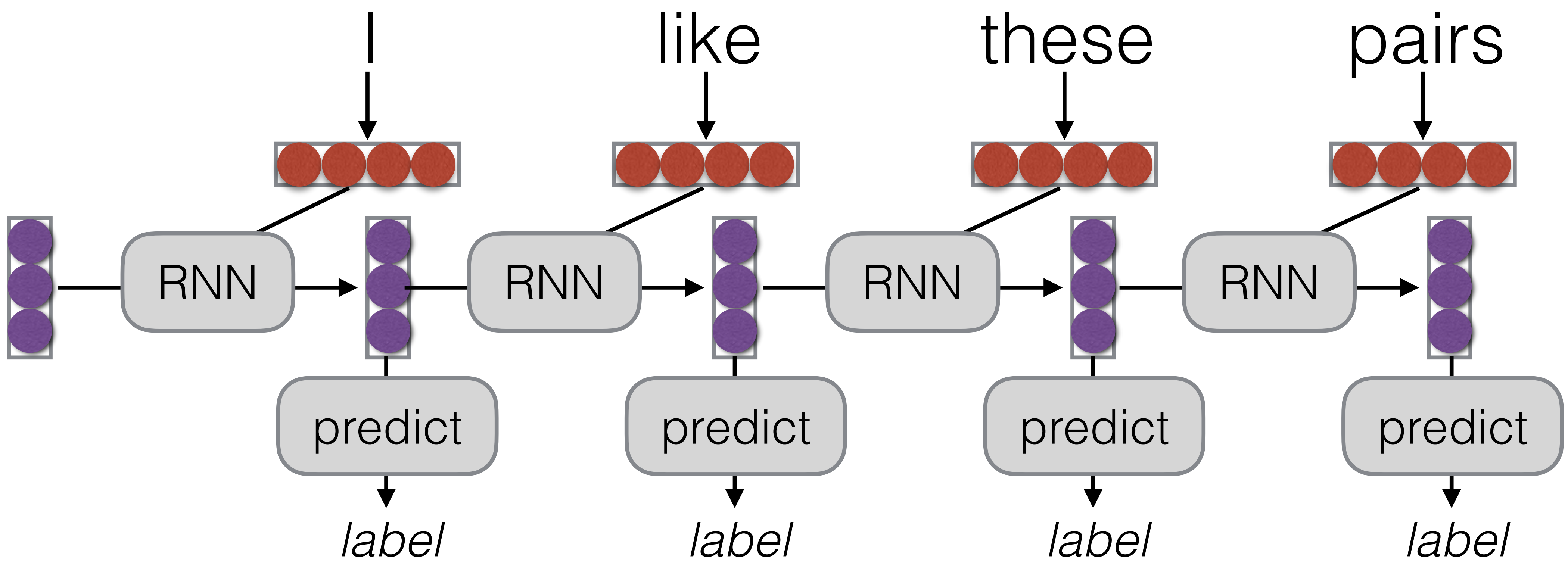


Representing Sentences



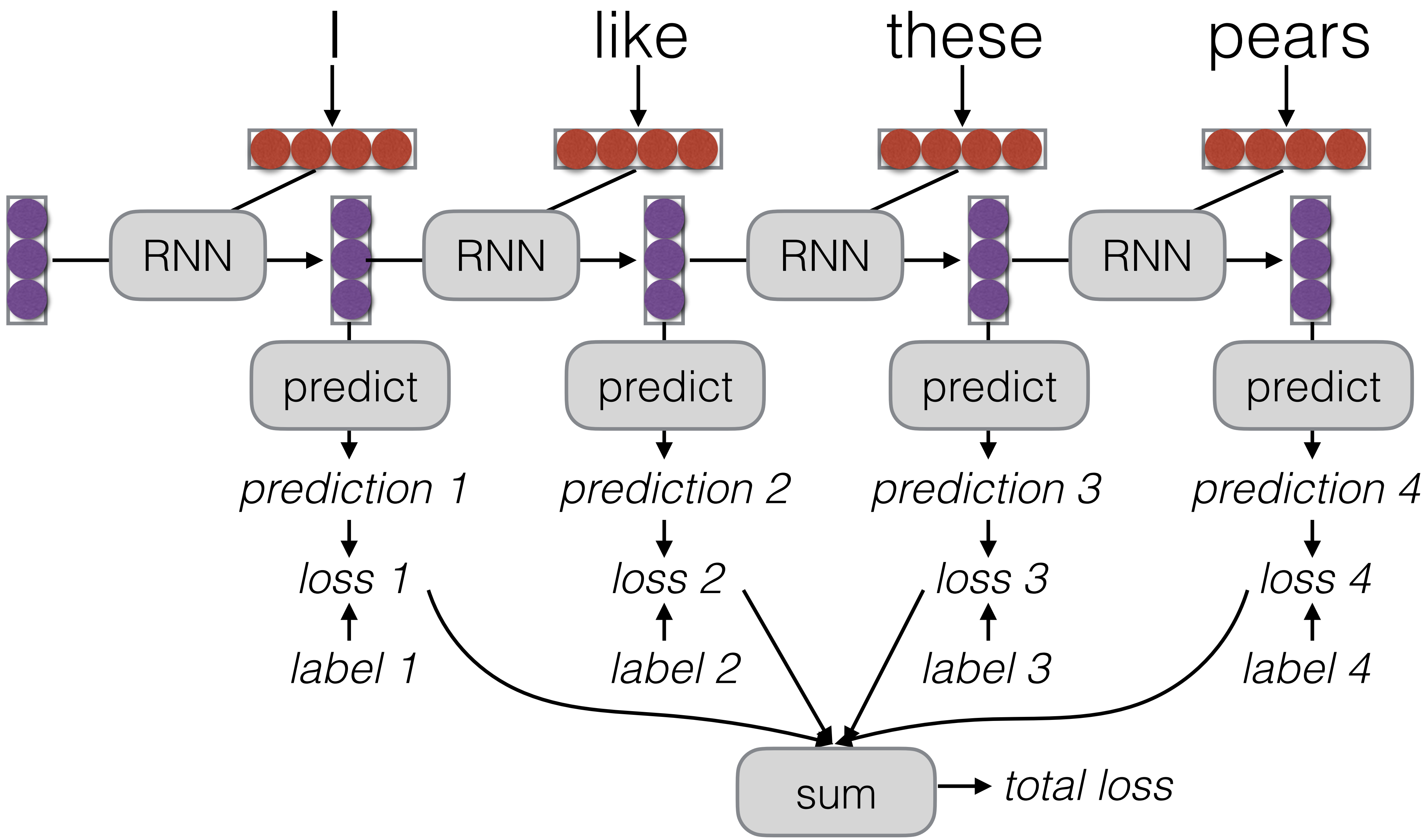
- Text Classification
- Conditioned Generation
- Retrieval

Representing Words



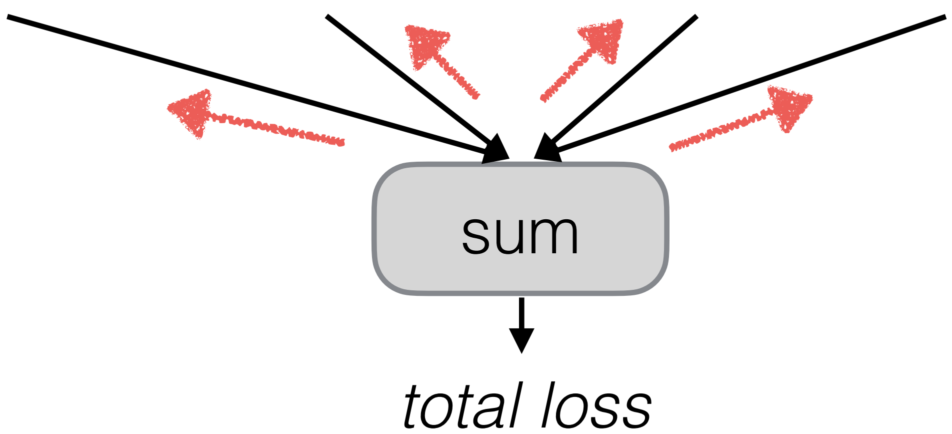
- Sequence Labeling
- Language Modeling
- Calculating Representations for Parsing, etc.

Training RNNs



RNN Training

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

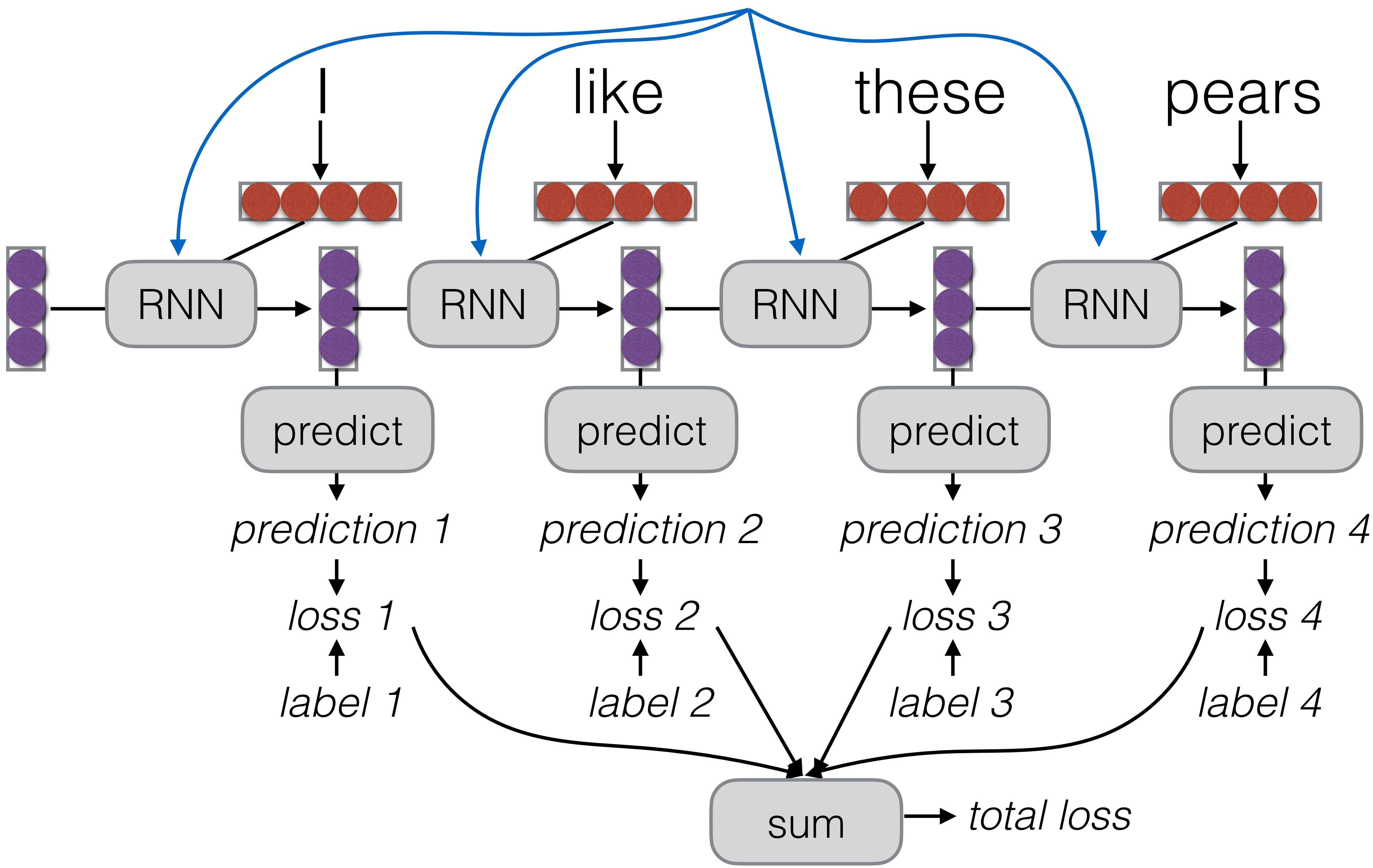


- Parameters are tied across time, derivatives are aggregated across all time steps

- This is historically called “backpropagation through time” (BPTT)

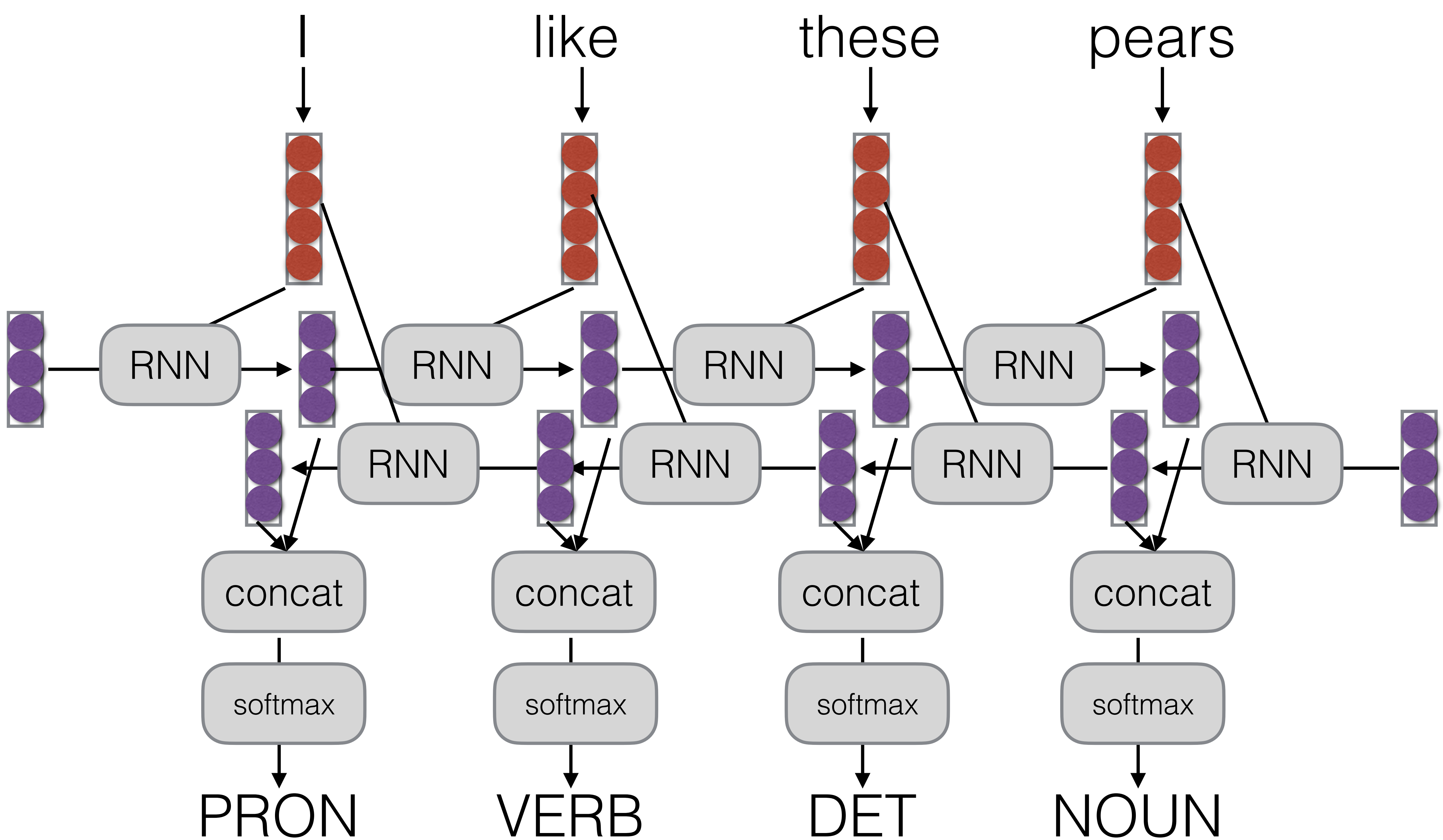
Parameter Tying

Parameters are shared! Derivatives are accumulated.



Bi-RNNs

- A simple extension, run the RNN in both directions



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 Word Scrambling, Cross-lingual Version

https://github.com/google-research-datasets/paws/tree/master/pawsx

- Paraphrase detection (sentence *pair* classification)

Cross-lingual Natural Language Inference (XNLI) corpus

https://cims.nyu.edu/~sbowman/xnli/

- Textual entailment prediction (sentence *pair* classification)

Cross-lingual Sentiment Classification

Available from: https://github.com/ccsasuke/adan

- Chinese-English cross-lingual sentiment dataset

Part of Speech/ Morphological Tagging

- Part of universal dependencies treebank

  https://universaldependencies.org/

- Contains parts of speech and morphologcal 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"

CoNLL 2002/2003 Language Independent Named Entity Recognition

https://www.clips.uantwerpen.be/conll2002/ner/
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

https://github.com/google-research/xtreme

- 10 different tasks, 40 different languages

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 Items

Tuesday January 25

- **Reading Assignment:**
  Ponti, E.M., O'horan, H., Berzak, Y., Vulić, I., Reichart, R., Poibeau, T., Shutova, E. and Korhonen, A., 2019. Modeling language variation and universals: A survey on typological linguistics for natural language processing. Computational Linguistics, 45(3), pp.559-601.

- **Discussion Question:**
  What are some unique typological features of a language that you know, regarding phonology, morphology, syntax, semantics, pragmatics?

Today

- **Assignment 1 introduction**
- **Code walk**