Learning Meters of Arabic Poems with Recurrent Neural Networks

A step forward for language understanding and synthesis

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A Thesis Presented to the Faculty
of Nile University
In Partial Fulfillment
of the Requirements for the Degree
of Master of Science

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Introduction

But ... What is poetry?

General Definition:

Remark

Poetry is a piece of writing or speaking, which **MUST** follow specific **Patterns**.

Example

ودعْ عنك آراءَ الرجالِ وقولَهم فقولُ رسولِ الله أزكى وأشرحُ

Arabic Prosody العَرُوض

Al-Farahidi (718 – 786 CE) analyzed the Arabic poetry, then he discovered the **Patterns** which is the succession of consonants and vowels.

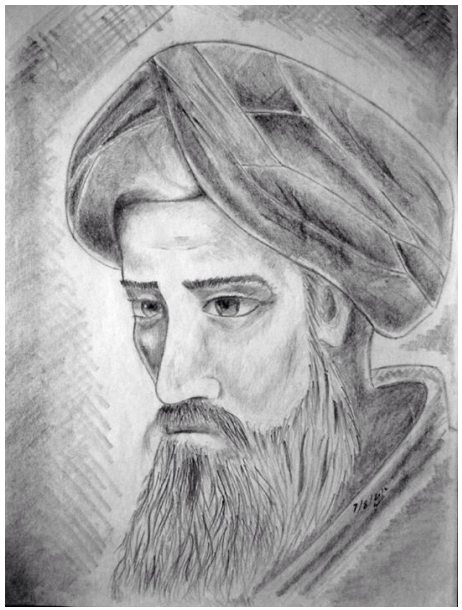

Figure: *Al-Farahidi* [5]

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- A **poem** is a set of verses having the same meter and rhyme.

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- **Shadaa** indicates the letter is doubled ◌ّ.
- **Tanween** *harakah* and *Noon* letter with consonant to the end of the word. It sounds /n/.

Arabic Prosody العَرُوض

- A **foot**(*tafa'ilah* التفعيلة) : is an **ordered** sequence of vowels and consonants. It is the basic units of meters
- **Meter** البحر: is an **ordered** sequence of feet.

Feet	Scansion
فَعُولُنْ	0/0//
فَاعِلُنْ	0//0/
مُسْتَفْعِلُنْ	0//0/0/
مَفَاعِيلُنْ	0/0/0//
مَفْعُولَاتُ	0//0///
فَاعِلَاتُنْ	0/0//0/
مُفَاعَلَتُنْ	0///0//
مُتَفَاعِلُنْ	0//0///

Example

وَمَنْ دَعَا النَّاسَ إِلَى ذَمِّهِ ذَمُّوهُ بِالْحَقِّ وَبِالْبَاطِلِ

ومن دعَ نْ ناس إِلَى ذَمْمِهِى ذَمُوهُ بِلْ حَقْقِ وبِلْ باطِلِ

0//0// 0//0/ 0//0/0/ 0//0/0/ 0//0/

مُتَفْعِلُنْ مُسْتَعِلُنْ مَفْعُلا مُسْتَفْعِلُنْ مُسْتَعِلُنْ مَفْعُلا

Meter Name	Meter *feet combination*
al-Wafeer	مُفَاعَلَتُنْ مُفَاعَلَتُنْ فَعُولُنْ
al-Taweel	فَعُولُنْ مَفَاعِيلُنْ فَعُولُنْ مَفَاعِلُنْ
⋮	⋮
al-Moktadib	مَفْعُولَاتُ مُسْتَفْعِلُنْ مُسْتَفْعِلُنْ
al-Modar'e	مَفَاعِيلُنْ فَاعِلَاتُنْ مَفَاعِيلُنْ

Thesis Working Steps.

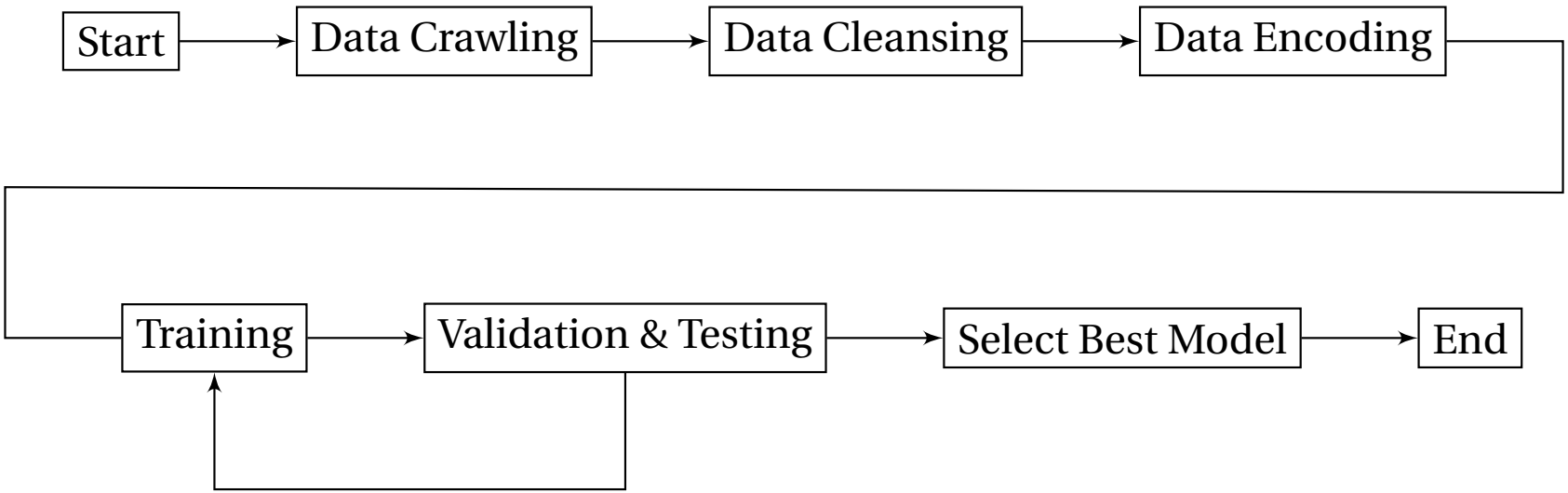

Figure: Thesis Working Steps.

Literature Review

Detecting Arabic poems meters

Deterministic Approach

There is some literature on recognizing the meters of written Arabic poem using rule-based deterministic algorithms

Machine Learning Approach

Learning and classifying poems to the right meter has not been addressed before!

Deterministic Approach

- **Abuata and Al-Omari [1]:**

Deterministic Approach

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  - Deterministic Algorithm
    1. Getting the input, carrying full diacritics.
    2. Metrical scansion rules are applied to the Arud writing. 0/0/..
    3. Grouping zero and ones to feet تفعيلات.
    4. A class is assigned to the input.

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  - **Results**: 82.2% of 417 verses.
- **Alnagdawi et al [2]**, similar approach; Context-Free Grammar; 75% correctly classed from 128.

Our point of departure

Issues;

- Dataset size.
- Accuracies: (75%, 82%) tested on (128, 417) verses respectively.
- Diacritics are a must.
- Converting verses into Al-Arud writing style is probabilistic.
- For detecting meters, all models are so **naive and primitive**. They do no have any clue about the real pattern.

Our Approach

- We present:
  1. Machine Learning approach.

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Datasets Design

Dataset

Our dataset consists of **1,722,321** labeled data points.

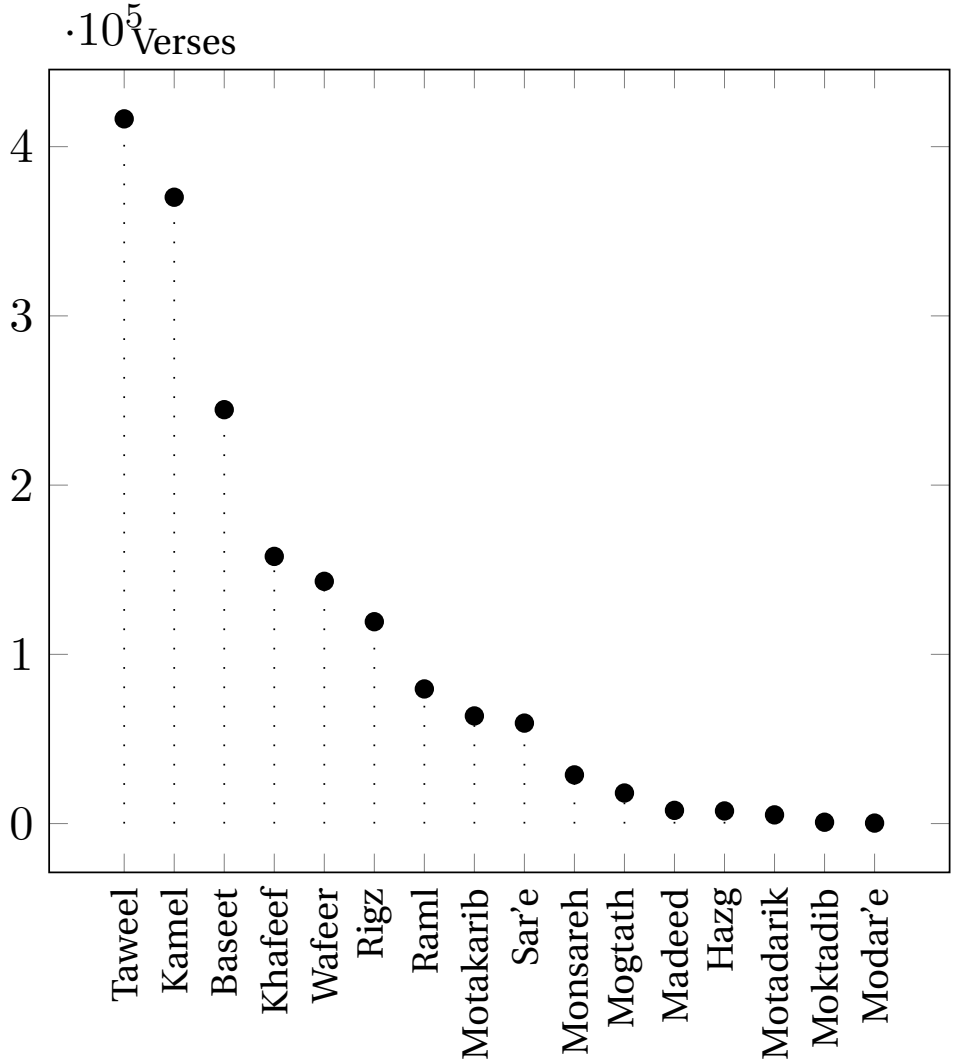


Figure: Number of verses per *meter* ordered descendingly on y-axis vs. meter name on x-axis.

Dataset

Basic cleansing rules:

- Filtering the 16 classic meters.
- Removing many unnecessary white spaces.
- Removing non-Arabic characters.
- Factoring Shadaa and Tanween.

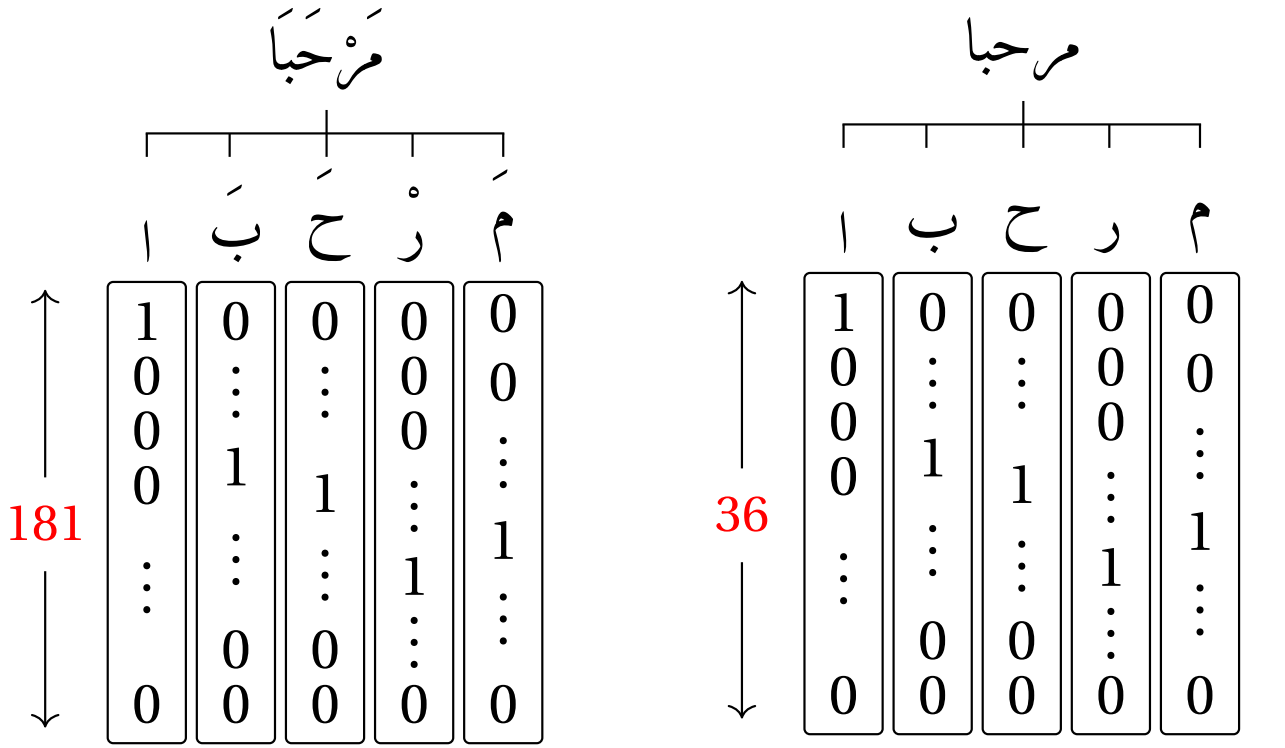
Diacritics	*With Shadda*	*Without shadaa*	*With tanween*	*Without tanween*
Shape	دَّ	دْدَ	دً	دَ+نْ

Table: Diacritics on the letter د

Data Representation

An Issue:

- Diacritics are standalone characters!
  - `len` مرحبا $\neq$ `len` مَرْحَبًا
  - We have represented the letter and its diacritic as a one character.



(a) *With Diacritics* (b) *Without Diacritics*

Figure: Example of *One-hot* encoding for Arabic word (مرحبا).

Encoding Techniques

1. One-Hot
2. Binary
3. Two-Hot (new technique)

Encoding Techniques

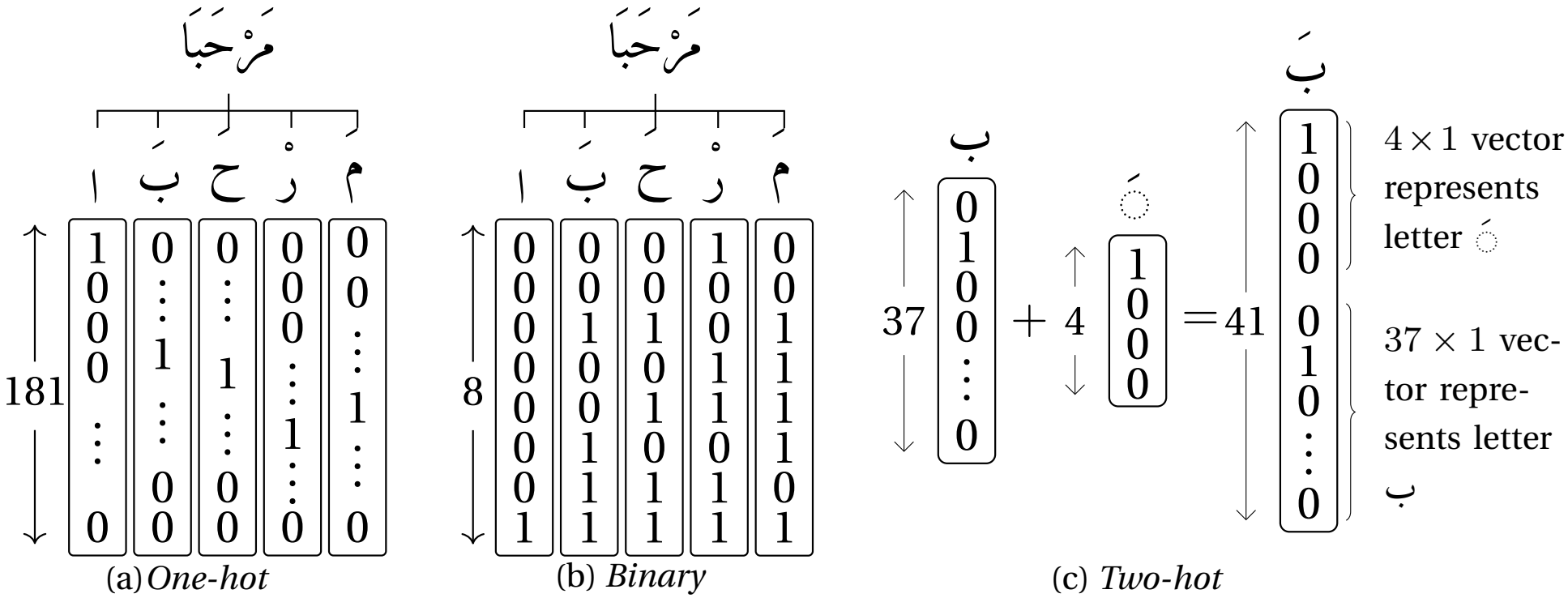


Figure: Different encoding mechanisms

Training and Architecture

Which Network!

- **Pattern**: is a sequence of characters.
- Unlike feedforward neural networks, RNNs can use their internal state (memory) to process sequences of inputs.
- In theory, RNNs are capable of handling long-term dependencies. However, in practice they do not, due to the exploding gradient problem
- LSTMs was designed to solve the long-term dependency problem using internal memory gates.

RNN, Architectures

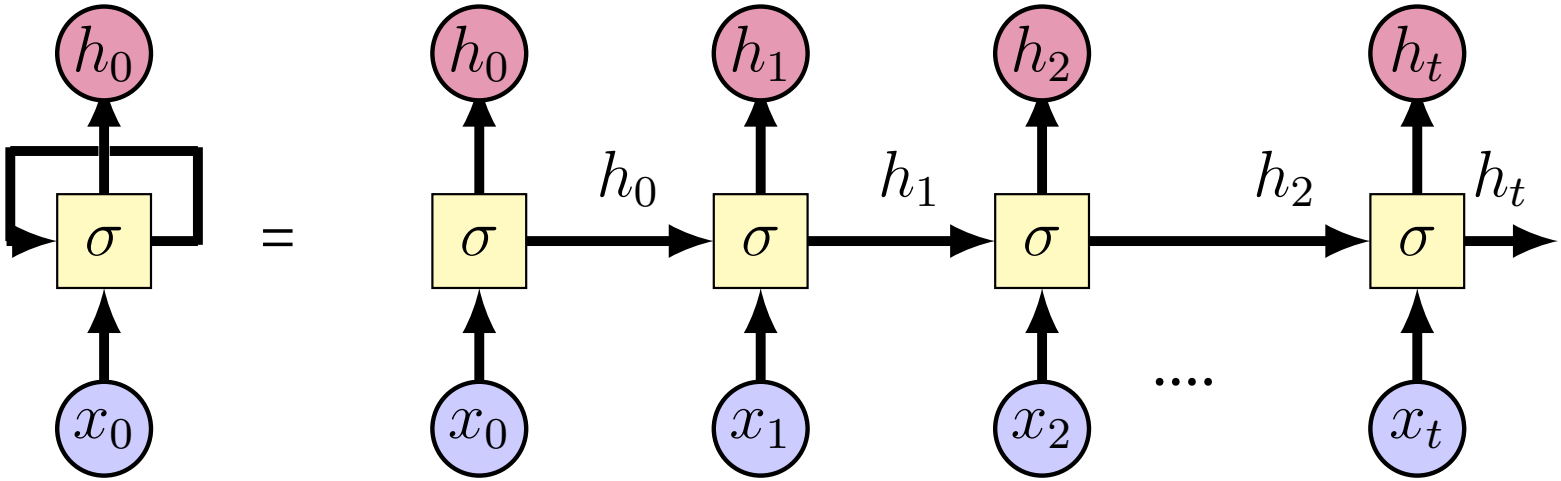


Figure: Recurrent Neural Networks Loops adapted from [3]

RNN, Architectures

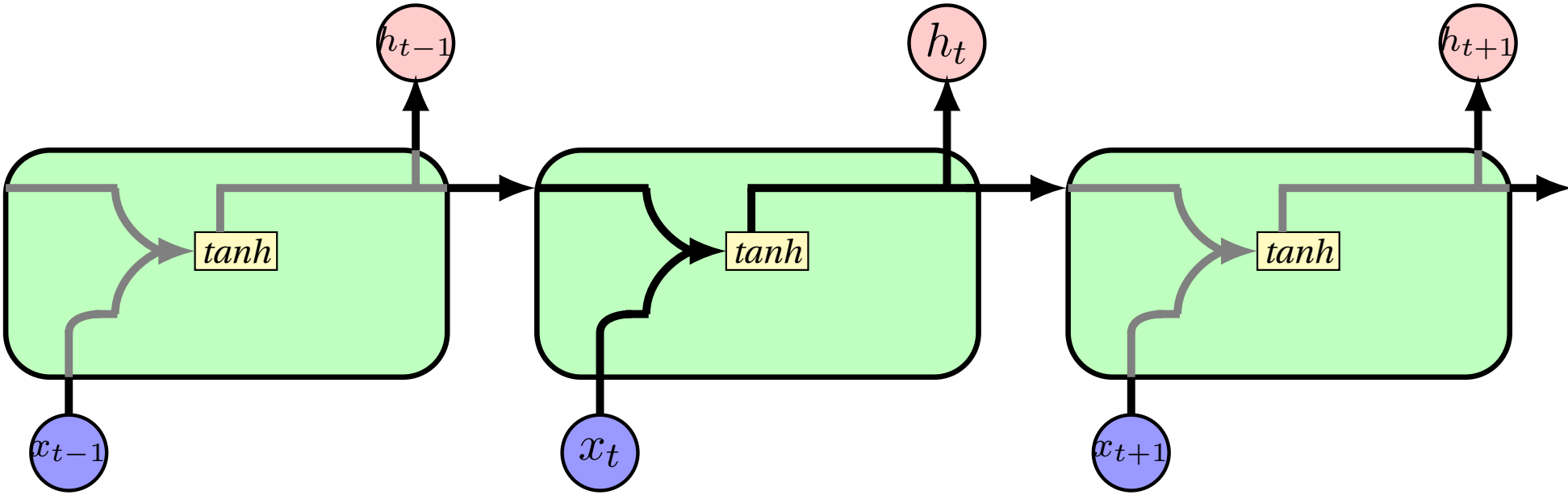


Figure: A single recurrent layer adapted from [3]

LSTM Architectures

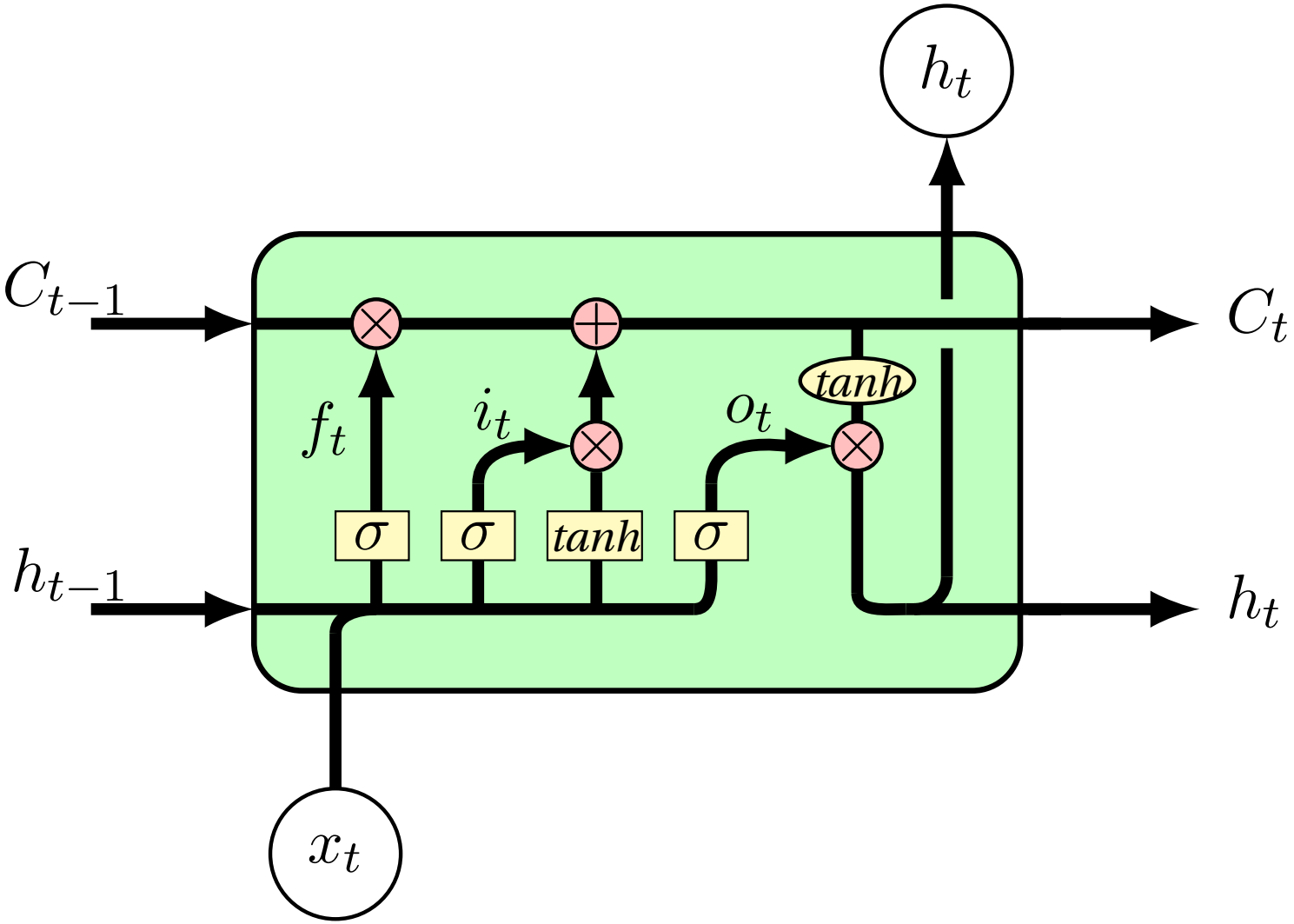


Figure: LSTM internal cell adapted from [3]

LSTM Architectures

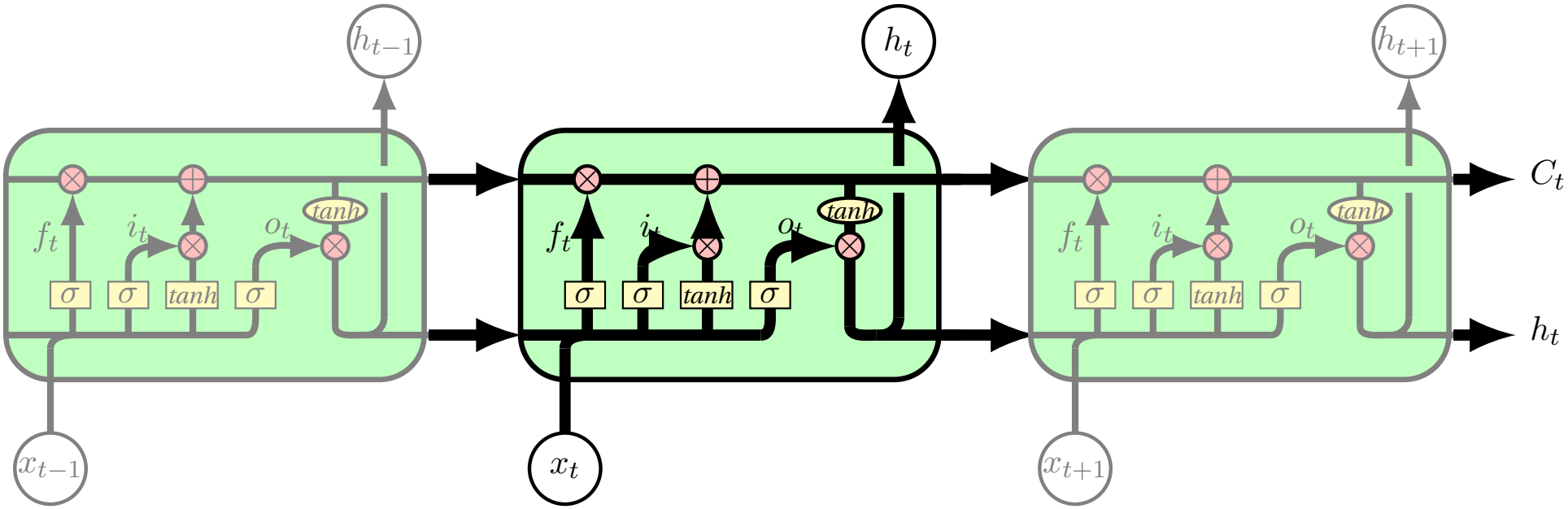


Figure: Unfold LSTM adapted from [3]

LSTM Architectures

Bi-LSTM Motivation

- ***Harry*** is the king, and he will travel next week.
- The new book which makes the big sale is named ***Harry*** Potter.

- Bi-LSTM models always outperform LSTM models.
- It means that models can't learn the pattern from one direction, it should be two directions together.

LSTM Architectures

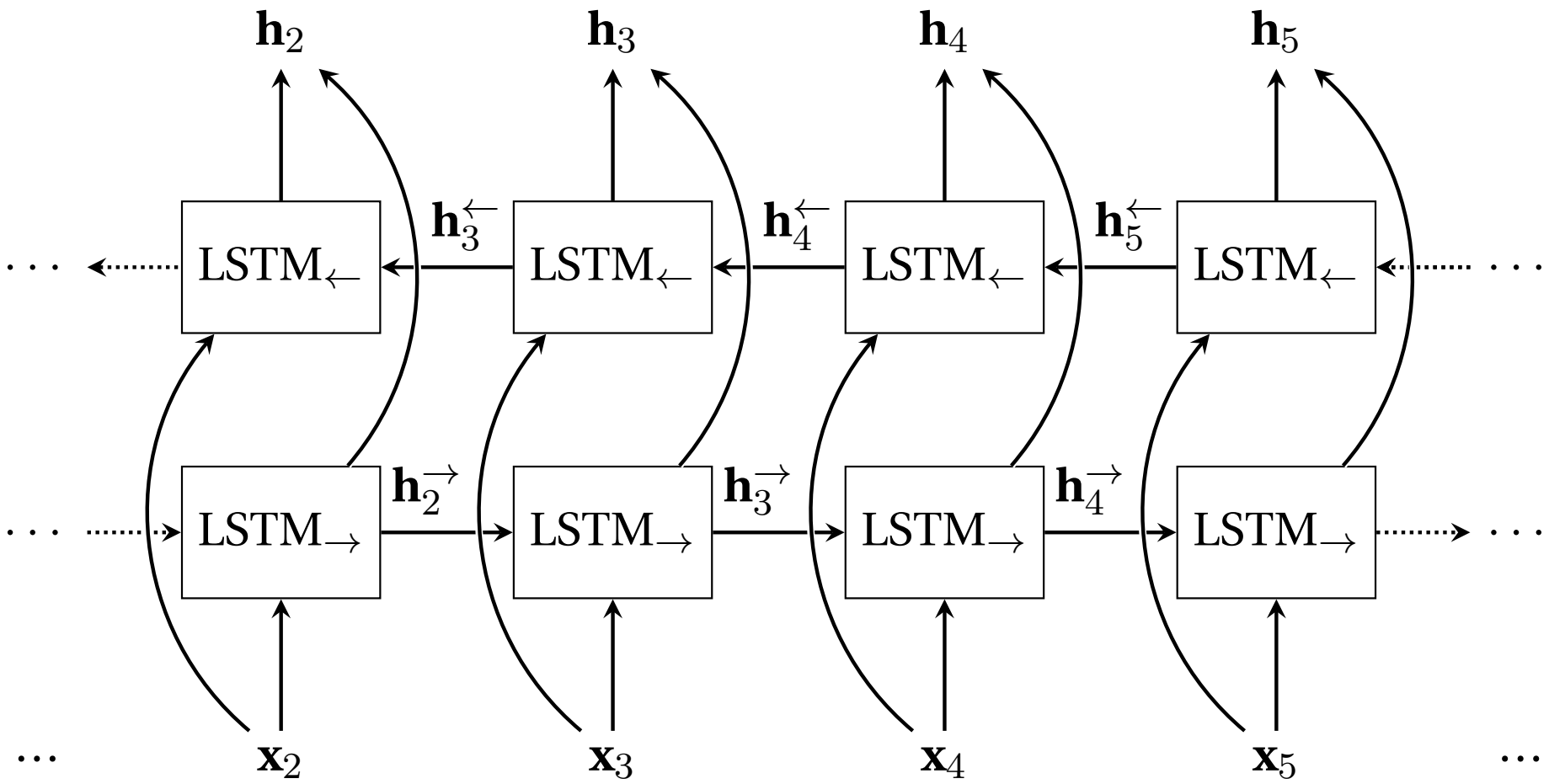


Figure: bidirectional long short-term memory [4]

Experiments and Results

Experiments Parameters

- **Dataset Configurations**:
  - Encoding technique: BinE, OneE, TwoE.
  - Diacritics: 0D, 1D.
  - Trimming: 0T, 1T.
- **Network Configurations**:
  - Loss functions: *Weighted* or *Non-Weighted* **(1, 0)** respectively.
  - The number of layers: nL.
  - The number of cell units: nU.
  - Cell type: LSTM, Bi-LSTM.

Overall Accuracy!

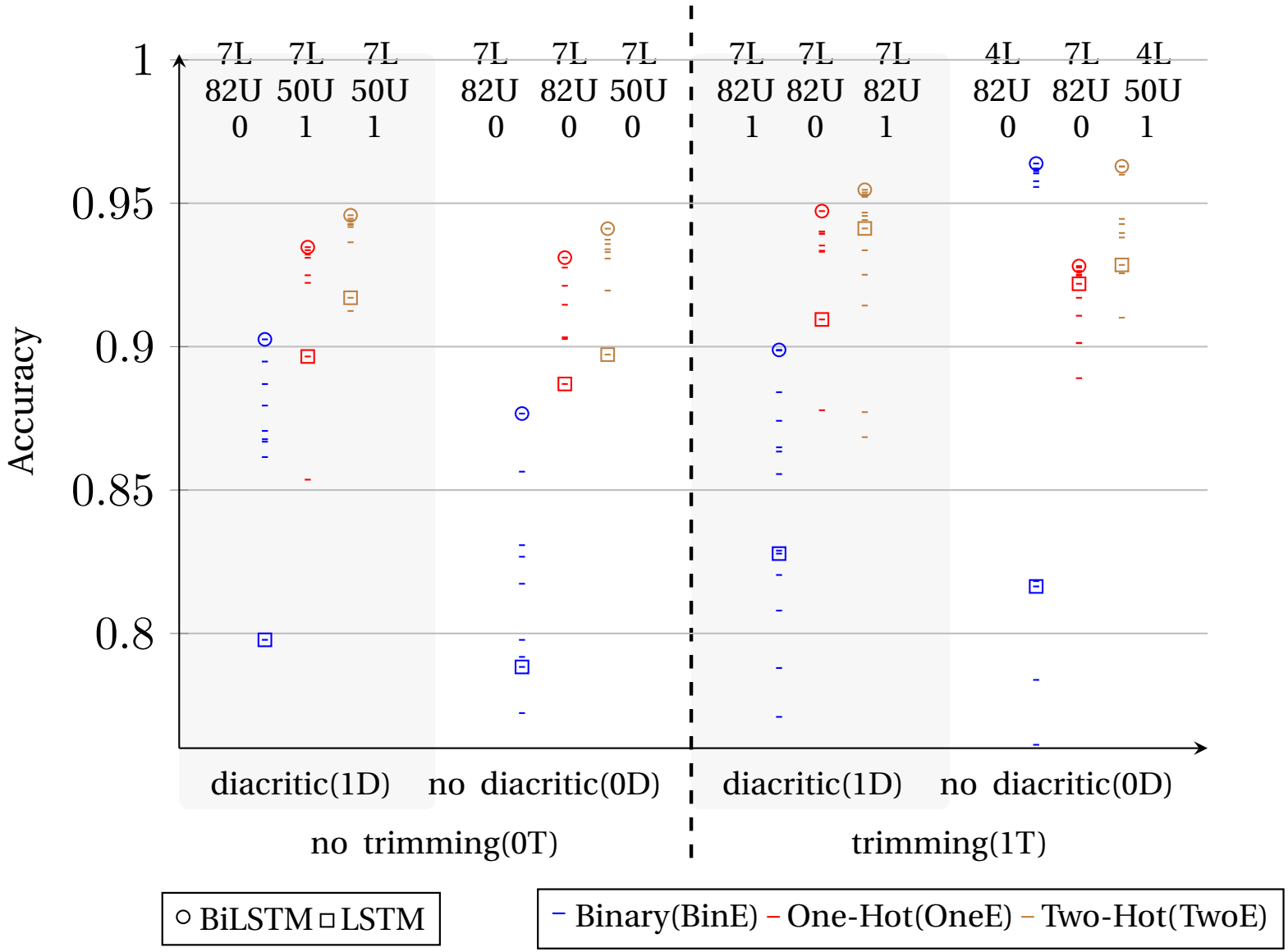


Figure: Overall accuracy of the 192 experiments

Comparison with related works

Ref.	Accuracy	Test Size
[2]	75%	128
[1]	82.2%	417
This article	96.38%	150,000

Table: Overall accuracy of this article compared to literature.

Discussions

Per-class Accuracy!

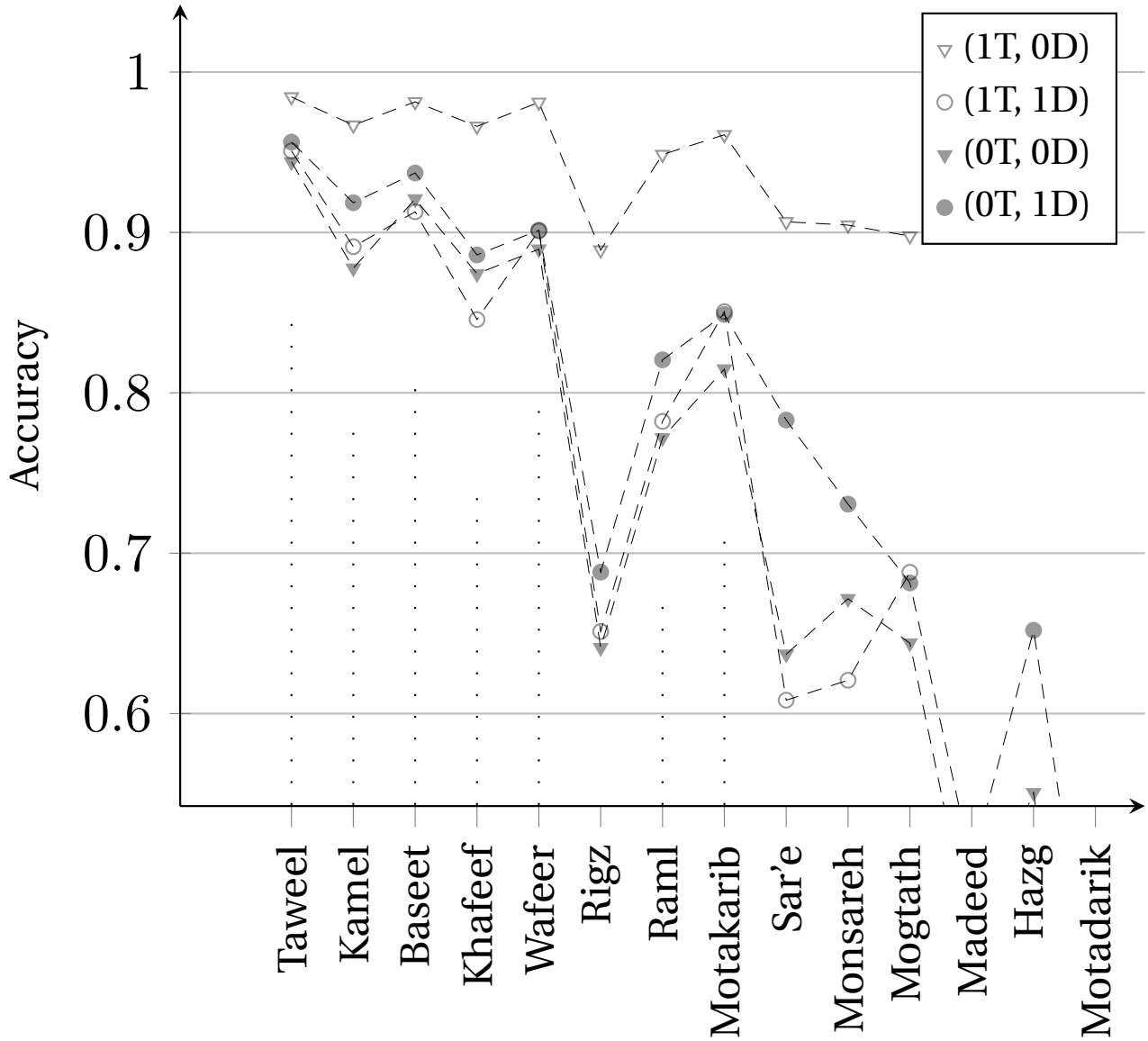


Figure: The per-class accuracy score of the best four models.

Encoding effect

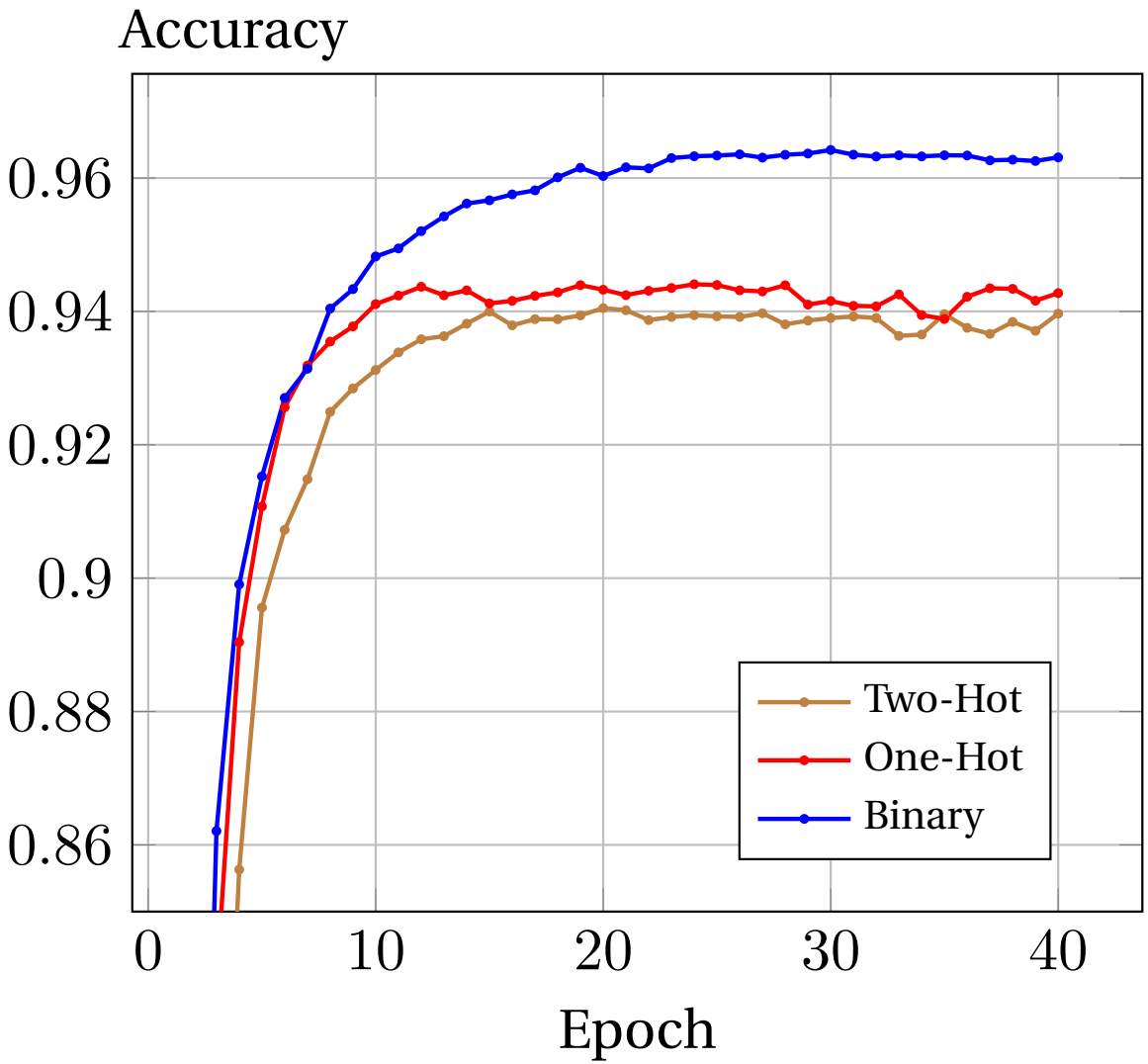


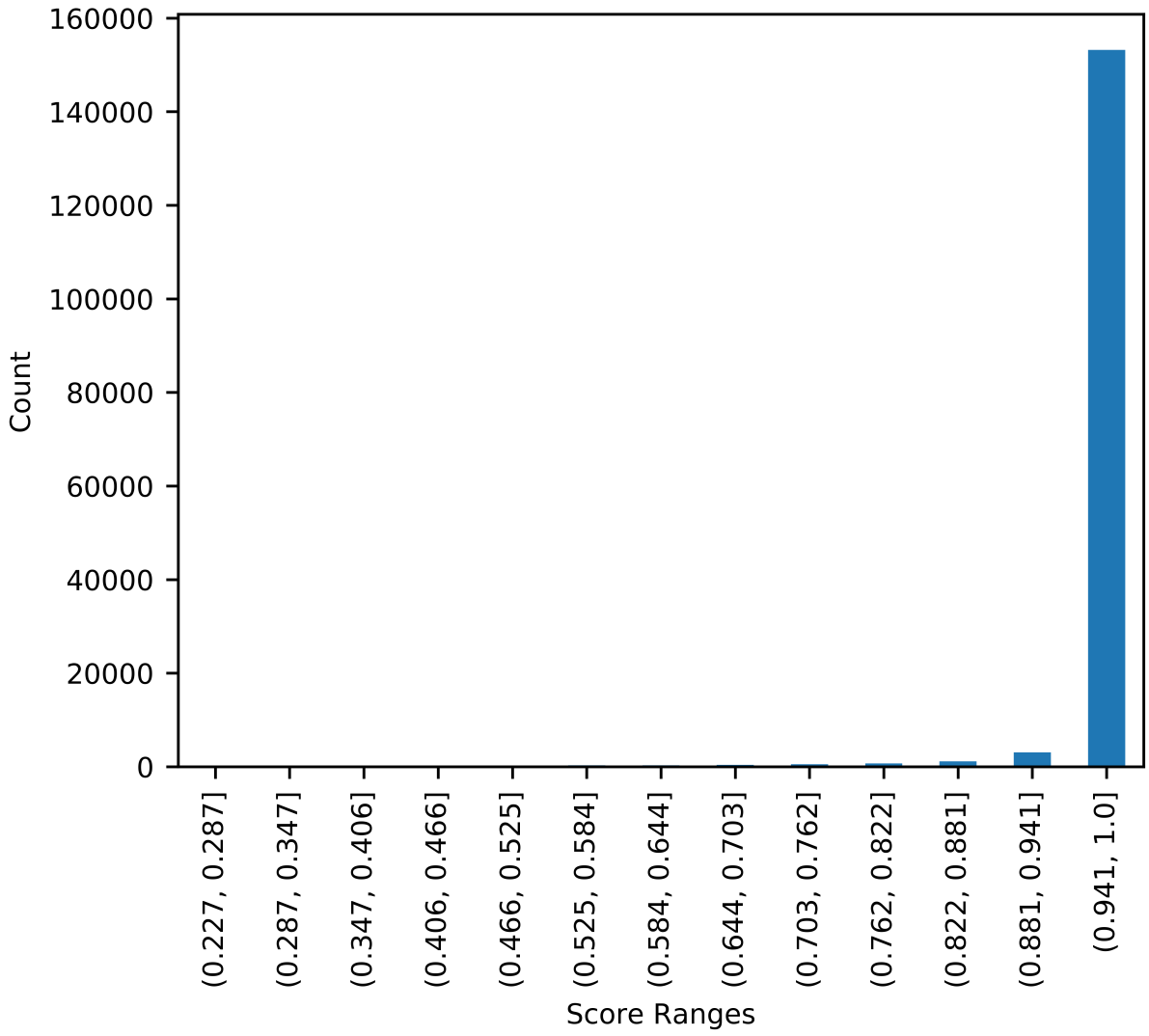
Figure: Encoding effect on Learning rate with the best model (1T, 0D, 4L, 82U, 0W, BinE) and when using the two other encodings instead of BinE.

Encoding effect

Encoding

- The encoding method is a transformer function $\mathcal{T}$ which transform a discrete input values X.
- If the network η_1 is the most accurate network which can "decode" $\mathcal{T}(X)$.
- If we have another encoding function $\mathcal{T}_2$ and we tried to use the same network η_1 for the $\mathcal{T}_2$ as $\eta_1\left(\mathcal{T}_1(X)\right) = \left(\eta_1 \cdot \mathcal{T}_1 \cdot \mathcal{T}_2^{-1}\right)\left(\mathcal{T}_2(X)\right)$. This network may be of complicated architecture to be able to "decode" a terse or complex pattern $\mathcal{T}_2(X)$.

Classifying Arabic Non-Poem Text



;

Figure: Testing data score ranges distribution.

Classifying Arabic Non-Poem Text

خلال	المباراة	التي	جمعتهما	مساء السبت بالجولة	الـ26 من المسابقة
خلالَلْ	مباراتل	لتيج	معتهما	مساءَسْ سبتبلجو	لتلمنل مسابقه
0/0//	0/0/0//	/0//	0//0//	0/0/// 0/0/0//	0//0// 0//0//
0/0//	0/0/0//	/0//	0//0///	0/0/// 0/0/0//	0//0// 0//0//
فَعُولُنْ	مَفَاعِيلُنْ	فَعُولُ	مَفَاعِلُنْ	فَعُولُنْ مَفَاعِيلُنْ	فَعُولُنْ مَفَاعِيلُنْ

Questions!

Questions.


Abuata, Belal and Al-Omari, Asma
A Rule-Based Algorithm for the Detection of Arud Meter in Classical Arabic Poetry
International Arab Journal of Information Technology. (2017), 15.


Alnagdawi, Mohammad and Rashaideh, Hasan and Aburumman, Ala
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Petar Veličković
Collection of Latex Tikz figures
https://github.com/PetarV-/TikZ.


Ibrahim Osman
https://goo.gl/ZJySa8.