Learning Meters of Arabic Poems with Recurrent Neural Networks

A step forward for language understanding and synthesis

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of Master of Science

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Introduction

But ... What is poetry?

Definition

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

Example

وُلِدَ الهُدى فَالكائِناتُ ضِياءُ وَفَمُ الزَمانِ تَبَسُّمٌ وَثَناءُ

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.

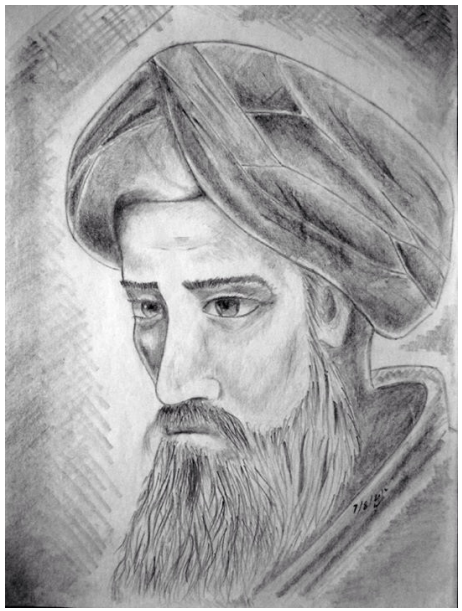

Figure: *Al-Farahidi*

figure taken from `https://goo.gl/ZJySa8`.

Arabic Prosody العَرُوض

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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

وَمَنْ دَعَا النَّاسَ إِلَى ذَمِّهِ			ذَمُّوهُ بِالْحَقِّ وبِالْبَاطِلِ		
وَمَنْ دَعَ نَـ	نَاسَ إِلَى	ذَمْمِهِي	ذَمُّوهُ بِلْـ	حَقْقِ وبِلْـ	بَاطِلِي
0//0//	0////0/	0//0/	0//0/0/	0///0/	0//0/
مُتَفْعِلُنْ	مُسْتَعِلُنْ	مَفْعُلا	مُسْتَفْعِلُنْ	مُسْتَعِلُنْ	مَفْعُلا

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

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

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///

Thesis Working Steps.

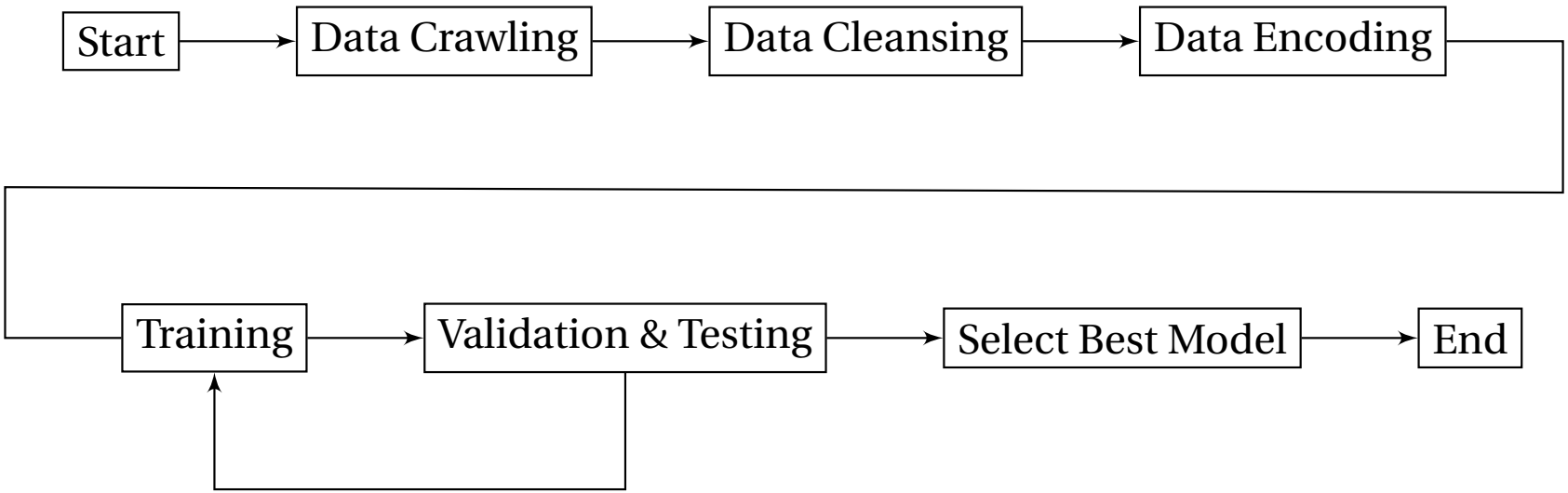

Figure: Thesis Working Steps.

Literature Review

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

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

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  - Deterministic Algorithm
    1. Getting the input, carrying full diacritics.
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  - **Results**: 82.2% of 417 verses.
- **Alnagdawi et al [2]**, similar approach; Context-Free Grammar; 75% correctly classed from 128.

Machine Learning approach: Our point of departure

- Dataset issues:

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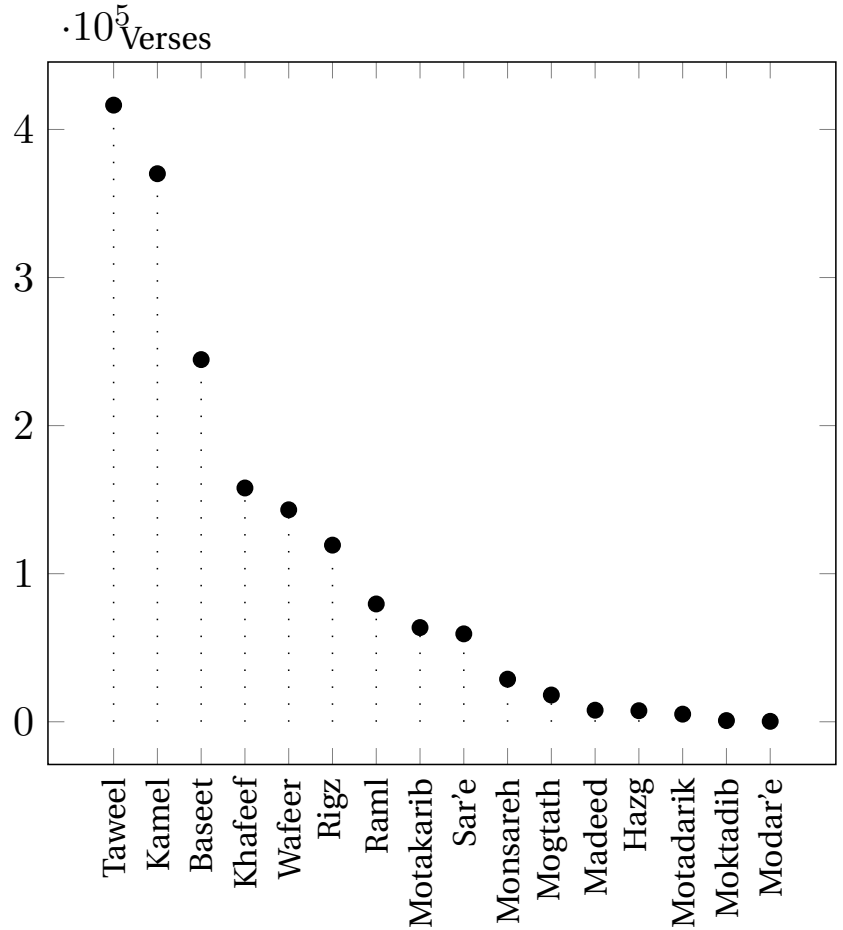
  - Accuracies: (75%, 82%) tested on (128, 417) verses respectively.
  - Encoding technique.

Datasets Design

Dataset acquisition and cleansing

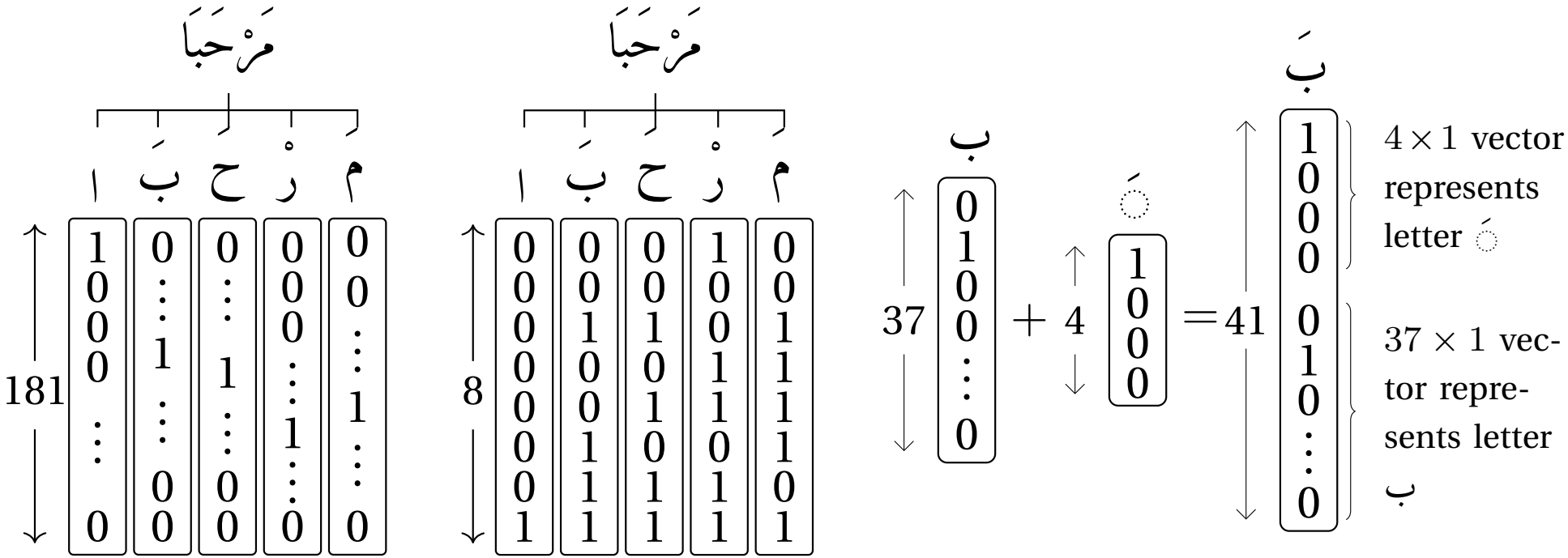
- **1,722,321** labeled data points.
- We have scrapped the Arabic datasets from الديوان [?], الموسوعة الشعرية [?].
- Basic cleansing rules:
  - Filtering the 16 classic meters.
  - Removing unnecessary spaces.
  - Removing non-Arabic characters.
  - Factoring Shadaa and Tanween.



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

Data Representation

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



(a) *One-hot* (b) *Binary* (c) *Two-hot*

Figure: Different encoding mechanisms

Network Architecture and Training

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

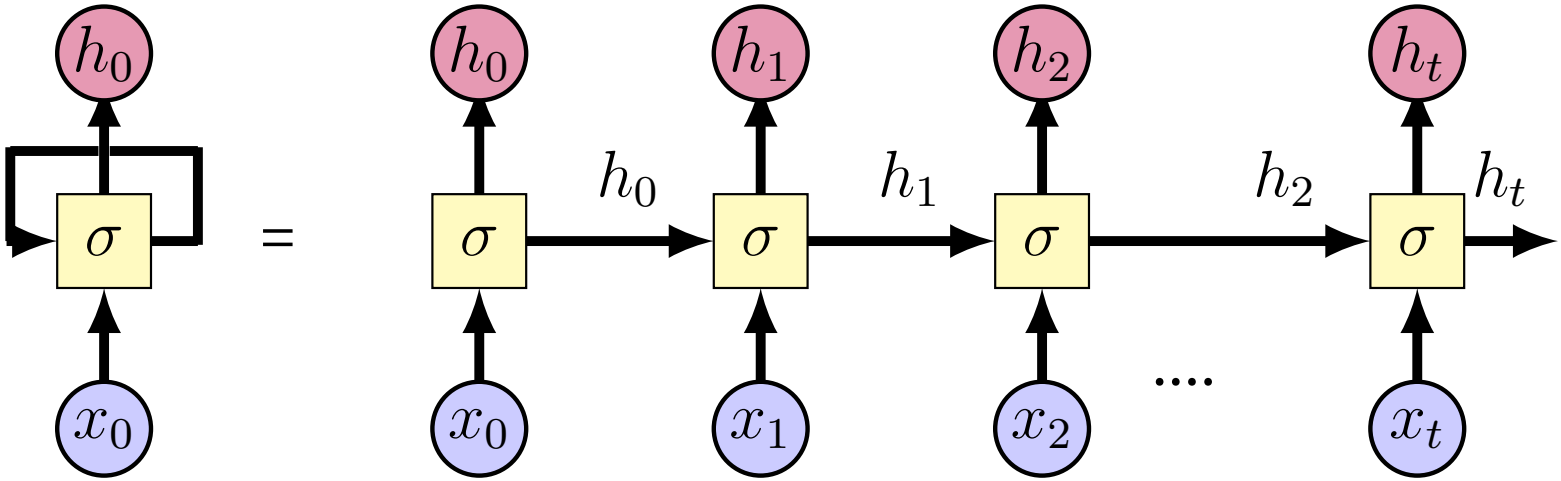


Figure: Recurrent Neural Networks Loops adapted from [3]

RNN, Architectures

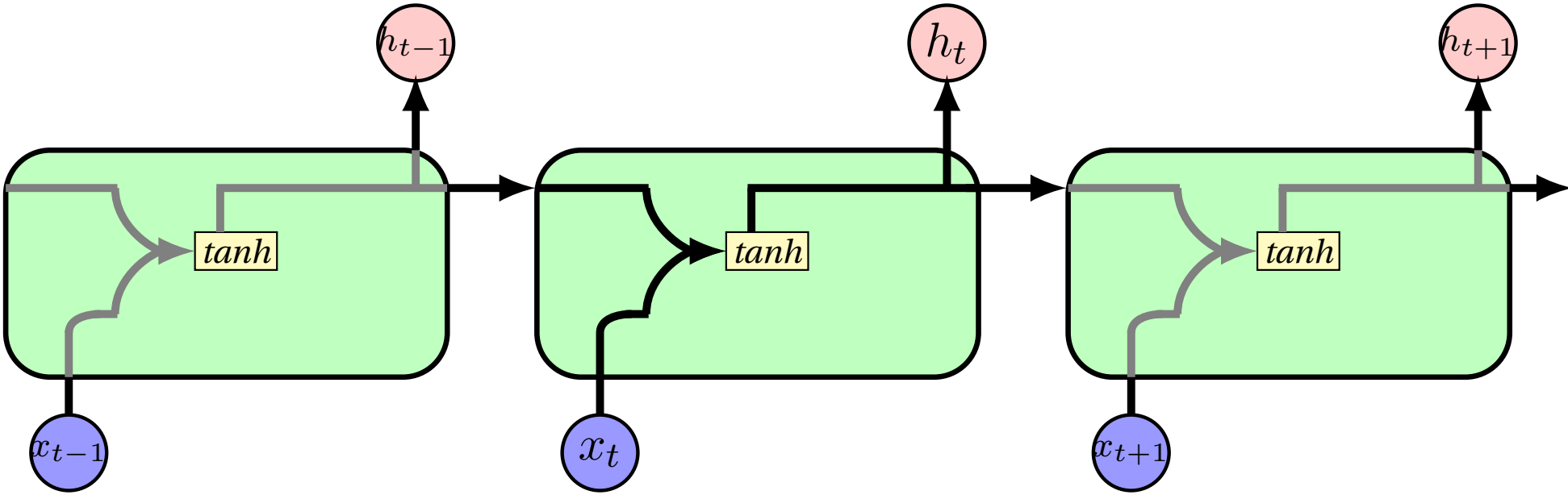


Figure: A single recurrent layer adapted from [3]

LSTM Architectures

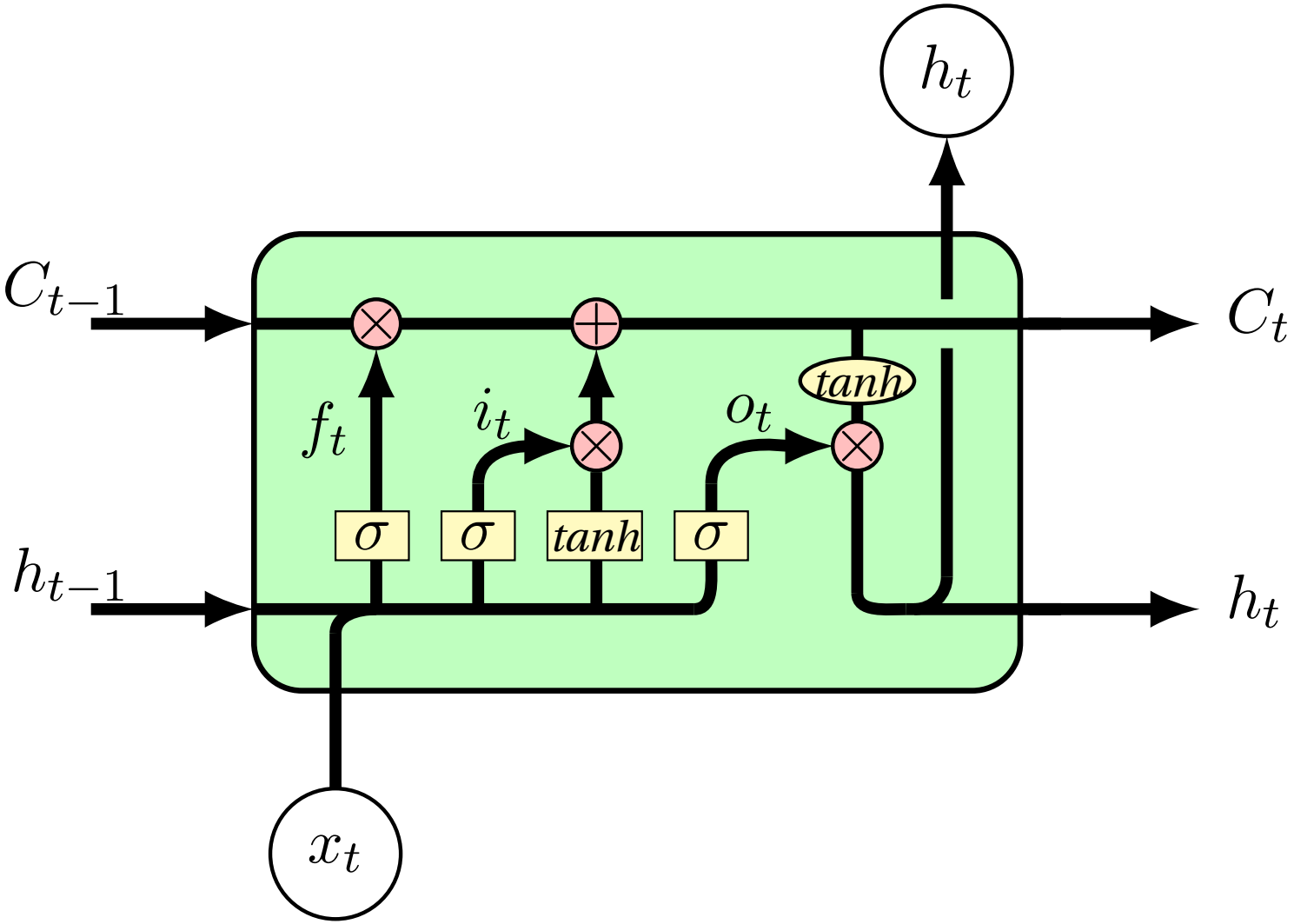


Figure: LSTM internal cell adapted from [3]

LSTM Architectures

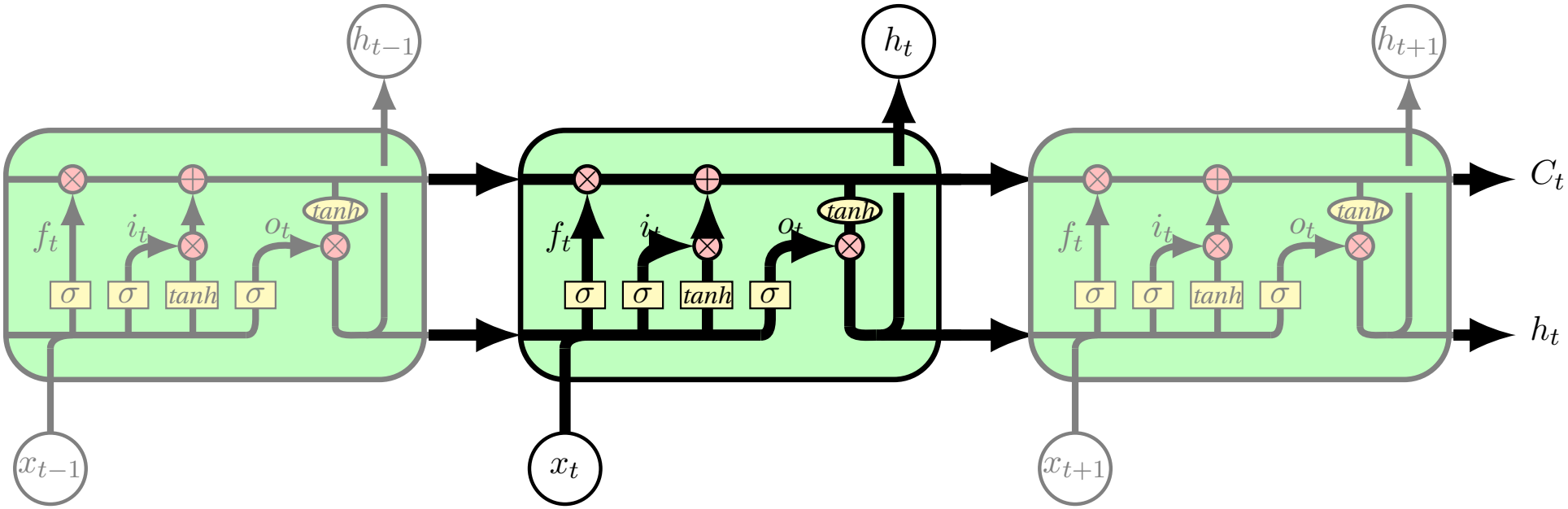


Figure: Unfold LSTM adapted from [3]

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

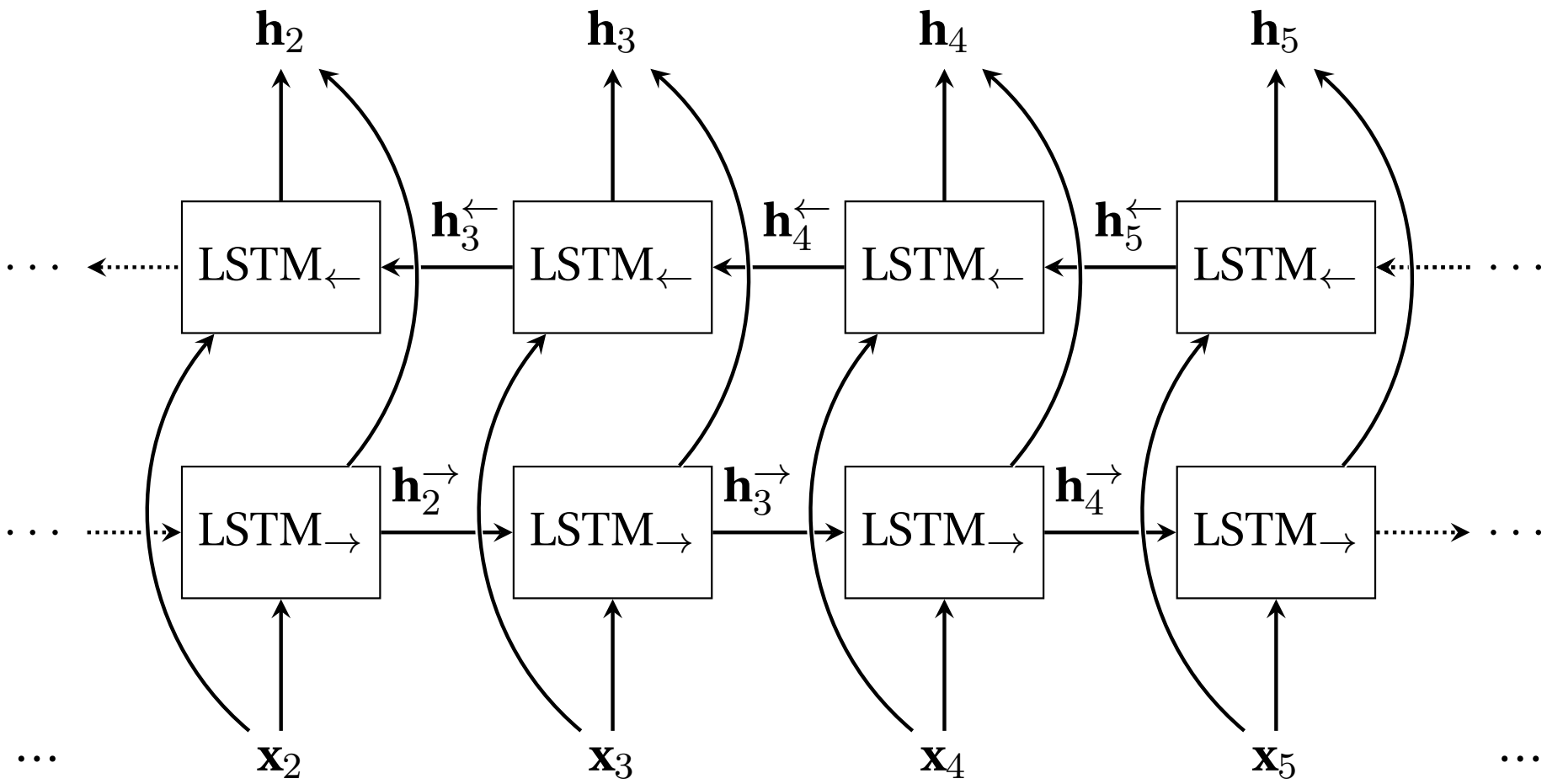


Figure: bidirectional long short-term memory [4]

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!

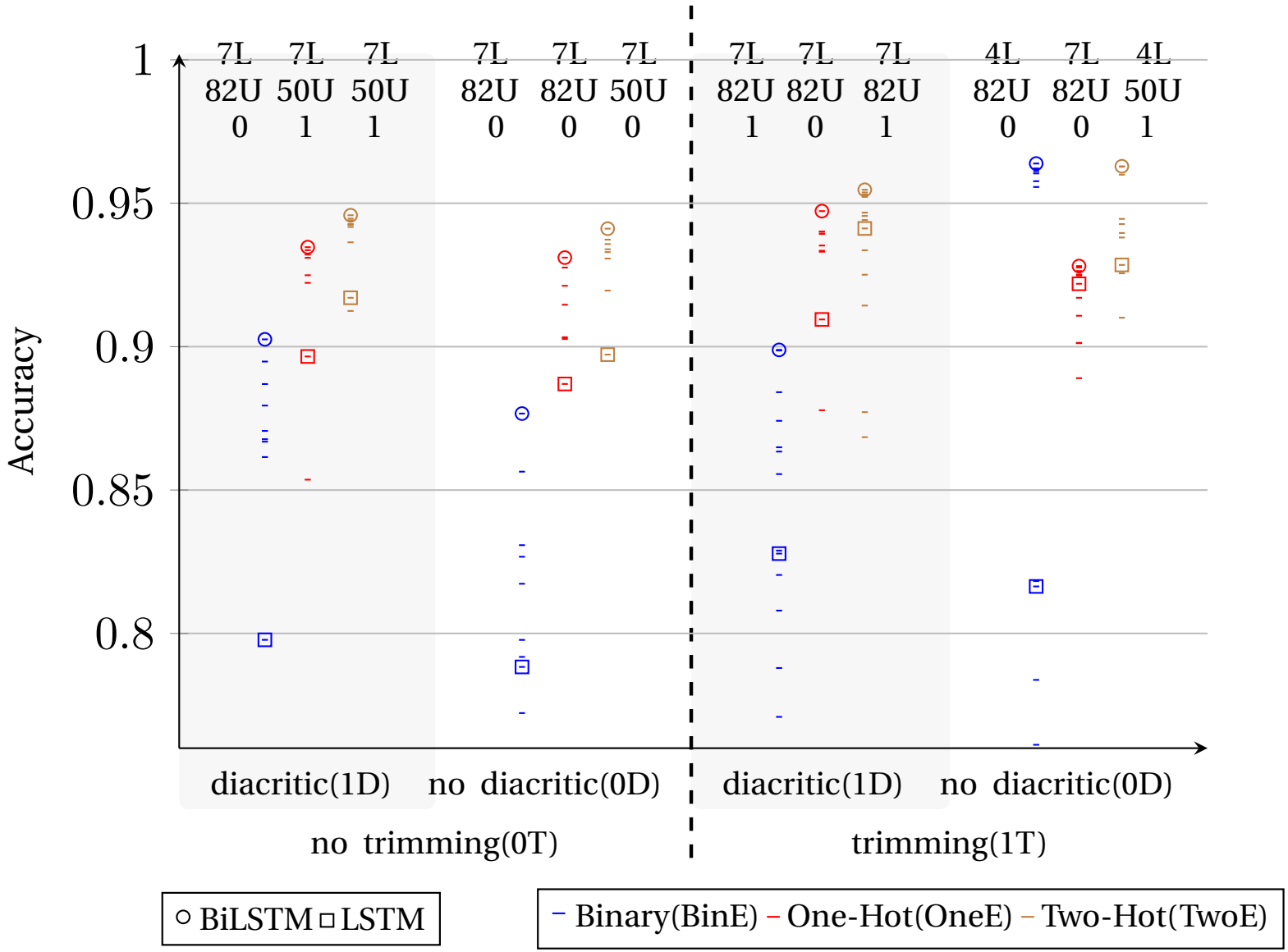


Figure: Overall accuracy of the 192 experiments

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.

Per-class Accuracy!

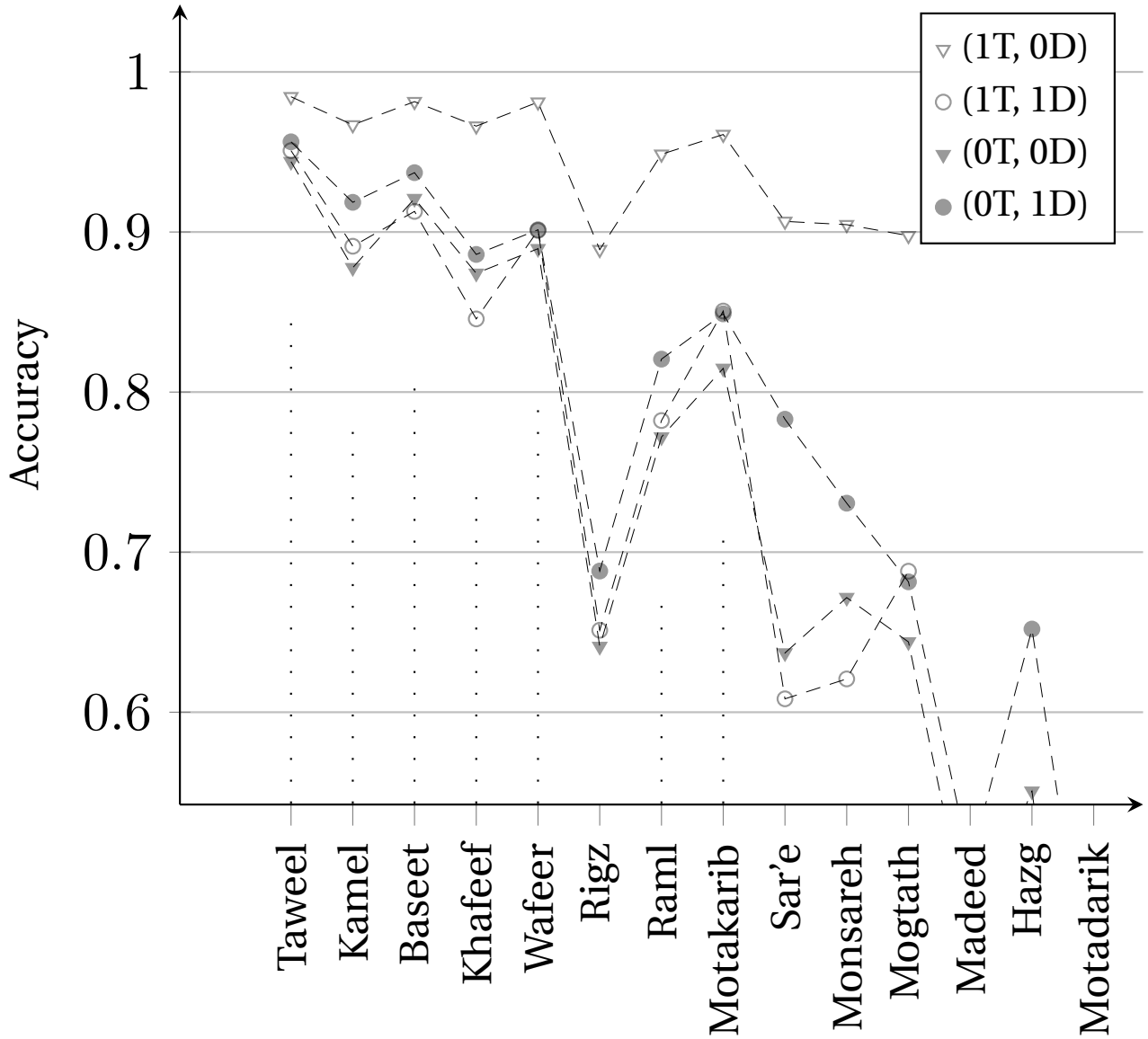


Figure: The per-class accuracy score of the best four models.

Discussions

Encoding effect

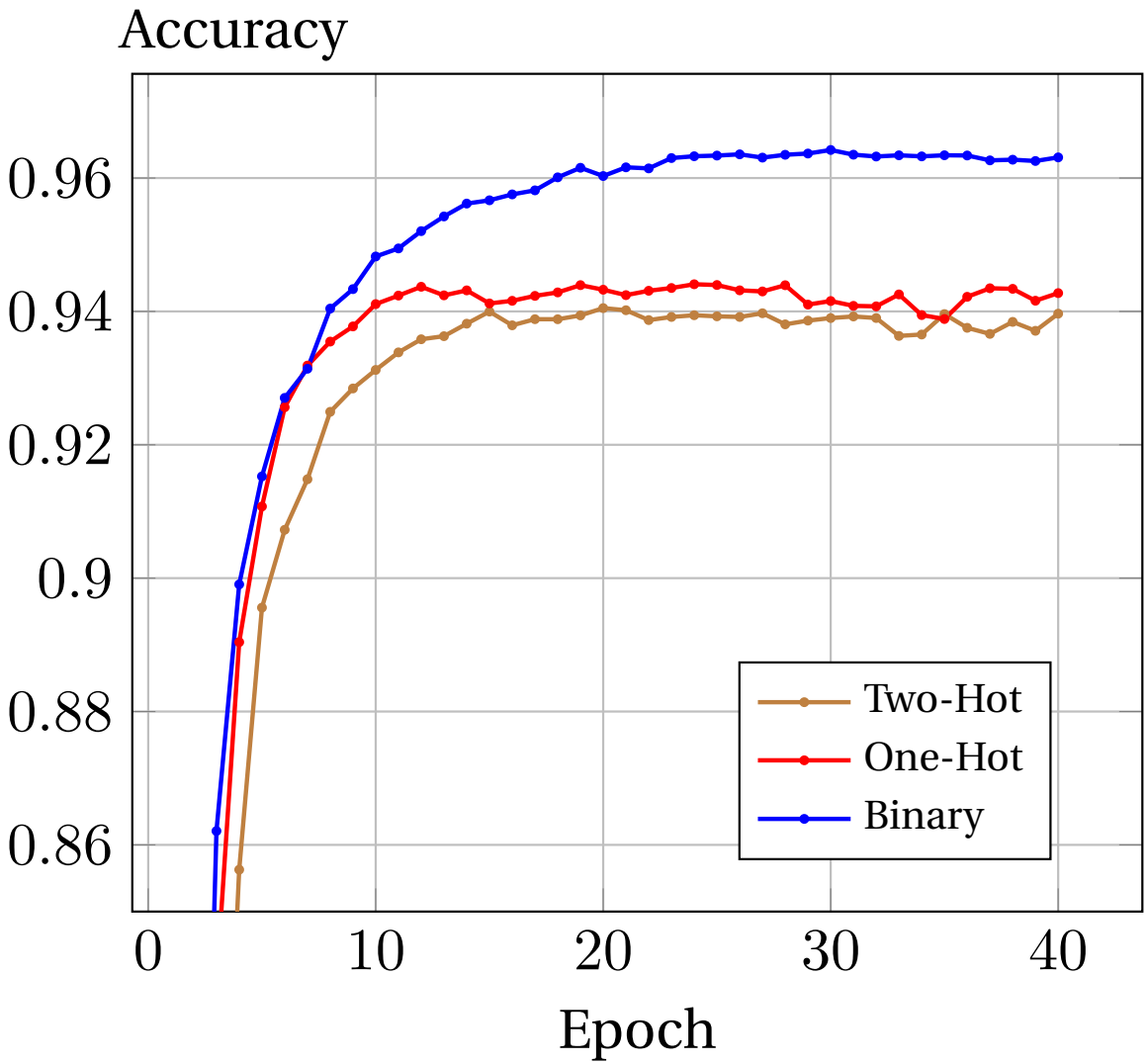


Figure: Encoding effect on Learning rate with the best model (1T, 0D, 4L, 82U, 0W, BinE) and when using the two other encodings instead of BinE.

Encoding effect

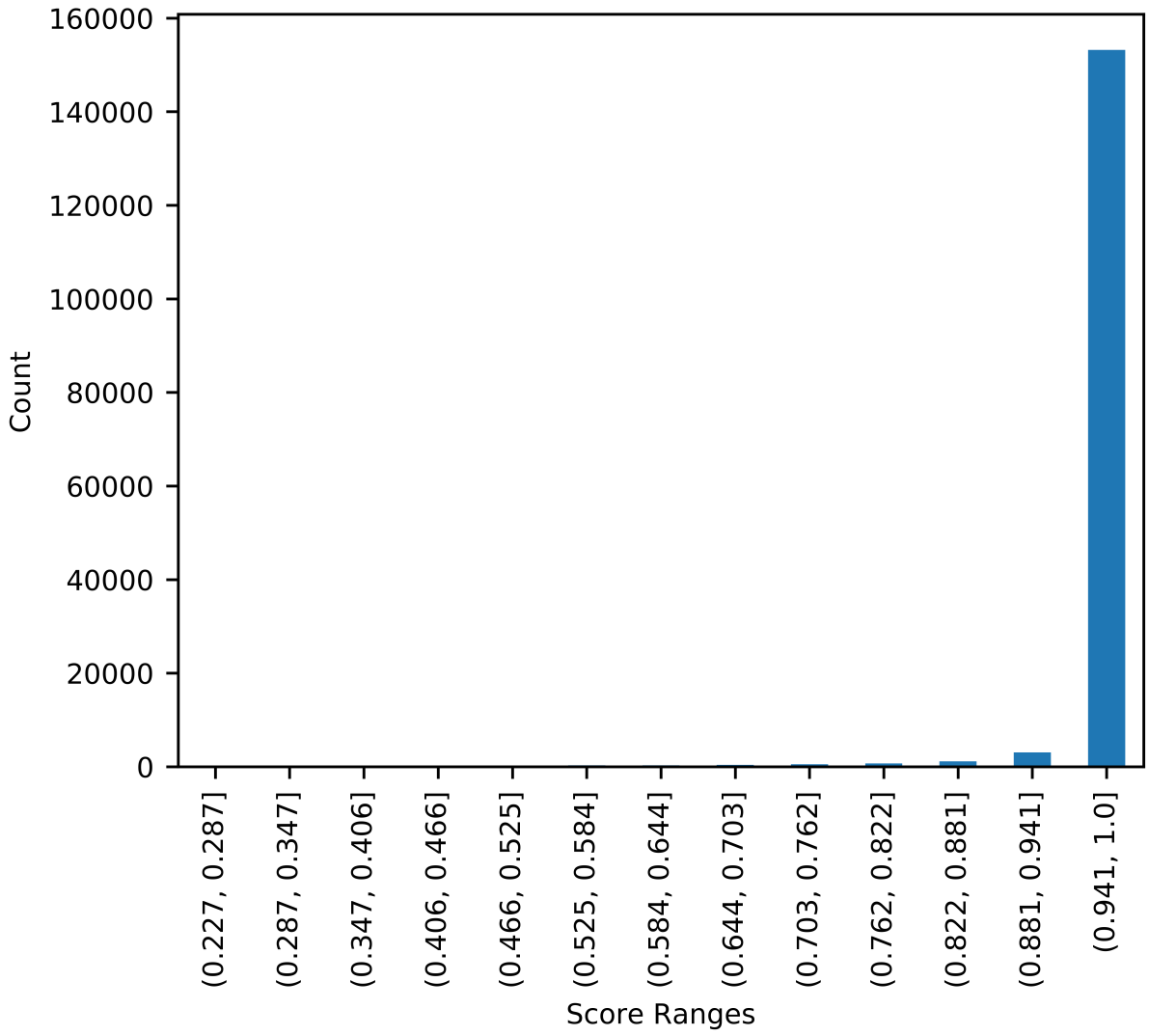
Encoding

- 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

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//
فَعولُنْ	مَفاعِيلُنْ	فَعولُ	مَفاعِلُنْ	فَعولُنْ مَفاعِيلُنْ	فَعولُنْ مَفاعِيلُنْ

Classifying Arabic Non-Poem Text



;

Figure: Testing data score ranges distribution.


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
Finding Arabic Poem Meter Using Context Free Grammar
J. of Commun. & Comput. Eng. (2013), 3, 52-59.


Colah
Understanding Lstm Networks
http://colah.github.io/posts/2015-08-Understanding-LSTMs/ , 2015.


Petar Veličković
Collection of Latex Tikz figures
https://github.com/PetarV-/TikZ.

Questions!

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