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 Information Technology and Computer Science
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In Partial Fulfillment
of the Requirements for the Degree
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

إِذَا لَمْ تَخْشَ عَاقِبَةَ اللَّيَالِي وَلَمْ تَسْتَحْيِ فَاصْنَعْ مَا تَشَاءُ

إِذَا لَمْ تَخْ	شَ عَاقِبَةَ لَ	لَيَالِيْ	وَلَمْ تَسْتَحْ	يِ فَصْنَعْ مَا	تَشَاءُوْ
0/0/0//	0/0/0//	0/0//	0/0/0//	0/0/0//	0/0//
مُفَاْعَلَتْنْ	مُفَاْعَلَتْنْ	مُفَاْعَلْ	مُفَاْعَلَتْنْ	مُفَاْعَلَتْنْ	مُفَاْعَلْ

Arabic Prosody العَرُوض

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

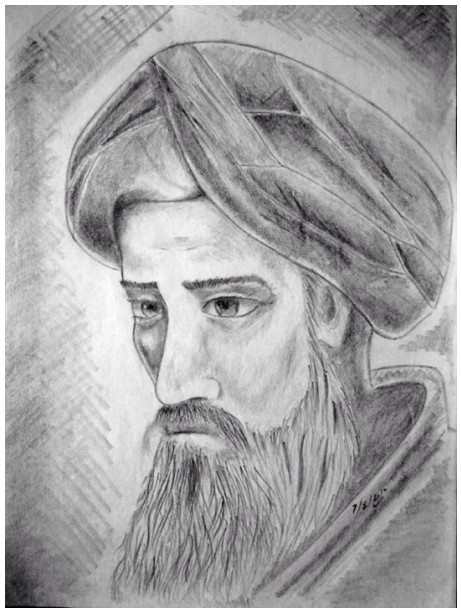

Figure: *Al-Farahidi*

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

Arabic Prosody العَرُوض

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

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

Arabic Prosody العَرُوض

- 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 مَفْاعَلْ
al-Taweel	فَعُوْلُنْ مَفَاْعِيْلُنْ فَعُوْلُنْ مَفَاْعِلُنْ
⋮	⋮
al-Moktadib	مَفْعُوْلَاتُ مُسْتَفْعِلُنْ مُسْتَفْعِلُنْ
al-Modar'e	مَفَاْعِيْلُنْ فَاْعِلَاتُنْ مَفَاْعِيْلُنْ

Feet	Scansion
فَعُوْلُنْ	0/0//
فَاعِلُنْ	0//0/
مُسْتَفْعِلُنْ	0//0/0/
مَفَاعِيْلُنْ	0/0/0//
مَفْعُوْلَاتُ	0//0///
فَاعِلَاتُنْ	0/0//0/
مُفَاعَلَتُنْ	0///0//
مُتَفَاعِلُنْ	0//0///

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Thesis Working Steps.

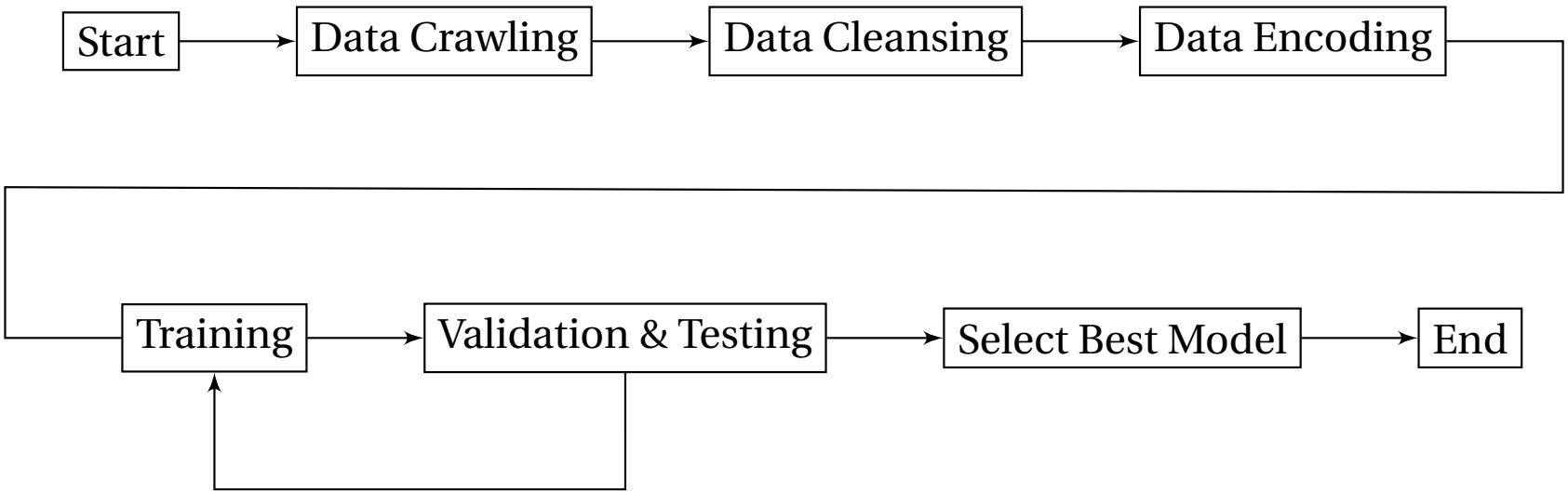

Figure: Thesis Working Steps.

Literature Review

Literature Review: Detecting Arabic poems meters

Deterministic Approach

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

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

Literature Review: Detecting Arabic poems meters

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    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

- Building the first intelligent model capable to learn meters from poems.

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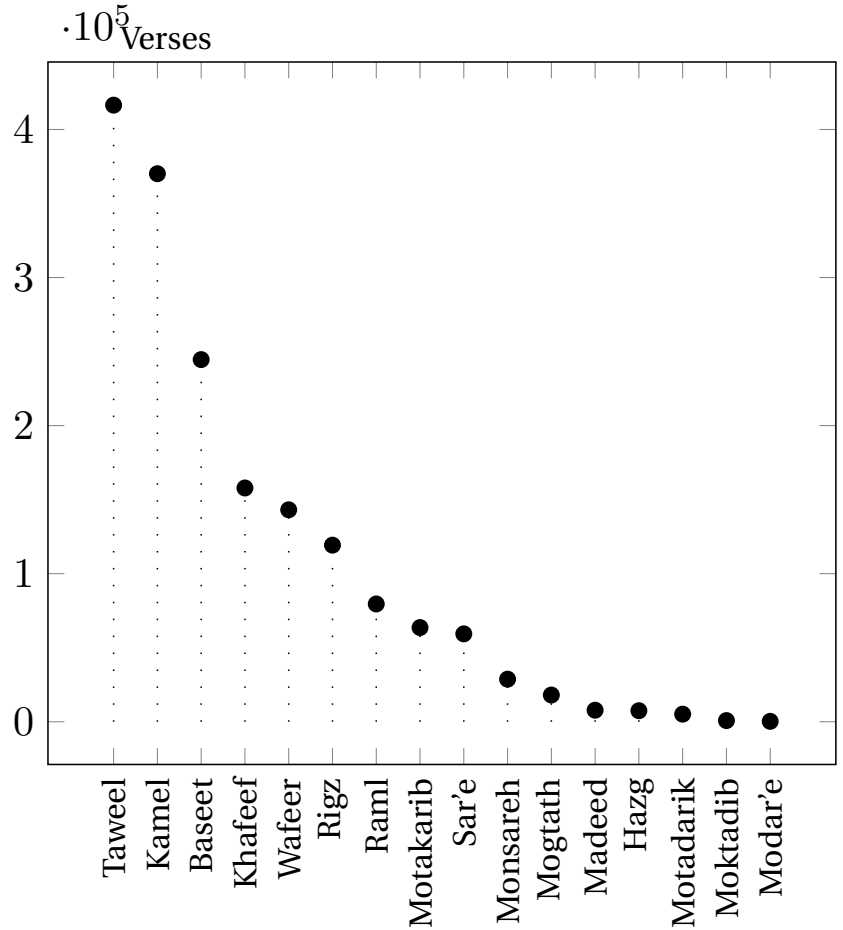
- Building the first intelligent model capable to learn meters from poems.
- Contributing the first public available dataset of 1.7M for scientific computing.

Datasets Design

Dataset acquisition and cleansing

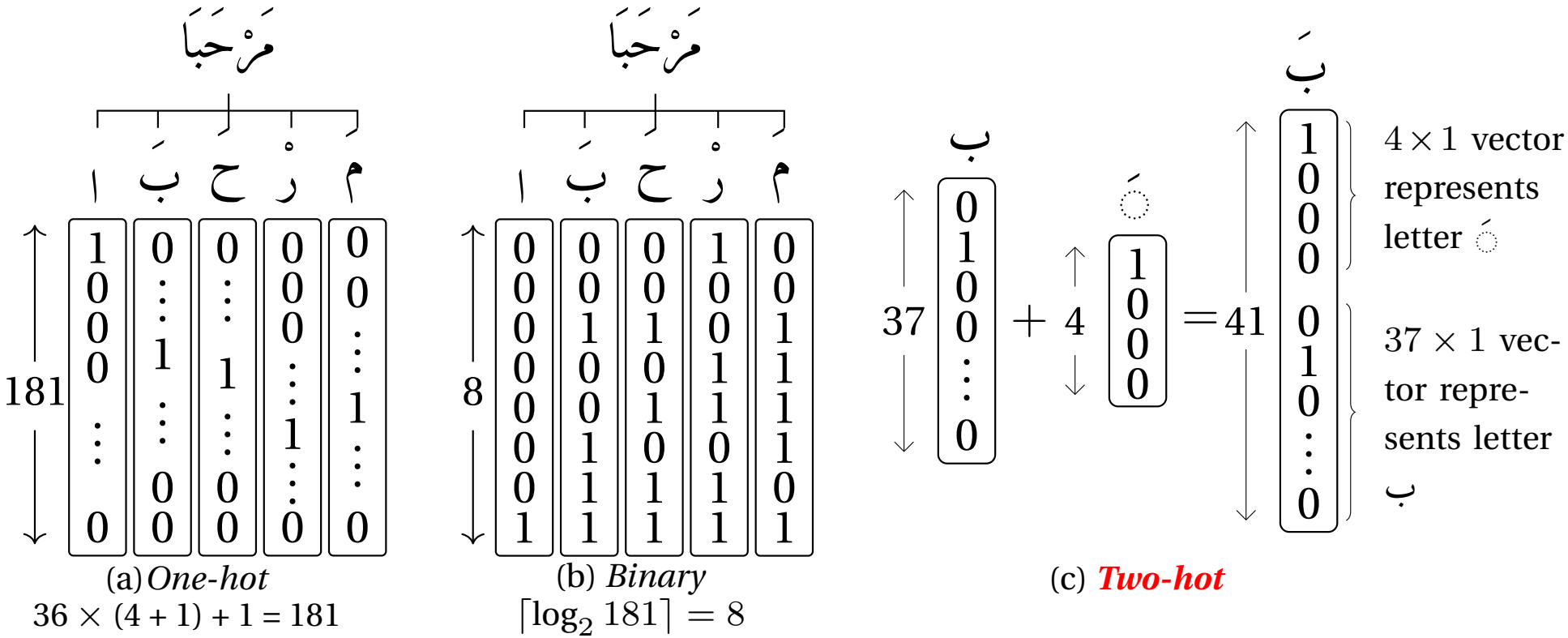
- **1,722,321** labeled data points.
- We have scrapped the Arabic datasets from الديوان [6], and الموسوعة الشعرية [5].
- Basic cleansing rules:
  - Filtering the 16 classic meters.
  - Removing unnecessary spaces.
  - Removing non-Arabic characters.
  - Factoring Shadaa and Tanween.



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 single character.



(a) *One-hot* $36 \times (4+1) + 1 = 181$

(b) *Binary* $\lceil \log_2 181 \rceil = 8$

(c) ***Two-hot***

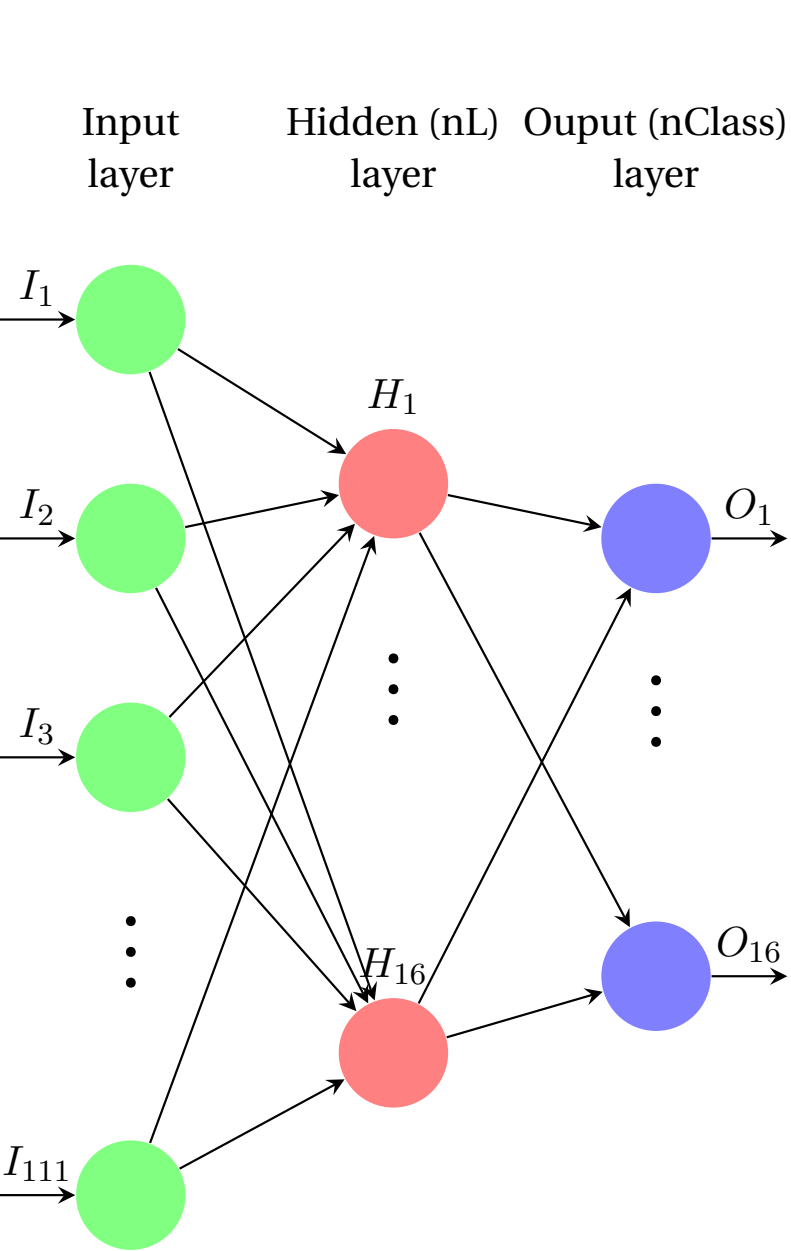
Figure: Different encoding mechanisms

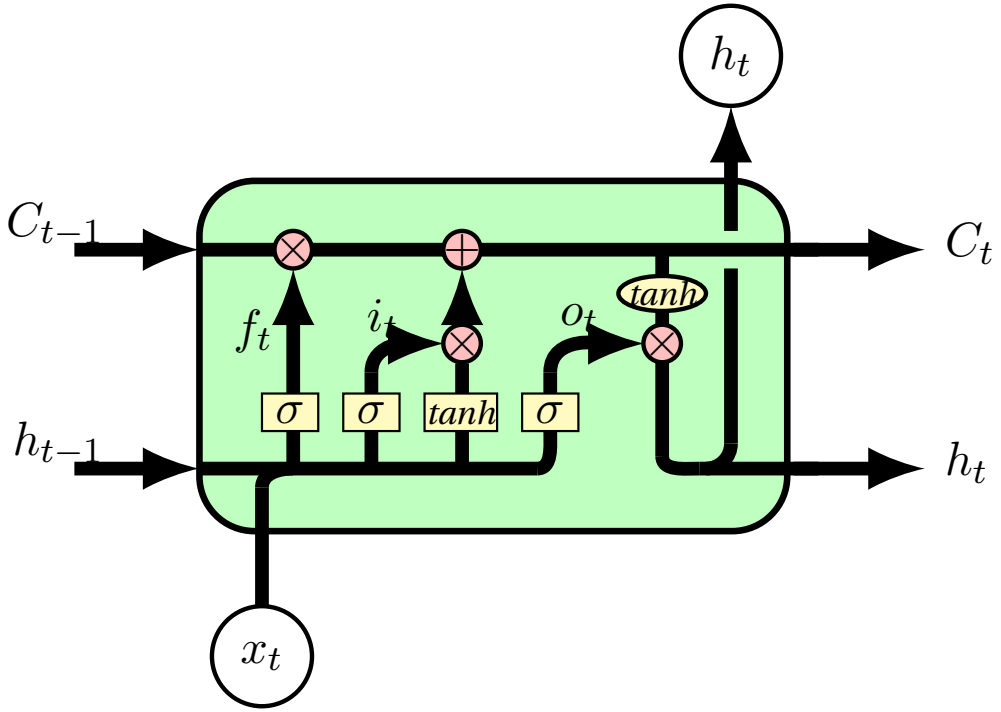
Network Architecture and Training

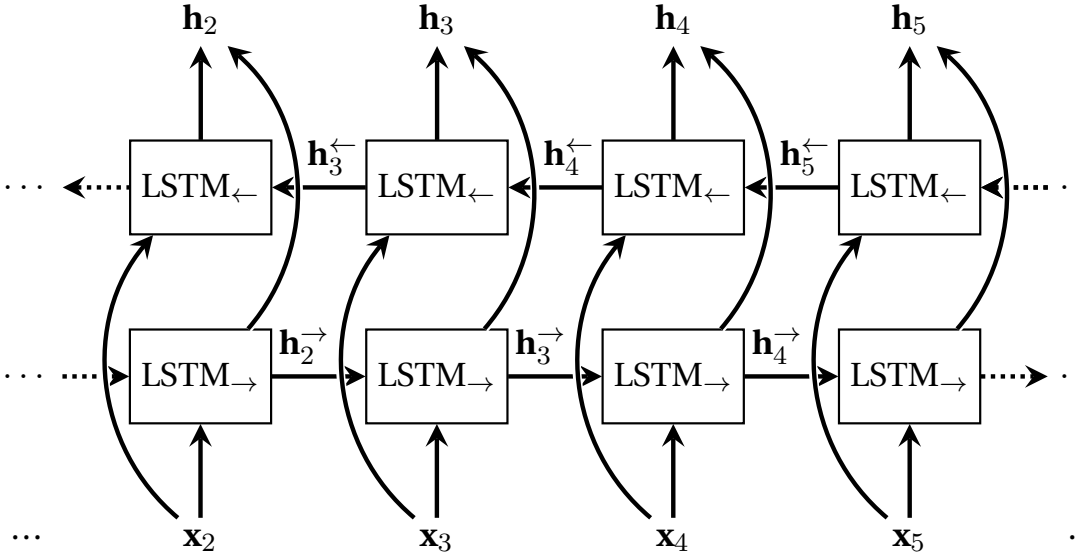
Which Network?

- **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.

Neural Networks Architectures







Experiments and Results

Experiments Parameters

- **Dataset Configurations** ($3 \times 2 \times 2$):
  - Encoding technique (3): BinE, OneE, TwoE.
  - Diacritics (2): 0D, 1D.
  - Trimming (2): 0T, 1T.
- **Network Configurations** ($2 \times 2 \times 2 \times 2$):
  - Loss functions (2): *Weighted* or *Non-Weighted* **(1, 0)** respectively.
  - The number of layers (2): nL.
  - The number of cell units (2): nU.
  - Cell type (2): LSTM, Bi-LSTM.

Total Experiements Configurations

Dataset Conf. (12) $\times$ Network Conf. (16) = 192 Experiement.

Overall Accuracy!

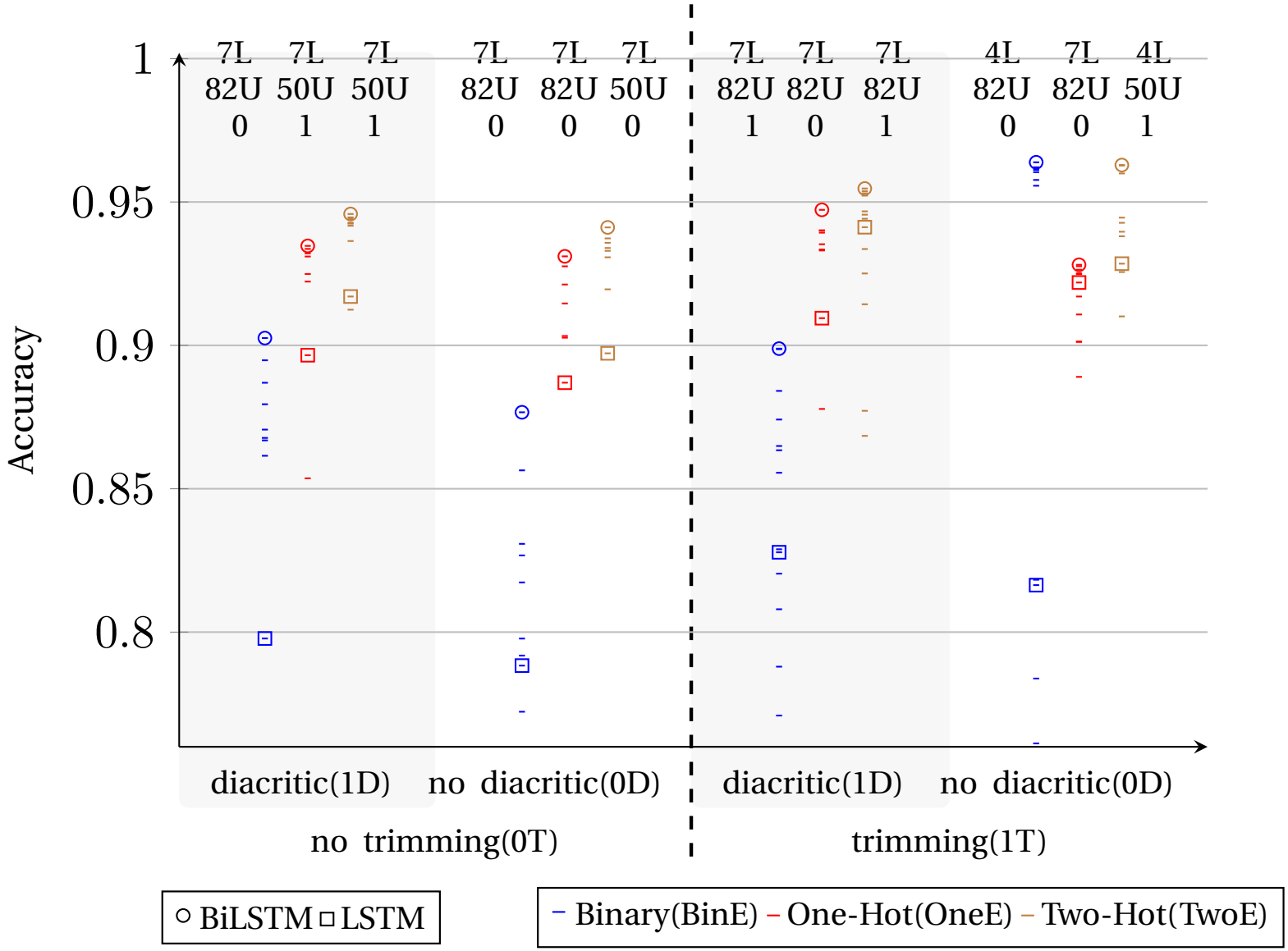


Figure: Overall accuracy of the 192 experiments

Detailed Analysis for Overall Accuracy winner!

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

Table: Overall accuracy of this article compared to literature.

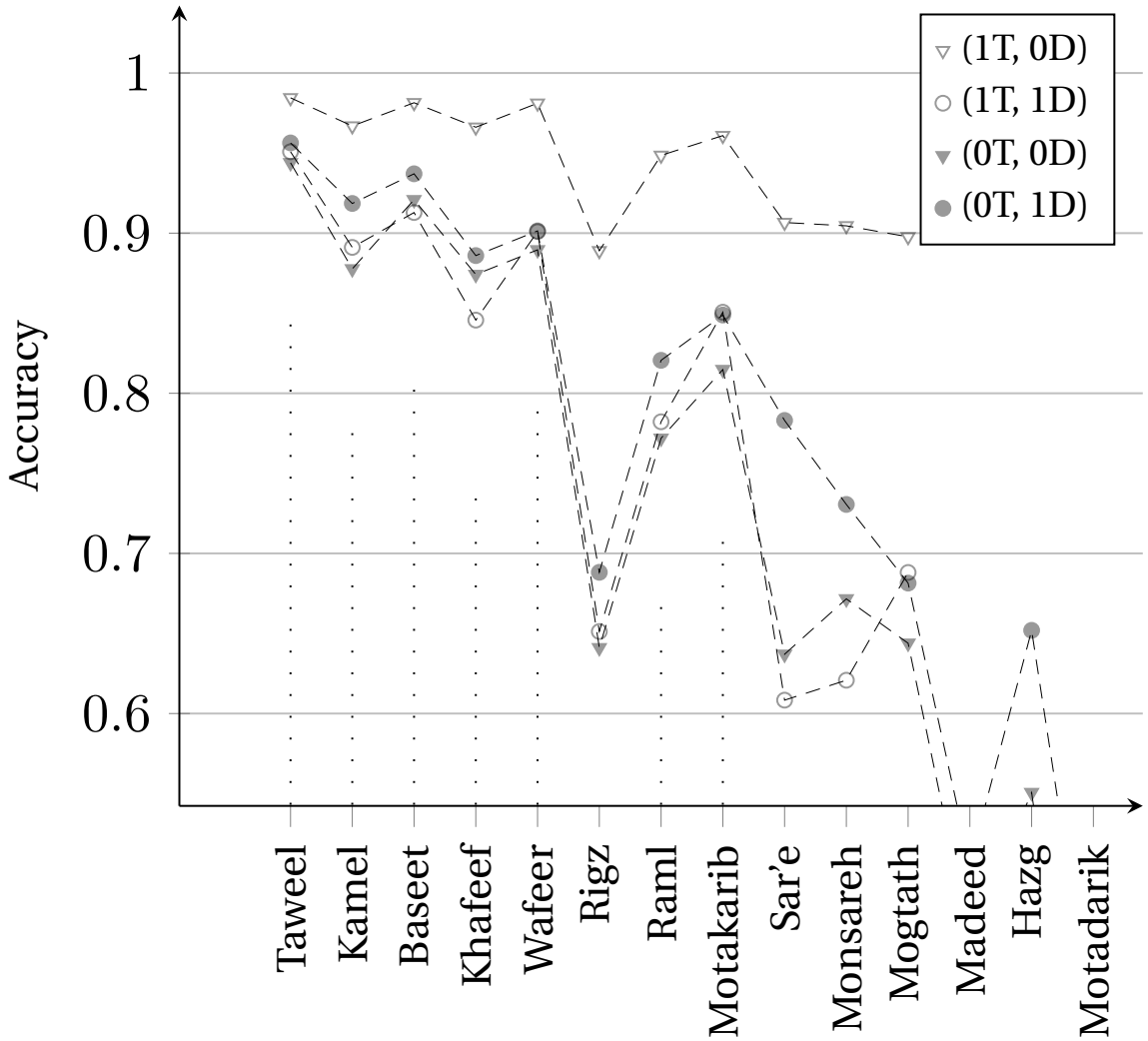


Figure: The per-class accuracy score of the best four models.

Discussions

Encoding effect

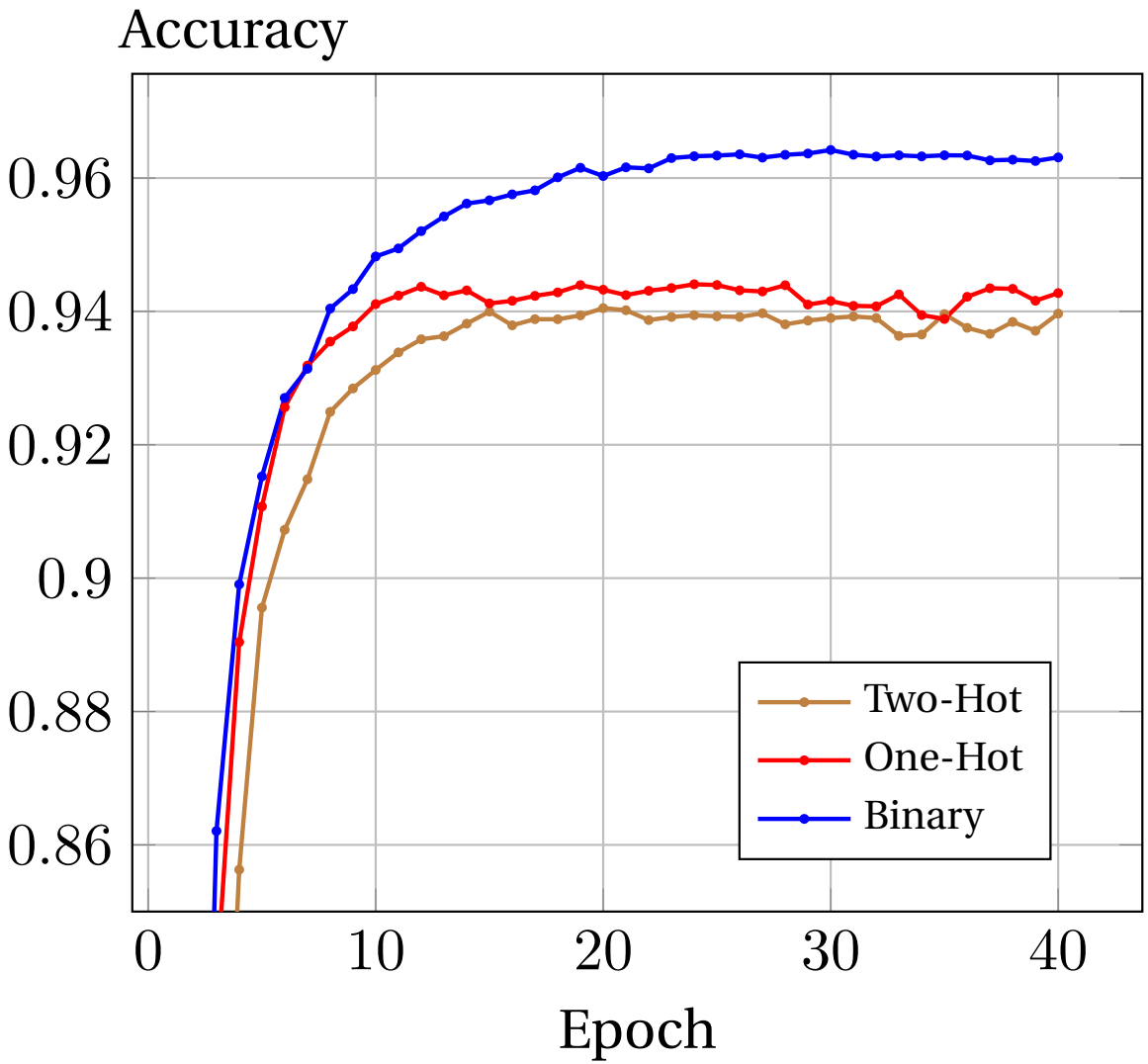


Figure: Encoding effect on Learning rate with the best model (1T, 0D, 4L, 82U, 0W, BinE) and when using the two other encodings instead of BinE.

Encoding effect

Encoding

- The encoding method is a transformer function $\mathcal{T}$, which transforms discrete input values X.
- It is assumed 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 try 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

We found 99.2% of our 150k testing observations which correctly classified have a score range between 0.94 and 1.0.

Arabic Article

قاد الدولي المصري محمد صلاح فريقه ليفربول للعودة إلى صدارة الدوري الإنجليزي الممتاز، بعد الفوز على ضيفه بورنموث بثلاثية نظيفة،

خلال المباراة التي جمتهما مساء السبت بالجولة الـ26 من المسابقة. ونستعرض في التقرير التالي أبرز الأرقام التي حققها صاحب الـ26 عامًا بعد العودة للتسجيل أمام بورنموث: يعد بورنموث بوابة صلاح للعودة للتسجيل هذا الموسم في بريميرليج

source: https://www.yallakora.com/epl/2545/News/360950/

خلال المباراة التي جمعتهما				مساء السبت بالجولة الـ26 من المسابقة			
خلالَلْ	مُباراتل	لَتِيجُ	مَعَتْهُما	مساءَسْ	سَبَتْبِلْجَوْ	لَتَلْمَنَلْ	مُسَابَقَه
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//
فَعُوْلُنْ	مَفَاعِيْلُنْ	فَعُولُ	مَفَاعِلُنْ	فَعُوْلُنْ	مَفَاعِيْلُنْ	فَعُوْلُنْ	مَفَاعِيْلُنْ

Bibliography

(1) 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.

(2) 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.

(3) Colah

Understanding Lstm Networks

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

(4) Petar Veličković

Collection of Latex Tikz figures

https://github.com/PetarV-/TikZ.

(5) المَوسُوعَةُ الشِعْرية

Department of Culture and Tourism – Abu Dhabi

https://poetry.dctabudhabi.ae.

(6) الدّيْوَانُ

Al-Diwan website

https://www.aldiwan.net.

Questions!

Questions.

Appendex

RNN, Architectures

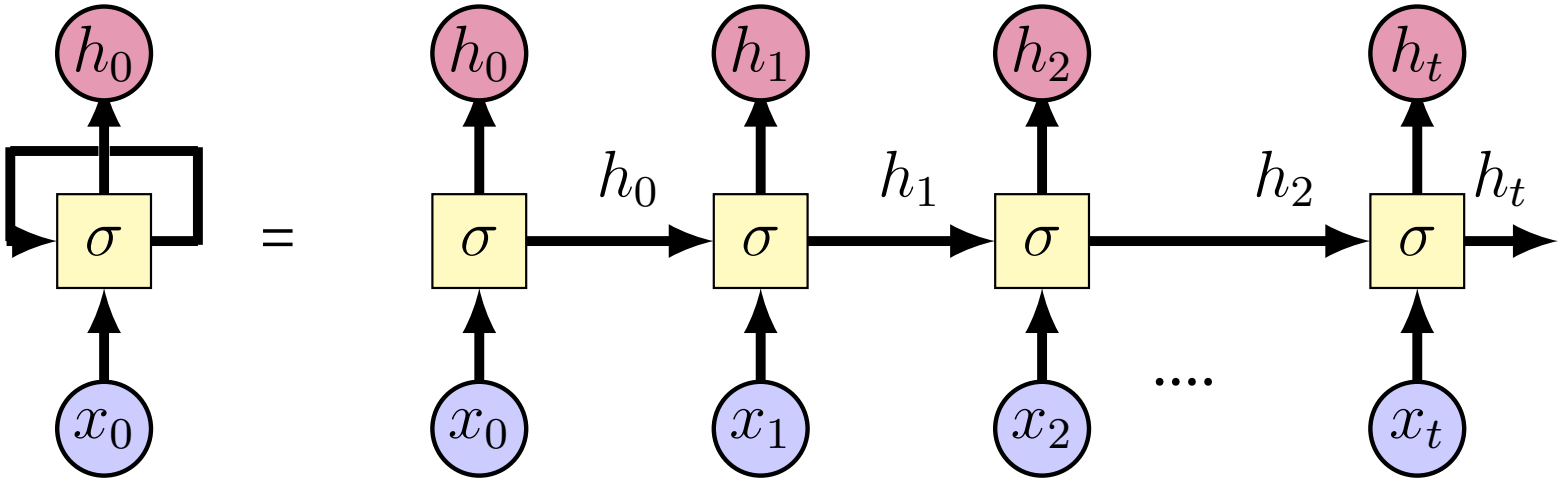


Figure: Recurrent Neural Networks Loops adapted from [3]

RNN, Architectures

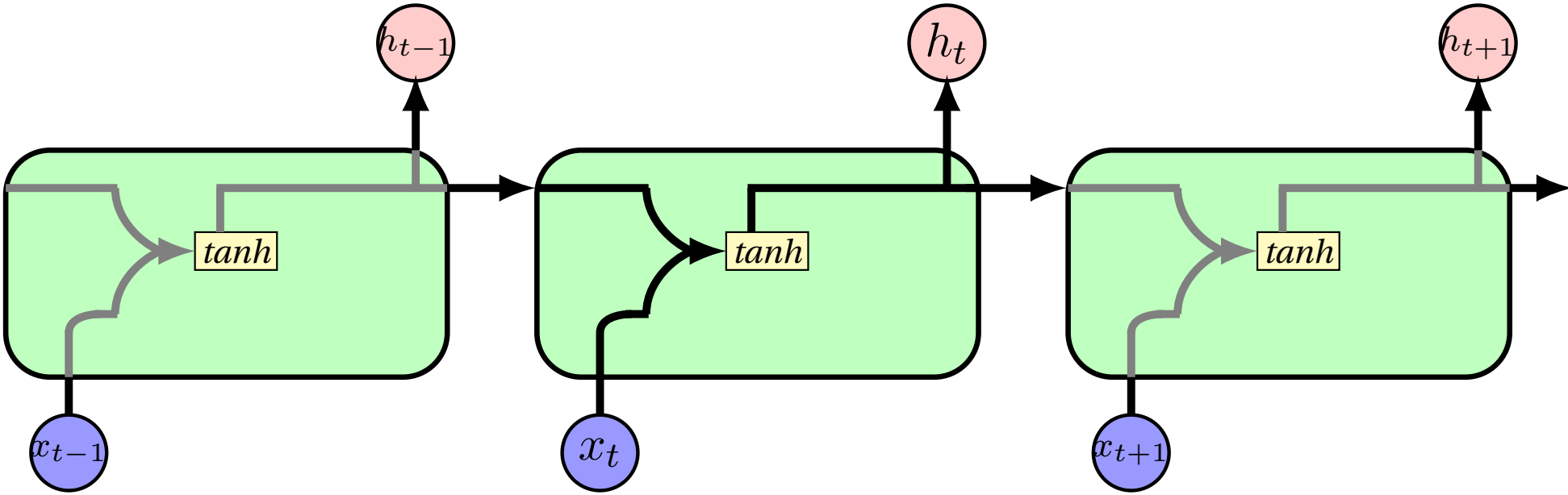


Figure: A single recurrent layer adapted from [3]

LSTM Architectures

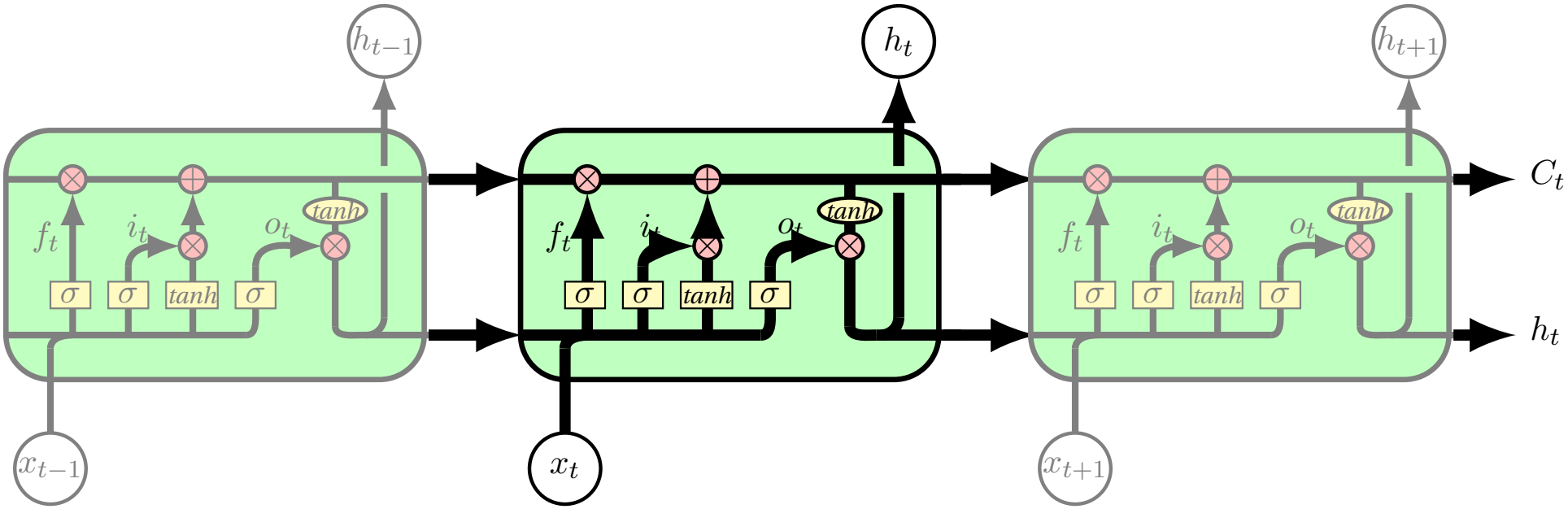


Figure: Unfold LSTM adapted from [3]

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.
- This means that models cannot learn the pattern from one direction; it should be two directions together.

LSTM Architectures

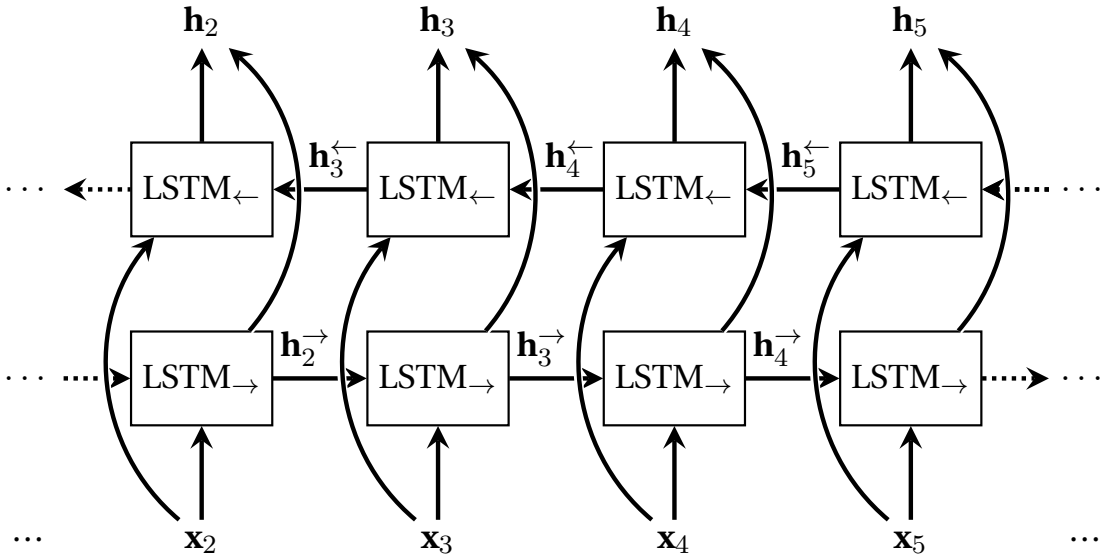


Figure: bidirectional long short-term memory [4]

Classifying Arabic Non-Poem Text

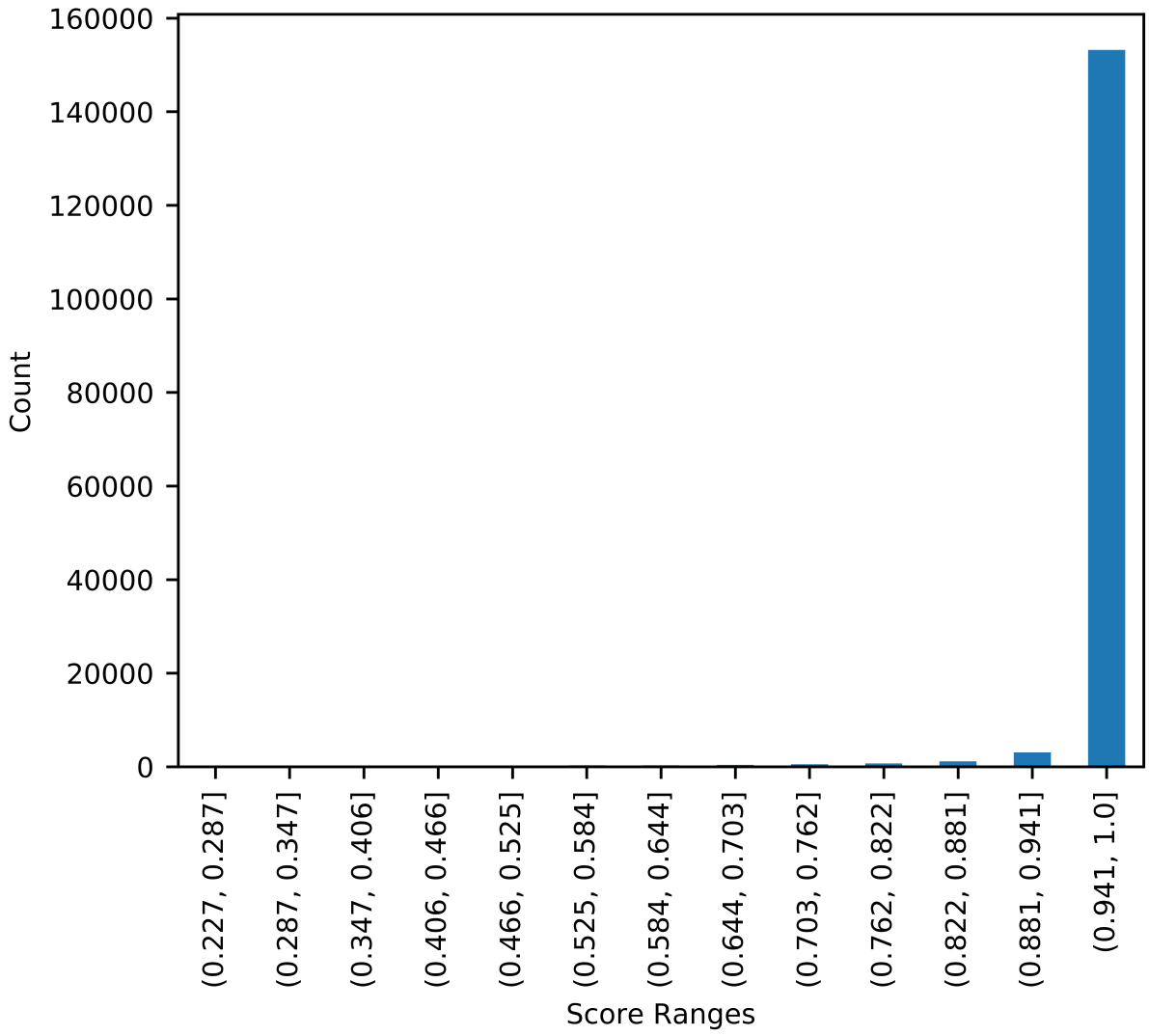


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Figure: Testing data score ranges distribution.

Classifying Arabic Non-Poem Text

تدفق في البطحاء بعد تبهطل وقعقع في البيداءغير مزركلِ
وسار بأركان العقيش مقرنصا وهـام بكـل القارطات بشنكلِ
يقول: وما بال البحاط مقرمطا ويسعى دواما بين هك وهنكلِ
إذا أقبـل البحراط طـاح بهمـة وإن أقرط البحطوش ناء بكلكلِ
يكاد على فرط الحطيف يبقبق ويضرب ما بين الهماط وكندلِ