

Learning Meters of Arabic Poems with Recurrent Neural Networks

A step forward for language understanding and synthesis

Mostafa A. Mahmoud

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

Supervised By,
Prof. Samhaa El-Beltagy
Assoc. Prof. Waleed A. Yousef

Table of Contents I

- 1 Introduction
- 2 Literature Review
- 3 Datasets Design
- 4 Network Architecture and Training
- 5 Experiments and Results
- 6 Discussions
- 7 Appendix

Introduction

But ... What is poetry?

Definition

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

Example

وُلِدَ الْهُدَى فَالْكَائِنَاتُ ضِيَاءُ وَفَمُ الزَّمَانِ تَبَسُّمٌ وَثَنَاءُ

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

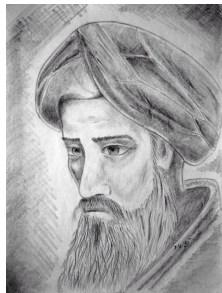


Figure: *Al-Farahidi*

figure taken from <https://goo.gl/ZJySa8>.

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

- A **poem** is a set of verses having the same meter and rhyme.
- **Vowels** carry one of ِ ُ َ which represent the following short vowels /a/, /u/, /i/.

- A **poem** is a set of verses having the same meter and rhyme.
- **Vowels** carry one of ِ ُ َ which represent the following short vowels /a/, /u/, /i/.
- **Consonants** carry ْ.

- A **poem** is a set of verses having the same meter and rhyme.
- **Vowels** carry one of ِ ُ َ which represent the following short vowels /a/, /u/, /i/.
- **Consonants** carry ّ.
- **Shadaa** indicates the letter is doubled ّ.

- A **poem** is a set of verses having the same meter and rhyme.
- **Vowels** carry one of ِ ُ َ which represent the following short vowels /a/, /u/, /i/.
- **Consonants** carry ّ.
- **Shadaa** indicates the letter is doubled ّ.
- **Tanween** *harakah* and *Noon* letter with consonant to the end of the word. It sounds /n/.

العروض Arabic Prosody

- 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
<i>al-Wafeer</i>	مفاعلتن مفاعلتن مفاعلتن مفاعلتن مفاعلتن مفاعلتن
<i>al-Taweel</i>	فعولن مفاعيلن فعولن مفاعيلن مفاعيلن مفاعيلن
:	:
<i>al-Moktadib</i>	مفعولات مستفعلن مستفعلن مستفعلن مستفعلن مستفعلن
<i>al-Modar'e</i>	مفاعيلن فاعلاتن مفاعيلن مفاعيلن مفاعيلن مفاعيلن

Feet	Scansion
فعولن	0/0//
فاعِلن	0//0/
مُسْتَفْعِلن	0//0/0/
مفاعيلن	0/0/0//
مفعولات	0//0///
فاعلاتن	0/0//0/
مفاعِلتن	0///0//
مُتفاعِلن	0//0///

إِذَا لَمْ تَخْشَ عَاقِبَةَ اللَّيَالِي وَلَمْ تَسْتَحْيِ فَاصْنَعْ مَا تَشَاءُ
 إِذَا لَمْ تَخْشَ عَاقِبَةَ لَيَالِي وَلَمْ تَسْتَحْ بِفِصْنَعِ مَا تَشَاءُ
 //0/0 //0/0/0 //0/0/0 //0/0 //0/0/0 //0/0/0
 مُفَاعِلتن مُفَاعِلتن مُفَاعِلتن مُفَاعِل مُفَاعِلتن مُفَاعِلتن

Thesis Working Steps.

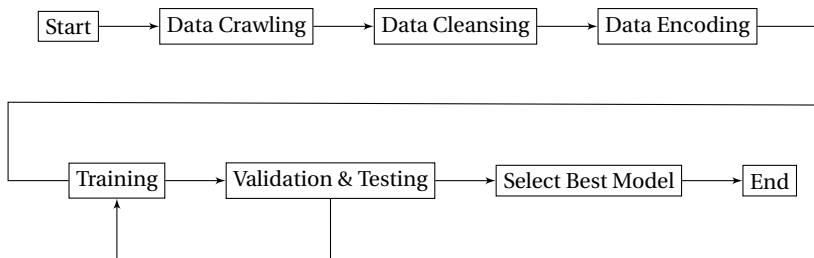


Figure: Thesis Working Steps.

Literature Review

Deterministic Approach

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

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

Deterministic Approach

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

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

- 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 تنقيلات.
- 4 A class is assigned to the input.

Deterministic Approach

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

– Abuata and Al-Omari [1]:

- 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 تنفعيلات.
 - 4 A class is assigned to the input.
- **Results:** 82.2% of 417 verses.

Deterministic Approach

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

- **Abuata and Al-Omari [1]:**
 - 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 تنفعيلات.
 - 4 A class is assigned to the input.
 - **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:

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.
 - Converting verses into Al-Arud writing style is probabilistic.

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.
 - Converting verses into Al-Arud writing style is probabilistic.
- Detection issues:

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.
 - Converting verses into Al-Arud writing style is probabilistic.
- Detection issues:
 - For detecting meters, all models are so **naive and primitive**. They do not have any clue about the real pattern.

Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.
 - Converting verses into Al-Arud writing style is probabilistic.
- Detection issues:
 - For detecting meters, all models are so **naive and primitive**. They do not have any clue about the real pattern.
 - Accuracies: (75%, 82%) tested on (128, 417) verses respectively.

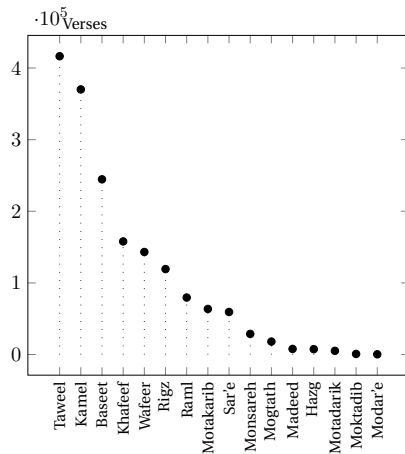
Machine Learning approach: Our point of departure

- Dataset issues:
 - Dataset size.
 - Diacritics are a must.
 - Converting verses into Al-Arud writing style is probabilistic.
- Detection issues:
 - For detecting meters, all models are so **naive and primitive**. They do not have any clue about the real pattern.
 - 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 [5] الموسوعة الشعرية, [6] الديوان.
- 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	دّ	دّ	دّ	دّ + دّ

Data Representation

- Diacritics are standalone characters!

- $\text{len مرَّحَبًا} \neq \text{len مَرَحَبًا}$
- We have represented the letter and its diacritic as a **one character**.

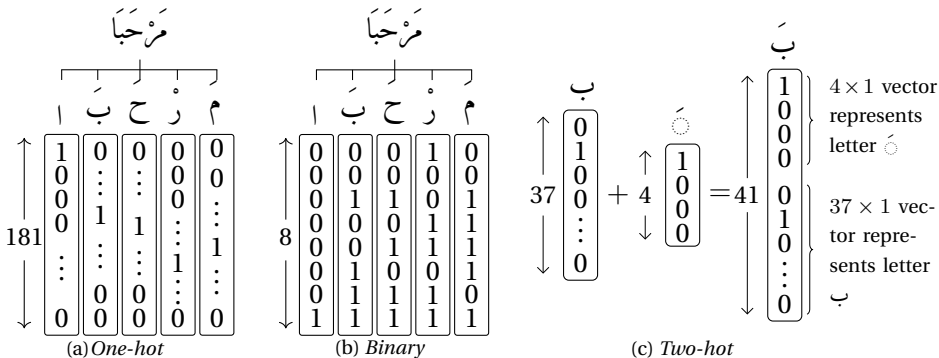


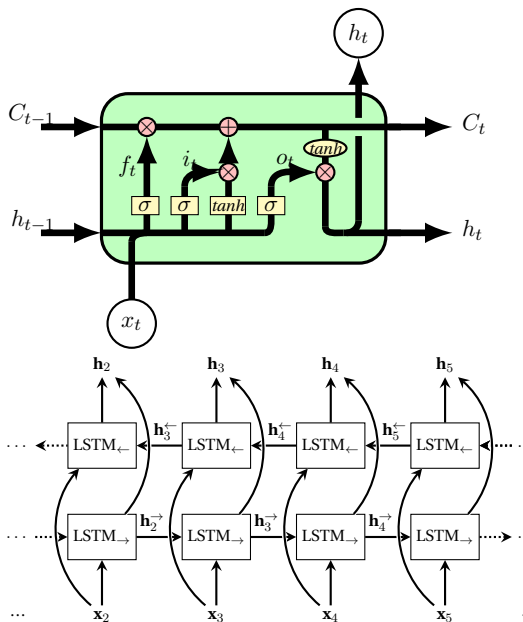
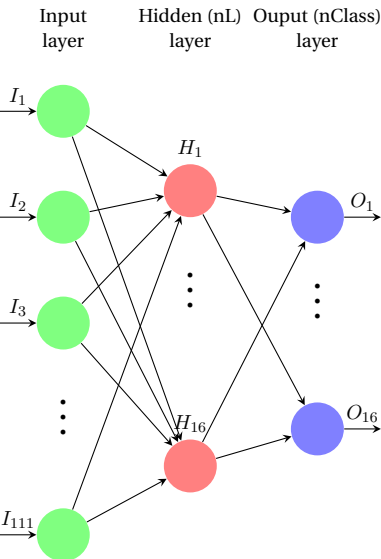
Figure: Different encoding mechanisms

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

- **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 Experiments Configurations

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

Overall Accuracy!

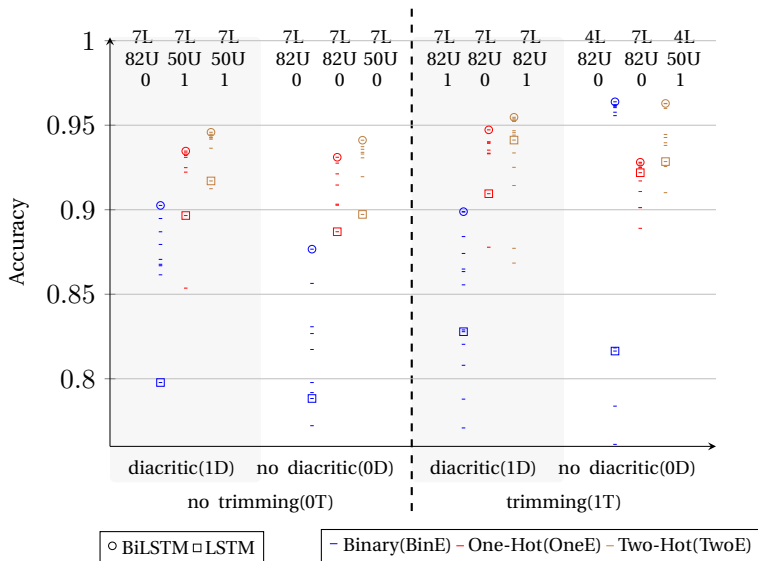


Figure: Overall accuracy of the 192 experiments

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.

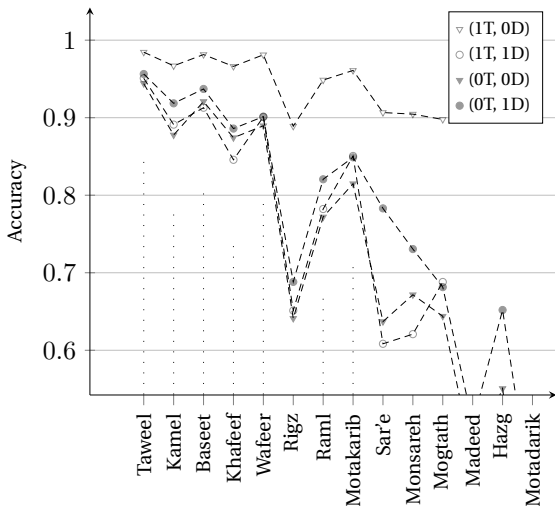


Figure: The per-class accuracy score of the best four models.

Discussions

Encoding effect

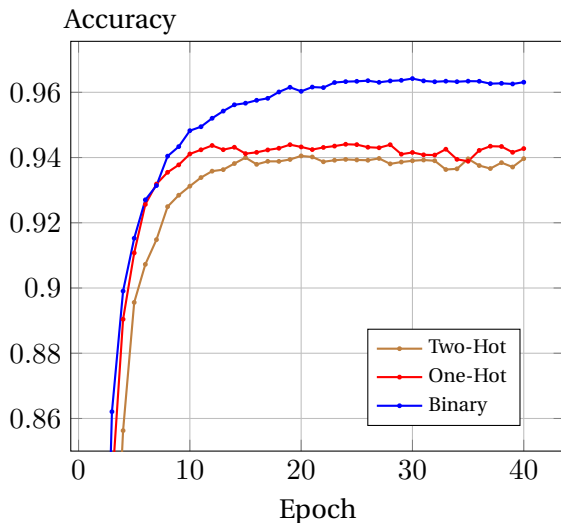


Figure: Encoding effect on Learning rate with the best model (1T, 0D, 4L, 82U, 0W, BinE) and when using the two other encodings instead of BinE.

Encoding

- 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 $\eta_1(\mathcal{T}_1(X)) = (\eta_1 \cdot \mathcal{T}_1 \cdot \mathcal{T}_2^{-1})(\mathcal{T}_2(X))$. 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

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 جمعتها مساء السبت بالجولة الـ 26 من المسابقة. ونستعرض في التقرير التالي أبرز الأرقام التي حققها صاحب الـ 26 عاماً بعد العودة للتسجيل أمام بورنموث: يعد بورنموث بوابة صلاح للعودة للتسجيل هذا الموسم في بريميرليج

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

مساء السبت بالجولة الـ 26 من المسابقة				خلال المباراة التي جمعتها			
مُسَابَقُهُ	لَتَلْنَلْ	سَبْتَلْجُوْ	مِساءَسْ	مَعْتَهُمَا	لَتَبِجْ	مُبَارَاتِلْ	خَلَالْ
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//
مَفَاعِلُنْ	فَعُولُنْ	مَفَاعِلُنْ	فَعُولُنْ	مَفَاعِلُنْ	فَعُولُ	مَفَاعِلُنْ	فَعُولُنْ

Classifying Arabic Non-Poem Text

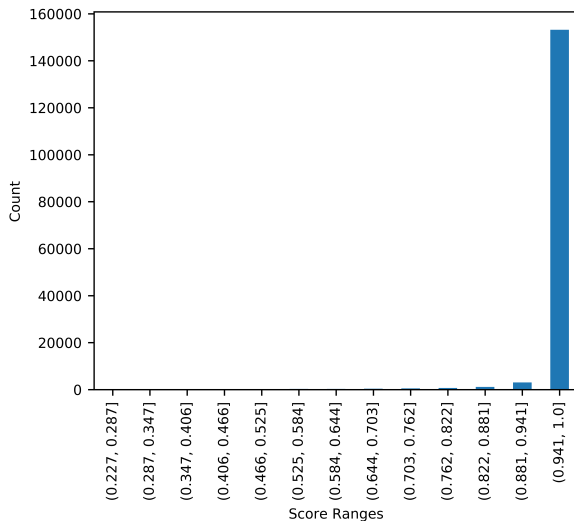


Figure: Testing data score ranges distribution.

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) الموسوعة الشعرية

Department of Culture and Tourism – Abu Dhabi

<https://poetry.dctabudhabi.ae>.



(6) الديوان

Al-Diwan website

<https://www.aldiwan.net>.

Questions!

Questions.

Appendix

RNN, Architectures

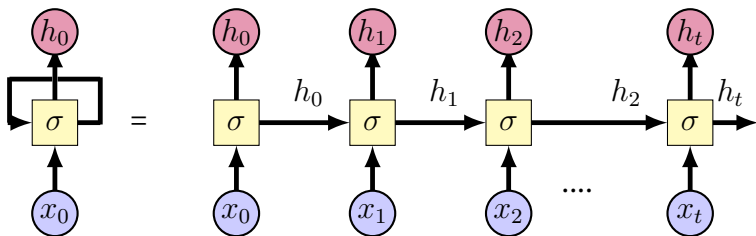


Figure: Recurrent Neural Networks Loops adapted from [3]

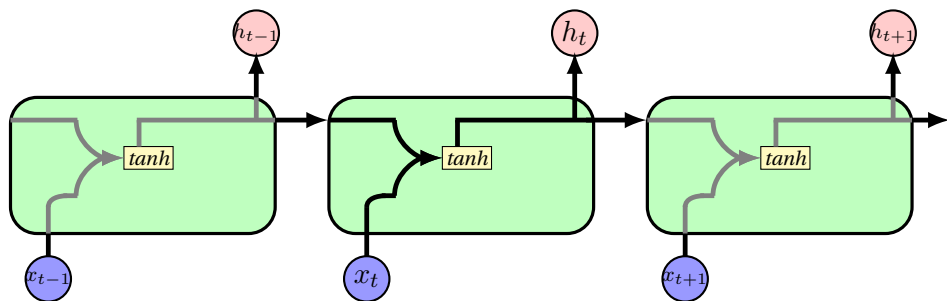


Figure: A single recurrent layer adapted from [3]

LSTM Architectures

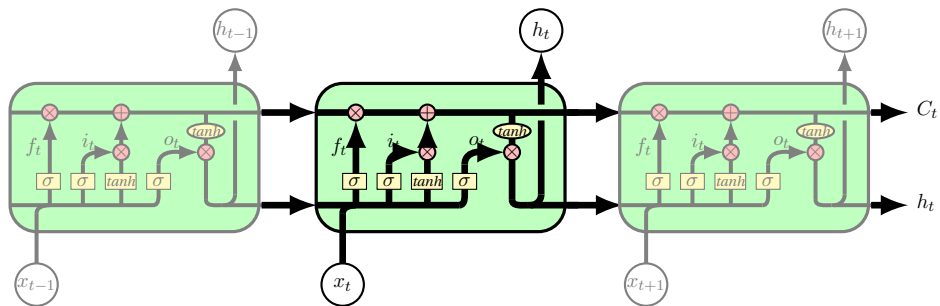


Figure: Unfold LSTM adapted from [3]

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

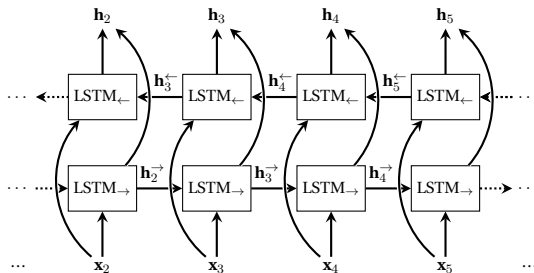


Figure: bidirectional long short-term memory [4]