Learning Meters of Arabic Poems with Deep Learning

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By
Moustafa Alaa Mohamed
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CERTIFICATION OF APPROVAL

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By
Moustafa Alaa Mohamed

_____ _____

Dr. Samhaa El-Beltagy (Chair) Date
Professor of Electrical and Computer Engineering

_____ _____

Dr. Waleed Yousef Date
Professor of Computer Science

ACKNOWLEDGMENT

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ABSTRACT

People can easily determine whether a piece of writing is a poem or prose, but only specialists can determine the class of poem.

In this thesis, we built a model that can classify poems according to their meters; a forward step towards machine understanding of Arabic language.

A number of different deep learning models are proposed for poem meter classification. As poems are sequence data, then recurrent neural networks are suitable for the task. We have trained three variants of them, LSTM, GRU with different architectures and hyper-parameters. Because meters are a sequence of characters, then we have encoded the input text at the character-level, so that we preserve the information provided by the letters succession directly fed to then models. Besides, We introduce a comparative study on the difference between binary and one-hot encoding regarding their effect on the learning curve. We also introduce a new encoding technique called *Two-Hot* which merges the advantages of both *Binary* and *One-Hot* techniques.

Deep Learning models, shows its ability to understand the text and can achieve an outstanding accuracy regarding text classification. In addition to, the new techniques discovered such as LSTM to solve the long sequence dependency problem. In this thesis, we will explain how to use the deep learning to classify the Arabic poem to classes. Also, explain in details the feature of Arabic poem and how to deal with this features.

Chapter 1

INTRODUCTION

Thesis Outline

The coming chapters are arranged as follows:

Chapter 1: presents some basic introduction and background knowledge as regards the Arabic Poem and its definitions. Also, it contains details about the Arabic language and some feature used during our work.

Chapter 2: introduces the essential pre-processing steps, and the justification for their need. Pre-processing steps are data extraction, data cleansing and data format.

Chapter 3: introduces the data encoding techniques used and the effect of each one. Also, it contains some comparisons between the three techniques used.

Chapter 4: presents the model's details and how we chose the model and the architecture and hyper-parameters details.

Chapter 5: Results and discussion.

Chapter 6 : Conclusion and future work

Arabic is the fifth most widely spoken language[1]. It is written from right to left. Its alphabet consists of 28 primary letters, and there are 8 more derived letters from the basic ones, so the total count of Arabic characters is 36 characters. The writing system is cursive; hence, most letters join to the letter that comes after them, a few letters remain disjoint.

Each Arabic letter represents a consonant, which means that short vowels are not represented by the 36 characters, for this reason, the need of *diacritics* rises. *Diacritics* are symbols that comes after a letter to state the short vowel accompanied by that letter. There are four diacritics ◌َ ◌ُ ◌ِ ◌ْ which represent the following short vowels /*a*/, /*u*/, /*i*/ and *no-vowel* respectively, their names are *fat-ha, dam-ma, kas-ra and sukun* respectively. The first three symbols are called *harakat*. Table 1.1 shows the 4 diacritics on a letter.

Diacritics	*without*	*fat-ha*	*kas-ra*	*dam-ma*	*sukun*
Shape	د	دَ	دِ	دُ	دْ

Table 1.1: *Diacritics on the letter* د

There are two more sub-diacritics made up of the basic four to represent two cases:

Definition 1 ***Shadaa***

to indicate the letter is doubled. Any letter with shaddah ( ) the letter should be duplicated: first letter with a constant (sukoon) and second letter with a vowel (haraka) [75]; Table 1.2 shows the dal with shadda and the original letters.

[1] *according to the 20th edition of Ethnologue, 2017*

Diacritics	*letter with Shadda*	*letters without shadaa*
Shape	دَّ	دْدَ

Table 1.2: *Shadaa diacritics on the letter* د

Definition 2 ***Tanween***

is doubling the short vowel, and can convert Tanween fathah, Tanween dhammah or Tanween kasrah by replacing it with the appropriate vowel (dhammah, fathah or kasrah) then add the Noon letter with constant to the end of the word [75]. Table 1.3 shows the difference between the original letter and the letter with Tanween

Diacritics	*letter with tanween*	*letters without tanween*
Tanween Dam-ma	دٌ	دُ+نْ
Tanween Kas-ra	دٍ	دِ+نْ
Tanween Fat-ha	دً	دَ+نْ

Table 1.3: *Tanween diacritics on the letter* د

Arabs pronounce the sound */n/* accompanied *sukun* at the end the indefinite words, that sound corresponds to this letter نْ, it is called *noon-sakinah*, however, it is just a phone, it is not a part of the indefinite word, if a word comes as a definite word, no additional sound is added. Since it is not an essential sound, it is not written as a letter, but it is written as *tanween* ◌ٍ ◌ً ◌ٌ. *Tanween* states the sound *noon-sakinah*, but as you have noticed, there are 3 *tanween* symbols, this because *tanween* is added as a diacritic over the last letter of the indefinite word, one of the 3 harakat*harakat* accompanies the last letter, the last letter's *harakah* needs to be stated in addition to the sound *noon-sakinah*, so *tanween* is doubling the last letter's *haraka*, this way the last letter's *haraka* is preserved in addition to stating the sound *noon-sakinah*; for example, رَجُلُ + نْ is written رَجُلٌ and رَجُلِ + نْ is written رَجُلٍ.

Those two definition, Definition 1 and Definition 2 will help us to reduce the dimension of the letter's feature vector as we will see in *preparing data* section.

Diacritics makes short vowels clearer, but they are not necessary. Moreover, a phrase without full diacritics or with just some on some letters is right linguistically, so it is allowed to drop them from the text.

In Unicode, Arabic diacritics are standalone symbols, each of them has its own unicode. This is in contrast to the Latin diacritics; e.g., in the set *{ê, é, è, ë, , , }*, each combination of the letter *e* and a diacritic is represented by one unicode.

1.1 Arabic Poetry

Arabic poetry الشعر العربى is the earliest form of Arabic literature. It dates back to the sixth century. Poets have written poems without knowing exactly what rules which make a collection of words a poem. People recognize poetry by nature, but only talented ones can write poems. This was the case until *Al-Farahidi* (718 786 CE) has analyzed the Arabic poetry, then he came up with that the succession of consonants and vowels produce patterns or *meters*, which make the music of poetry. He has counted them fifteen meters. After that, a student of *Al-Farahidi* has added one more meter to make them sixteen. Arabs call meters بحور which means "*seas*".

Definition 3 ***Meter***

Poetic meters define the basic rhythm of the poem. Each meter is described by a set of ordered feet which can be represented as ordered sets of consonants and vowels [76].

ولد الهدى فالكائنات ضياء *** وفم الزمان تبسم وثناء انشاء
الروح والملأ الملائك حوله *** للدين والدنيا به بشراء

Definition 4 ***Arabic Verse***

refers to "poetry" as contrasted to prose. Where the common unit of a verse is based on meter or rhyme, the common unit of prose is purely grammatical, such as a sentence or paragraph[2]*. A verse know as Bayt in Arabic* بيت

Definition 5 ***Shatr***

A verse consists of two halves, each of them is called shatr and carries the full meter. We will use the term shatr to refer to a verse's half; whether the right or the left half.

[2] *https://en.wikipedia.org/wiki/Verse_(poetry).*

Feet	Scansion
فَعُولُنْ	0/0//
فَاعِلُنْ	0//0/
مُسْتَفْعِلُنْ	0//0/0/
مَفاعِيلُنْ	0/0/0//
مَفْعُولاَت	0//0///
فَاعِلاَتُنْ	0/0//0/
مُفَاعَلَتُنْ	0///0//
مُتَفَاعِلُنْ	0//0///

Table 1.4: The eight feet. Every digit represents the corresponding diacritic over each latter in the feet. / If a letter has got *harakat* (◌َ ◌ُ ◌ِ), 0 if a letter has got *sukun* (◌ْ). Any *mad* (و, ا, ى) is equivalent to *sukun*.

Definition 6 ***Poem***

is a set of verses has the same meter and rhyme.

Definition 7 ***al-arud*العروض[3]*;*

*it is the study of poetic meters, in which he has laid down rigorous rules and measures, with them we can determine whether a meter of a poem is sound or broken. A meter is an ordered sequence of feet. Feet are the basic units of meters, there are eight of them. A Foot consists of a sequence of consonant and vowels. Traditionally, feet are represented by mnemonic words called tafa'il (*تفاعيل*). According to al-Farahidi and his student, there are sixteen combinations of tafa'il. A meter appears in a verse twice; each shatr carries the same complete meter.*

For example, the following *shatr* وَيُسأَلُ في الحَوادِثِ ذو صَوابِ is equivalent to the *meter* مفاعلتن مفاعلتن فعول, which means it belongs to *Al-Wafeer* meter. We can get the pattern of the *sukun* and *harakat* by replacing each feet by the corresponding code in table 1.4, which produces the following pattern that should be read from right to left:

[3] it is often called the *Knowledge of Poetry*.

Meter Name	**Meter** *feet combination*
al-Wafeer	مُفَاعَلَتُن مُفَاعَلَتُن فَعُولُن
al-Taweel	فَعُوْلُنْ مَفَاْعِيْلُنْ فَعُوْلُنْ مَفَاْعِلُنْ
al-Taweel	فَعُوْلُنْ مَفَاْعِيْلُنْ فَعُوْلُنْ مَفَاْعِلُنْ
al-Kamel	مُتَفَاْعِلُنْ مُتَفَاْعِلُنْ مُتَفَاْعِلُنْ
al-Baseet	مُسْتَفْعِلُنْ فَاْعِلُنْ مُسْتَفْعِلُنْ فَاْعِلُنْ
al-Khafeef	فَاْعِلاتُنْ مُسْتَفْعِلُنْ فَاْعِلاتُنْ
al-Rigz	مُسْتَفْعِلُنْ مُسْتَفْعِلُنْ مُسْتَفْعِلُنْ
al-Raml	فَاْعِلاتُنْ فَاْعِلاتُنْ فَاْعِلاتُنْ
al-Motakarib	فَعُوْلُنْ فَعُوْلُنْ فَعُوْلُنْ
al-Sar'e	مُسْتَفْعِلُنْ مُسْتَفْعِلُنْ مَفْعُوْلاتُ
al-Monsafeh	مُسْتَفْعِلُنْ مَفْعُوْلاتُ مُسْتَفْعِلُنْ
al-Mogtath	مُسْتَفْعِلُنْ فَاْعِلاتُنْ فَاْعِلاتُنْ
al-Madeed	فَاْعِلاتُنْ فَاْعِلُنْ فَاْعِلاتُنْ
al-Hazg	مَفَاْعِيْلُنْ مَفَاْعِيْلُنْ
al-Motadarik	فَاْعِلُنْ فَاْعِلُنْ فَاْعِلُنْ فَاْعِلُنْ
al-Moktadib	مَفْعُوْلاتُ مُسْتَفْعِلُنْ مُسْتَفْعِلُن
al-Modar'e	مَفَاْعِيْلُنْ فَاْعِلاتُنْ مَفَاْعِيْلُنْ
al-Kamel	مُتَفَاْعِلُنْ مُتَفَاْعِلُنْ مُتَفَاْعِلُنْ
al-Baseet	مُسْتَفْعِلُنْ فَاْعِلُنْ مُسْتَفْعِلُنْ فَاْعِلُنْ

Table 1.5: *The sixteen Arabic poem meters*

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

This is a very brief introduction to *Arud*, many details are reduced.

1.2 Thesis Objectives

Chapter 2

BACKGROUND AND LITERATURE REVIEW

Chapter 3

DATASET

We have scrapped the Arabic dataset from two big poetry websites: الديوان[1], الموسوعة الشعرية[2]. Both are merged into one large dataset. It is important to note that the verses' diacritic states are not consistent, this means that a verse can carry full, semi diacritics or it can carry nothing. The total number of verses is 1,862,046 poetic verses; each verse is labeled by its meter, the poet who wrote it, and the age which it was written in. There are 22 meters, 3701 poets and 11 ages; and they are Pre-Islamic, Islamic, Umayyad, Mamluk, Abbasid, Ayyubid, Ottoman, Andalusian, era between Umayyad and Abbasid, Fatimid and modern. We are only interested in the 16 classic meters which are attributed to *Al-Farahidi*, and they are the majority of the dataset with a total number of 1,722,321 verses[3].

3.1 Preparing Data

3.1.1 Data Cleaning

[1] *aldiwan.net*

[2] *poetry.tcaabudhabi.ae*

[3] https://wwww.github.com/tahamagdy

Chapter 4

DATA ENCODING

4.0.1 Arabic Poem Encoding

4.0.1.1 One-Hot encoding

4.0.1.2 Binary Encoding

4.0.1.3 Two-Hot encoding

Chapter 5

MODEL TRAINING

Chapter 6

RESULTS AND DISCUSSION

Chapter 7

CONCLUSION AND FUTURE WORK

7.1 Future Work

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[76] Abdulrahman Almuhareb

APPENDICES

APPENDIX A

Phase Correlation Theory

Let $D_1(x,y)$ and $D_2(x,y)$ be the dilated images to be registered, the Fourier transform for both $F_1(u,v)$ and $F_2(u,v)$ is given by:

$$F_k(u,v) = \mathcal{F}\{D_k(x,y)\}$$

$$= \int_{y=-\infty}^{y=\infty} \int_{x=-\infty}^{x=\infty} D_k(x,y) \exp^{(-i2\pi\omega xy)} \, dxdy \tag{7.1}$$

where, $\mathcal{F}$ is the Fourier operator, K denotes image 1 or 2, ω is the frequency (in hertz), x and y are the spatial domain coordinates, u and v are the frequency domain coordinates of the two images.

Given two images of size $N \times M$ shifted against each other, according to the Fourier

shift property, their Fourier becomes:

$$F_2(u,v) = F_1(u,v)\exp^{\left(-i2\pi\left(\frac{u\Delta x}{M}+\frac{v\Delta y}{N}\right)\right)} \tag{7.2}$$

The Normalized Cross Power Spectrum ($C(u,v)$) is defined as:

$$C(u,v) = \frac{F_1(u,v)\cdot F_2(u,v)^*}{|F_1(u,v)\cdot F_2(u,v)^*|} \tag{7.3}$$

where '.' denotes the element-wise product, '*' denotes the complex conjugate.

Using equation 7.2:

$$C(u,v) = \frac{F_1(u,v)\cdot F_1(u,v)^*\exp^{\left(i2\pi\left(\frac{u\Delta x}{M}+\frac{v\Delta y}{N}\right)\right)}}{\left|F_1(u,v)\cdot F_1(u,v)^*\exp^{\left(i2\pi\left(\frac{u\Delta x}{M}+\frac{v\Delta y}{N}\right)\right)}\right|} \tag{7.4}$$

Since the phase term of $F_1(u,v)\cdot F_1(u,v)^*$ is zero, only the magnitude remains, i.e. $F_1(u,v)\cdot F_1(u,v)^* = |F_1(u,v)\cdot F_1(u,v)^*|$ and since the magnitude of any complex exponential is 1, the equation drops to:

$$C(u,v) = \frac{|F_1(u,v)\cdot F_1(u,v)^*|\exp^{\left(i2\pi\left(\frac{u\Delta x}{M}+\frac{v\Delta y}{N}\right)\right)}}{|F_1(u,v)\cdot F_1(u,v)^*|}$$

$$= \exp^{\left(i2\pi\left(\frac{u\Delta x}{M}+\frac{v\Delta y}{N}\right)\right)} \tag{7.5}$$

the inverse Fourier transform of which is a delta function, i.e. a single peak.

The Normalized Cross Correlation (c) equals:

$$c = \mathcal{F}^{-1}\{C\} = \delta(x + \Delta x, y + \Delta y) \tag{7.6}$$

The shift in x and y between the two images $(\Delta x, \Delta y)$ takes the location of the maximum peak in c, such that:

$$(\Delta x, \Delta y) = \underset{x,y}{\text{argmax}}\{c\} \tag{7.7}$$