Adversarial Examples in Arabic- Supplementary Material

I. Background: Arabic Language

Arabic is a Semitic language spoken by more than 420 million people in 22 countries[1]. It is a highly structured language where morphology plays a very important role [1]. Arabic shares some special features along with other Semitic languages [2] such as: (1) It is written from right to left; (2) There is no capitalization; and (3) Letters change their shape according to their position in the word.

A. Adjectives in Arabic

Unlike in English, adjectives in Arabic follow the nouns they modify and agree with them in gender, number, and definiteness [3]. For example:

(1) بنت جميلة, (βɪnt ʤaːmiːlh, girl pretty-singular-feminine-indefinite).

(2) البنت الجميلة, (ɑlbɪnt alʤaːmiːlh, the girl pretty-singular-feminine-definite).

The adjective جميلة (ʤaːmiːlh, pretty-singular-feminine-indefinite) in (1) and الجميلة (alʤaːmiːlh, pretty-singular-feminine-definite) in (2) both agree with the preceding nouns بنت (βɪnt, girl-indefinite) in (1) and البنت (ɑlbɪnt, girl-definite) in (2) respectively in number (singular), gender (feminine), and definiteness.

1) Definite Adjectives in Arabic:
To form a definite adjective from a singular, dual, or plural masculine or feminine adjective, one can attach ال (al) to the *beginning* of the indefinite adjective. For example:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) الكبير, (alkaːbiːr, Big-singular-masculine-definite).

(3) كبيرات, (kaːbiːraːt, Big-plural-feminine-indefinite).

(4) الكبيرات, (alkaːbiːraːt, Big-plural-feminine-definite).

2) Feminine Adjectives in Arabic:
To form a singular feminine adjective from a singular masculine adjective, one can add ة, sounds (t) or (h), to the *end* of the adjective. For example:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) كبيرة, (kaːbiːrh, Big-singular-feminine-indefinite).

3) Dual Adjectives in Arabic:
Unlike English, which has only two numbers, singular and plural, Arabic has a third number called dual. It is applied to situations where there are two individuals being referred to, as a group. To form a dual masculine adjective from a singular masculine, one can add ان (aːn) or ين (ajn) to the end of the adjective. For instance:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) كبيران, (kaːbiːraːn, Big-dual-masculine-indefinite).

On the other hand, a dual feminine adjective can be formed by adding تان (taːn) or تين (tajn) to the end of a singular masculine adjective:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) كبيرتان, (kaːbiːrtaːn, Big-dual-feminine-indefinite).

4) Plural Adjectives in Arabic:
To form a plural masculine adjective, one can add ون (oːn) or ين (iːn) to the end of the singular masculine adjective. For instance:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) كبيرون, (kaːbiːroːn, Big-plural-masculine-indefinite).

On the other hand, a plural feminine adjective can be formed by adding ات (aːt) to the end of the singular masculine adjective:

(1) كبير, (kaːbiːr, Big-singular-masculine-indefinite).

(2) كبيرات, (kaːbiːraːt, Big-plural-feminine-indefinite).

Note that the rules mentioned in I-A1, I-A2, I-A3, and I-A4 are not always applicable, as there are some exceptions [4]. Due to space constraints, we leave investigating these exceptions to the reader.

II. MADAMIRA Arabic Morphological Analyzer

TABLE I
The morphological features provided by MADAMIRA and their descriptions.

Feature	Description
diac	word with diacritic markers
lex	lexicon
asp	aspect
cas	case
enc	enclitic values
gen	gender
mod	mood
num	number
per	person
pos	part-of-speech
prc	proclitic values
stt	state
vox	voice
gloss	English gloss
stem	stem
source	source of the word analysis

TABLE II
The morphological features provided by MADAMIRA for the sentence ممتاز فندق (IPA: funduq mumtaːz, English: excellent hotel, word by word: hotel excellent-singular-masculine-indefinite). Descriptions of the features provided in Table I.

Feature	فندق (Hotel)	ممتاز (Excellent)
diac	فُندُقٍ	مُمتازٌ
lex	فندق	ممتاز
asp	na	na
cas	n	n
enc	0	0
gen	m	m
mod	na	na
num	s	s
per	na	na
pos	noun	adj
prc	0	0
stt	i	i
vox	na	na
gloss	hotel	excellent; superior
stem	فندق	ممتاز
source	lex	lex

TABLE III
The morphological features provided by MADAMIRA for the sentence سيئة رواية (IPA: riwaːjaːh saːjah, English: Bad novel, word by word: novel bad-singular-feminine-indefinite). Descriptions of the features provided in Table I.

Feature	رواية (Novel)	سيئة (Bad)
diac	روايَةً	سَيِئَةً
lex	رُوايَة	سيىءٌ
asp	na	na
cas	n	n
enc	0	0
gen	f	f
mod	na	na
num	s	s
per	na	na
pos	noun	adj
prc	0	0
stt	i	i
vox	na	na
gloss	novel; story	bad
stem	رواي	سيىءٌ
source	lex	lex

References

[1] A. Farghaly, "Three level morphology for arabic," in *Proceedings of the Arabic Morphology Workshop, Linguistics Summer Institute, Stanford, CA*, 1987.

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[3] M. S. Al Mahmoud, "Prenominal and postnominal adjectives in arabic: A proposed analysis," *SAGE Open*, vol. 4, no. 2, pp. 1–8, 2014.

[4] E. A. R. Hobi, "A contrastive study of attributive adjectives in English and Arabic," *Al-Ma'mon College Journal*, no. 17, pp. 264–274, 2011.