Unified Simplified Grapheme Acoustic Modeling for Medieval Latin LVCSR

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SpeechTex

What is the problem with Latin speech recognition?

- Latin is not spoken natively
- There is no available speech database, and it is resource-heavy to create one
- Many variants/dialects exists, and we can only make guesses about the pronunciation
- The pronunciation mainly depends on
  - the era of the read text
  - the native language of the speaker

Text data

Regions of origin: Kingdom of Bohemia (CZ), Kingdom of Hungary (HU), Kingdom of Poland (PL)

- In-domain data (Monasterium): medieval charters (HU), 480k/35k token/type
- Background data (Latin Library): historical texts, 1.3M/115k token/type

Spelling variants

jam	iam
judex	iudex
gracia	gratia

Speech data

Languages: CZ, HU, PL, RO

Test data

- Independent medieval charters
- Region of read text: CZ, HU, PL
- Native language of test speakers: CZ, HU, PL, SK

Perplexity measures on test

Table 1: Perplexity/OOV rate

	Text region			
Corpus	CZ	HU	PL	All
Monasterium	551	82	3130	671
Latin Library	3266	3549	2305	4303
Interpolated	924	82	2288	953

Language model

Acoustic model

Dimensions of data

Native language of test speakers: CZ, HU, PL, SK

Region of read text: CZ, HU, PL

Speech data: CZ, HU, PL, RO

Model type: baseline, knowledge-based, USG

Baseline Grapheme Model

Languages: Czech (CZ), Hungarian (HU), Polish (PL), Romanian (RO)

- All graphemes are trained
- Only those grapheme models are retained that are part of the Latin alphabet

Table 2: Word Error Rate (WER[%]) results for monolingual grapheme-based acoustic models of Czech, Hungarian, Polish and Romanian (CZ, HU, PL, RO).

	Speaker				
AM Language	CZ	HU	PL	SK	$\sum$
CZ	53.6	73.8	62.9	45.7	59.0
HU	33.7	28.6	47.1	29.1	**34.6**
PL	65.0	67.6	46.4	51.1	57.5
RO	53.6	69.1	44.7	43.8	52.8

Knowledge-based grapheme-to-phoneme (G2P) mapping

Languages: CZ, HU

Table 3: Latin digraph context-insensitive rewrite rules.

	Digraph			
	ae	oe	ph	qu
CZ	e	oe	f	kv
HU	e	ø	f	kv

Table 4: Latin context-sensitive rewrite rules. V: vowel, VP: palatal vowel, ^VP: everything but a palatal vowel, C: consonant, $*$: zero or any, ^: beginning of word, $[\hat{}\,stx]$: not s, t or x.

GR	c	c	ch	ch	gu	gu	ti	ti
PH	ts	k	h	k	gv	gu	tsi	ti
rule	cVP	c^VP	VC*ch	^C*ch	guV	guC	$[\hat{}\,stx]$tiV	tiC

Table 5: WER[%] for Czech-Latin source-target G2P model. Acoustic model training set: 76 hours.

	Latin Test Text			
Speaker	CZ	HU	PL	$\sum$
CZ	43.8	28.2	49.1	40.4
HU	48.7	40.0	58.7	49.1
PL	53.3	18.2	53.2	41.6
SK	30.3	30.0	44.0	34.8
$\sum$	43.9	28.9	50.8	41.2

Table 6: WER[%] for Hungarian-Latin source-target G2P model. Acoustic model training set: 567 hours.

	Latin Test Text			
Speaker	CZ	HU	PL	$\sum$
CZ	19.4	**6.4**	28.0	17.9
HU	25.0	25.4	20.2	23.5
PL	28.9	15.4	41.3	28.5
SK	20.4	**9.1**	22.9	17.5
$\sum$	22.6	12.5	28.1	**21.1**

Unified Simplified Grapheme (USG) Model

Languages: CZ, HU, PL, RO

Table 7: Simplification examples for the unified model.

Language	CZ	HU	PL	RO
Orthographic form	řekl	őz	miś	apă
USG transcription	rekl	oz	mis	apa

Table 8: WER[%] for all the three-language USG models.

	Speaker				
AM Language	CZ	HU	PL	SK	$\sum$
CZ+HU+PL	28.2	28.2	27.7	22.4	26.6
CZ+HU+RO	23.3	21.4	23.9	19.2	**21.9**
CZ+PL+RO	24.6	33.1	25.6	19.8	25.8
HU+PL+RO	24.8	21.5	25.7	20.7	23.2

Table 9: WER[%] for USG model of Czech, Hungarian, Polish and Romanian (CZ+HU+PL+RO).

	Latin Test Text			
Speaker	CZ	HU	PL	$\sum$
CZ	20.4	11.8	30.7	21.0
HU	21.1	14.6	25.7	20.5
PL	23.0	**10.0**	33.0	22.0
SK	14.5	12.7	24.8	17.3
$\sum$	19.9	12.2	29.0	**20.4**

Conclusions

- Four-language USG is the best
- It is able to generalize over different speaker test sets