The SIGMORPHON 2016 shared task—morphological reinflection

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Shared task

- SIGMORPHON's first shared task!
- First shared task on supervised learning of (inflectional) morphology
- featuring …
  - 3 tasks
  - 3 "tracks"
  - 10 languages
  - 9 systems submitted

Shared task

Overview

- Tasks [MH]
- Language data [CK]
- Systems overview & results [RC]

Shared task

Tasks

- 1 Inflection (synthesis/generation)
- 2 Reinflection (analysis + synthesis)
- 3 Unlabeled Reinflection

Task 1 (inflection)

train

lemma MSD (feature/value pairs) word form

test

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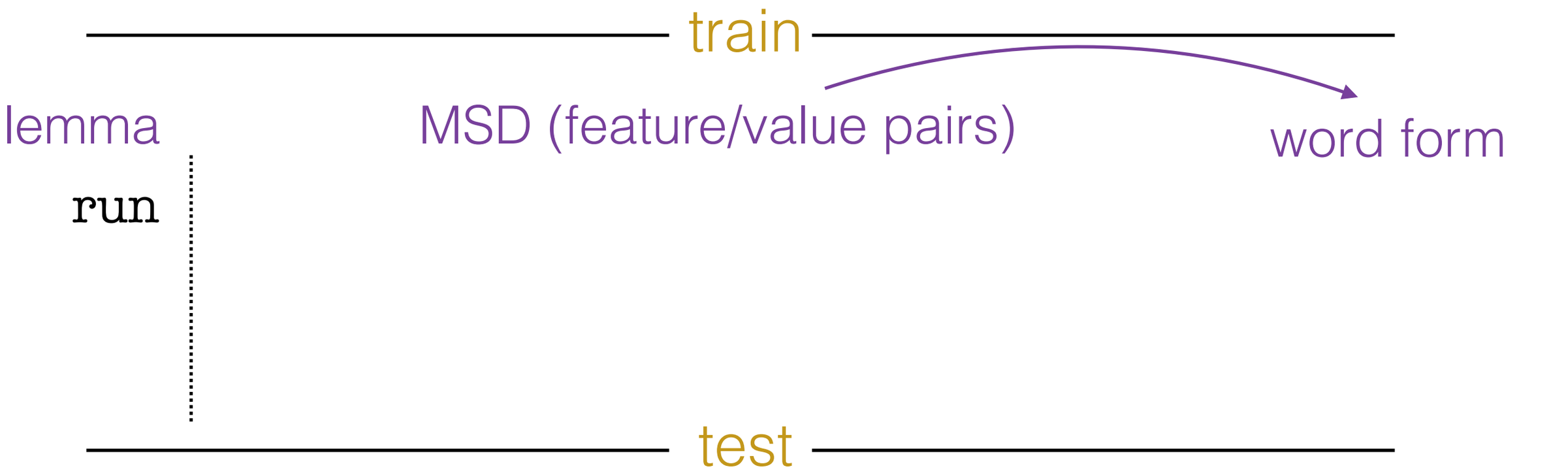
Task 1 (inflection)



Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	

test

Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	ran

test

Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	ran
love	pos=V,tense=PRS	loving
eat	pos=V,mood=IND,tense=PST,per=1,num=SG	ate
	...	

test

Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	ran
love	pos=V,tense=PRS	loving
eat	pos=V,mood=IND,tense=PST,per=1,num=SG	ate
	...	

test

hate	pos=V,tense=PRS	?

Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	ran
love	pos=V,tense=PRS	loving
eat	pos=V,mood=IND,tense=PST,per=1,num=SG	ate
	...	

test

hate	pos=V,tense=PRS	?
read	pos=V,mood=IND,tense=PST,per=3,num=SG	?

Task 1 (inflection)

train

lemma	MSD (feature/value pairs)	word form
run	pos=V,mood=IND,tense=PST,per=3,num=SG	ran
love	pos=V,tense=PRS	loving
eat	pos=V,mood=IND,tense=PST,per=1,num=SG	ate
	...	

test

hate	pos=V,tense=PRS	hating
read	pos=V,mood=IND,tense=PST,per=3,num=SG	read

Training data

Conjugation [edit]

conjugation of schreiben [hide ▲]

infinitive	schreiben				
present participle	schreibend				
past participle	geschrieben				
auxiliary	haben				
	indicative			**subjunctive**	
present	ich schreibe	wir **schreiben**	**i**	ich schreibe	wir **schreiben**
	du schreibst	ihr schreibt		du schreibest	ihr schreibet
	er schreibt	sie **schreiben**		er schreibe	sie **schreiben**
preterite	ich schrieb	wir schrieben	**ii**	ich schriebe	wir schrieben
	du schriebst	ihr schriebt		du schriebest	ihr schriebet
	er schrieb	sie schrieben		er schriebe	sie schrieben
imperative	schreib (du) schreibe (du)	schreibt (ihr)			

composed forms of schreiben [show ▼]

Training data

Conjugation [edit]

conjugation of schreiben [hide ▲]

infinitive					
present participle			schreibend		
past participle					
auxiliary			haben		
	indicative			**subjunctive**	
present	ich schreibe	wir **schreiben**	**i**		wir **schreiben**
					ihr schreibet
				er schreibe	
preterite		wir schrieben	**ii**	ich schriebe	wir schrieben
imperative	schreib (du)				

composed forms of schreiben [show ▼]

Training data

Conjugation [edit]

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present participle			schreibend		
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present	ich schreibe	wir **schreiben**	**i**		wir **schreiben**
					ihr schreibet
				er schreibe	
preterite		wir schrieben	**ii**	ich schriebe	wir schrieben
imperative	schreib (du)				

composed forms of schreiben [show ▼]

schreiben pos=V,mood={OPT/SBJV},tense=PRS,per=1,num=PL schreiben

WIKTIONARY
the free dictionary

Task 2 (reinflection)

train

MSD1 form1 MSD2 form2

test

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Task 2 (reinflection)

train

MSD1	form1	MSD2	form2
pos=V,tense=PRS	running	pos=V,tense=PST	ran

test

Task 2 (reinflection)

train

MSD1	form1	MSD2	form2
pos=V,tense=PRS	running	pos=V,tense=PST	ran

...

test

pos=V,tense=PST	sought	pos=V,tense=INF	

Task 2 (reinflection)

train

MSD1	form1	MSD2	form2
pos=V,tense=PRS	running	pos=V,tense=PST	ran

...

test

pos=V,tense=PST	sought	pos=V,tense=INF	?

...

Task 2 (reinflection)

train

MSD1	form1	MSD2	form2
pos=V,tense=PRS	running	pos=V,tense=PST	ran

...

test

pos=V,tense=PST	sought	pos=V,tense=INF	seek

...

Task 3 (unlabeled reinflection)

train

MSD1	form1	MSD2	form2
pos=V,tense=PRS	running	pos=V,tense=PST	ran

...

test

pos=V,tense=PST	sought	pos=V,tense=INF	seek

...

Task 3 (unlabeled reinflection)

train

~~MSD1~~	form1	MSD2	form2
~~pos=V,tense=PRS~~	running	pos=V,tense=PST	ran

...

test

~~MSD1~~	form1	MSD2	form2
~~pos=V,tense=PST~~	sought	pos=V,tense=INF	seek

...

Task 3 (unlabeled reinflection)

train

form1	MSD2	form2
running	pos=V,tense=PST	ran

...

test

sought	pos=V,tense=INF	seek

...

Summary of tasks

Summary of tasks

auto

Lemma > inflection

Task 1

		singular	plural
nominative		auto	autot
accusative	nom.	auto	autot
	gen.	auton	
genitive		auton	autojen
partitive		autoa	autoja
inessive		autossa	autoissa
elative		autosta	autoista
illative		autoon	autoihin
adessive		autolla	autoilla
ablative		autolta	autoilta
allative		autolle	autoille
essive		autona	autoina
translative		autoksi	autoiksi
instructive		—	autoin
abessive		autotta	autoitta
comitative		—	autoineen

Finnish

Summary of tasks

Task 1

auto

Lemma > inflection

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Finnish

Summary of tasks

Task 2

auto inflection > inflection

		singular	plural
nominative		auto	autot
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Finnish

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Task 2

Finnish

Summary of tasks

auto unk > inflection

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Task 3

?

autona

Finnish

Summary of tasks

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Finnish

Summary of tasks

auto unk > inflection

Task 3

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auto inflection > inflection

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Finnish

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unk > inflection

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Finnish

Summary of tasks

Task 3 (reduction)

auto

unk > inflection

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autona

Finnish

Tracks

	Restricted	Standard	Bonus
Task 1	1	1	1, M
Task 2	2	1, 2	1, 2, M
Task 3	3	1, 2, 3	1, 2, 3, M

Tracks

	Restricted	Standard	Bonus
Task 1	1	1	1, M
Task 2	2	1, 2	1, 2, M
Task 3	3	1, 2, 3	1, 2, 3, M

can reduce

Tracks

	Restricted	Standard	Bonus
Task 1	1	1	1, M
Task 2	2	1, 2	1, 2, M
Task 3	3	1, 2, 3	1, 2, 3, M

can't reduce

can reduce

Tracks

	Restricted	Standard	Bonus
Task 1	1	1	1, M
Task 2	2	1, 2	1, 2, M
Task 3	3	1, 2, 3	1, 2, 3, M

can't reduce

can reduce

can reduce+
raw text dumps

Evaluation

Three types, averaged over all inputs

- Accuracy (0/1)
- Levenshtein distance to gold form
- Reciprocal rank (for multiple guesses)
  - $1/\text{rank}_i$ (rank_i = position of gold form among guesses)

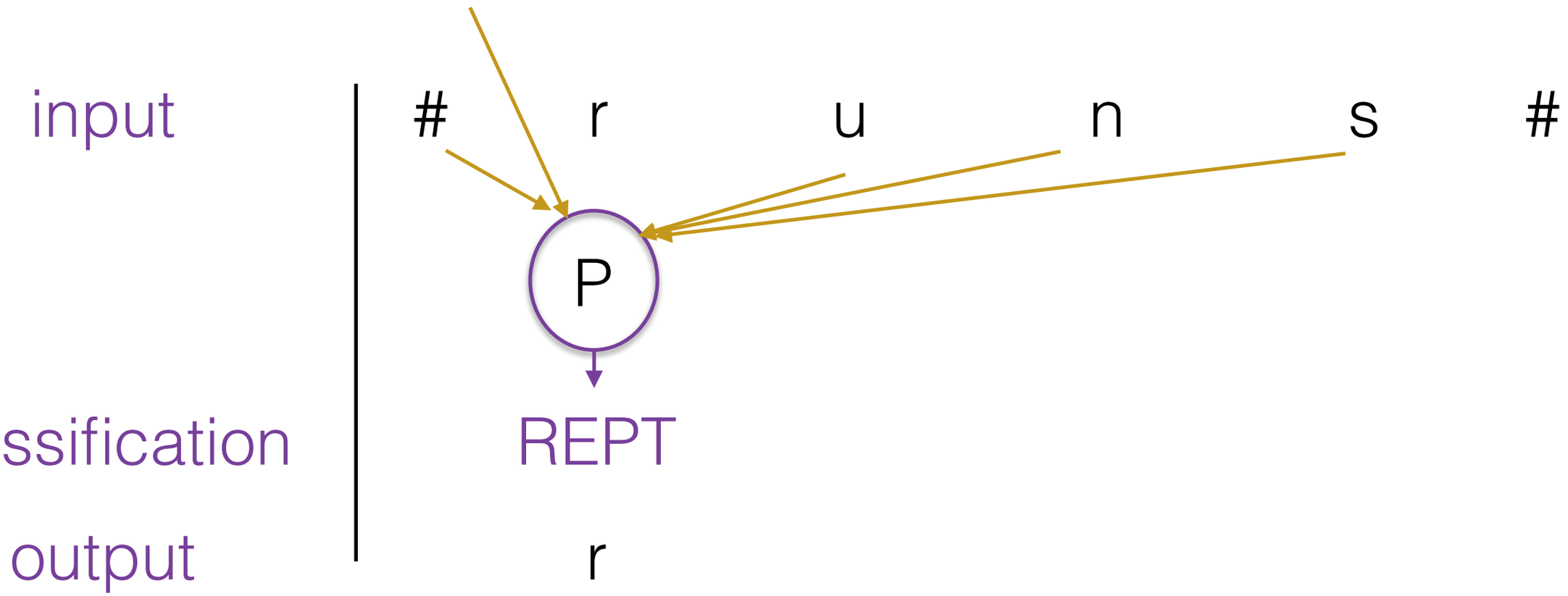
Baseline

- Simple discriminative string transduction (similar to recent work*)
- Classifier is averaged perceptron
- Applies greedy labeling of input characters, given target features + features of surrounding characters, previous decisions

*Durrett & DeNero (2013), Nicolai et al (2015)

Baseline

source = [pos=V,tense=PRES…]
target = lemma



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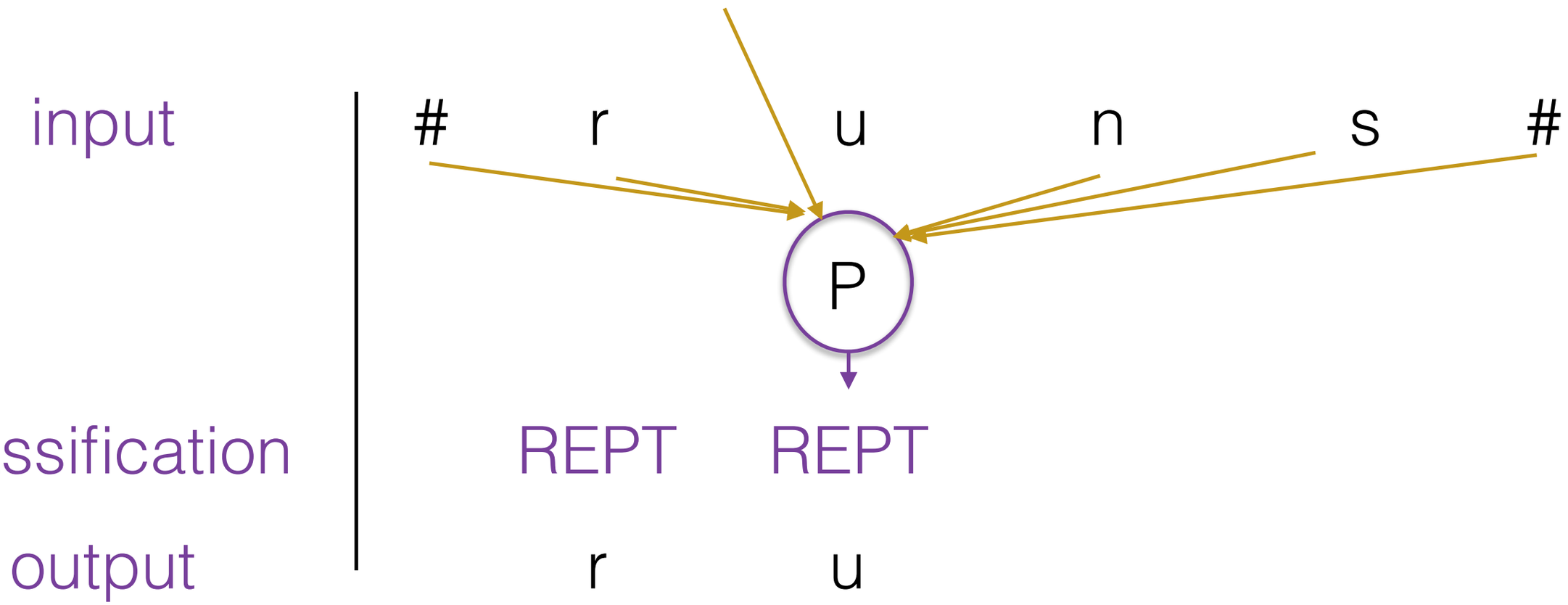

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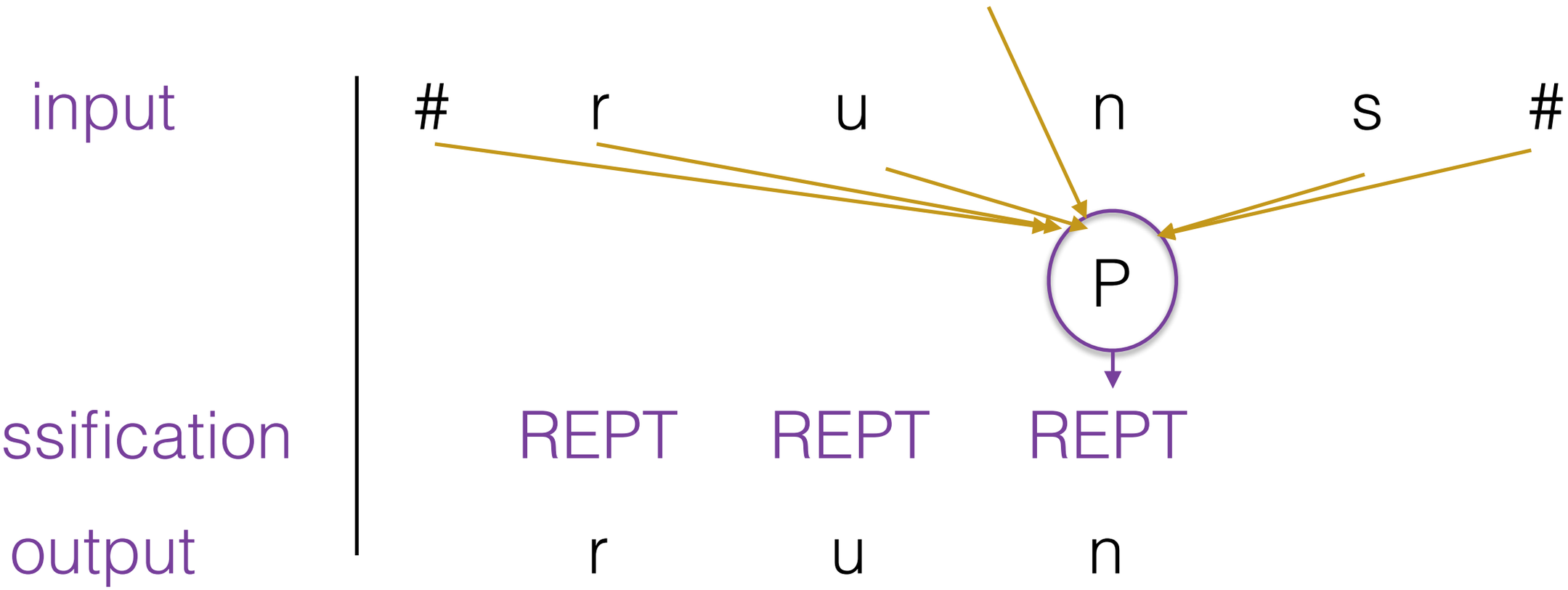

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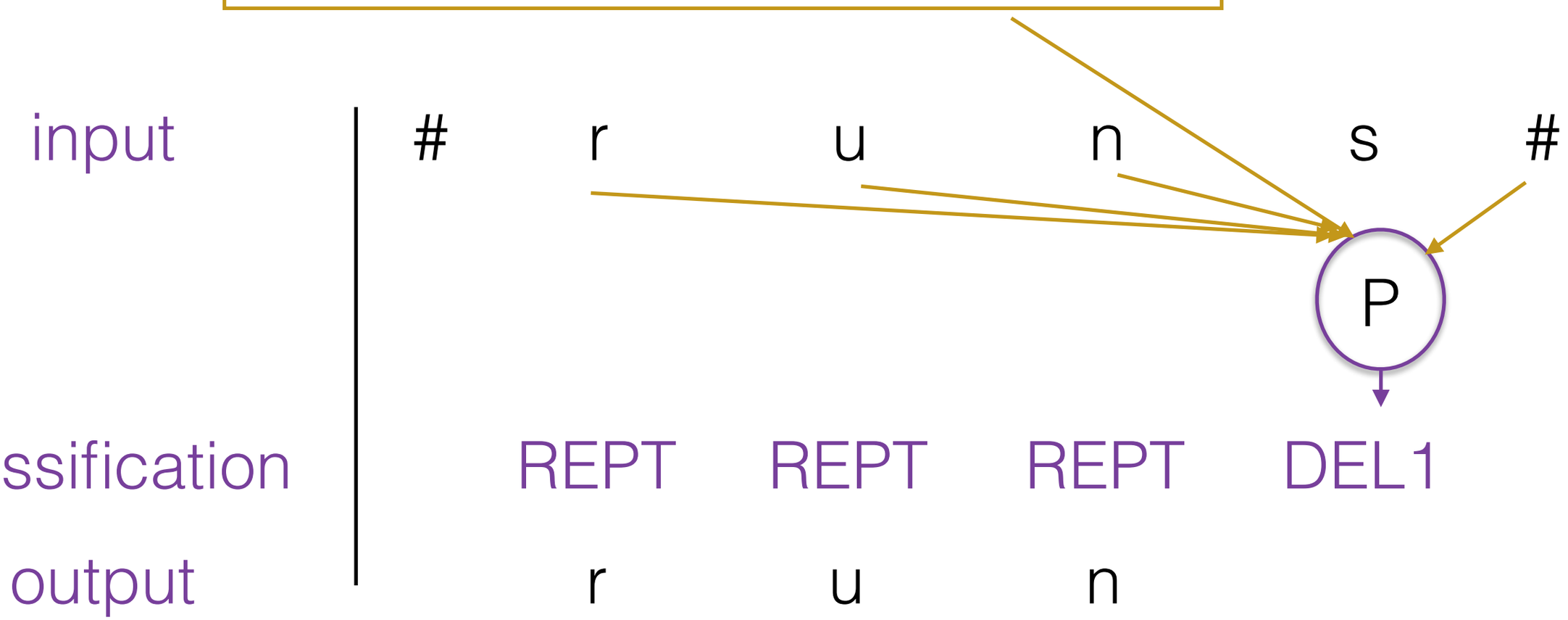

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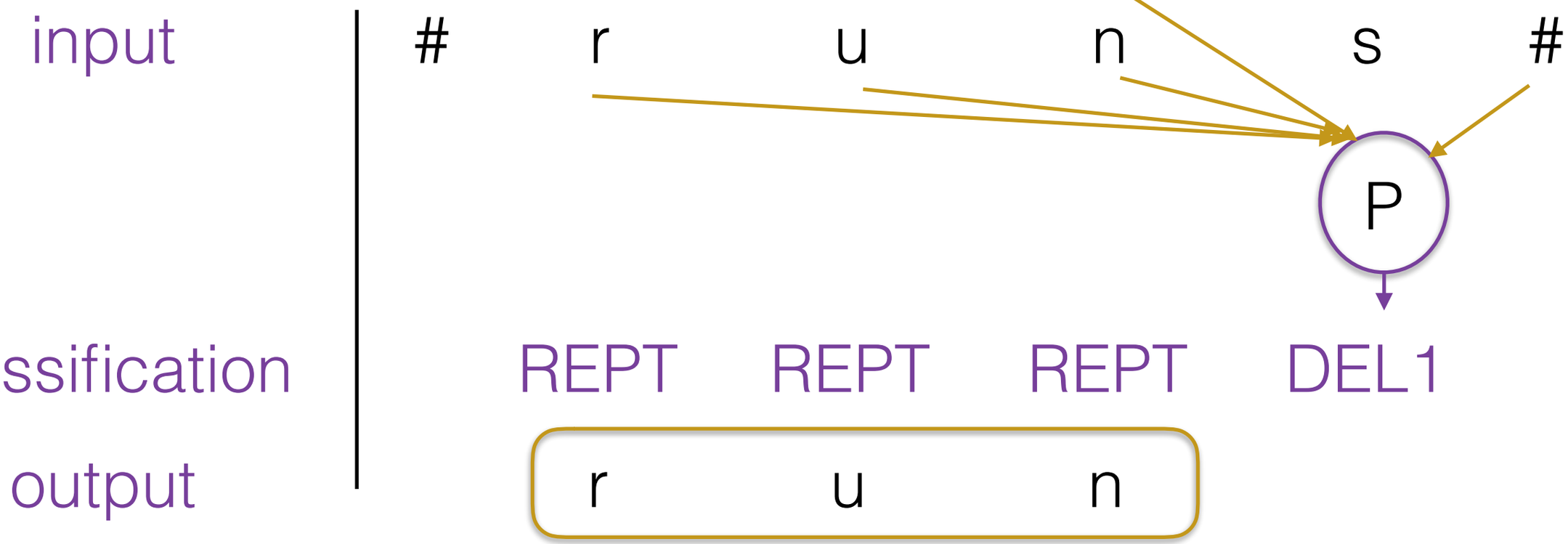

Data Overview

- N, V, ADJ paradigms from 10 languages
- 8 Development Languages
  - Arabic, Finnish, Georgian, German, Navajo, Russian, Spanish, Turkish
- 2 Surprise Languages
  - Hungarian, Maltese

Morphological Processes

- German, Russian, Spanish
  - Fusional suffixing with stem changes (Sp. *denostar* → *denuesto*)
- Finnish, Hungarian, Turkish
  - Agglutinating suffixing with vowel harmony
  - (Tr. *akbaba* → *akbabalar, başkent* → *başkentler*)
- Navajo
  - Prefixing with sibilant consonant harmony (*atsee'* → *sitsee', á'ázhoozh* → *shí'ázhoozh*)
- Georgian
  - Circumfixing (აბრუნებს *abrunebs* → ვაბრუნებთ *vabrunebt*)
- Arabic, Maltese
  - Templatic, non-concatenative morphology (Maltese also concatenating from Italian contact; Ar. *kātaba* → *ʾukātib, Ma. irreaġixxa* → *irreaġejt*)

Data Sources

- 9 Languages except Maltese (Arabic, Spanish, German, Georgian, Russian, Turkish, Hungarian, Navajo, Finnish): Wiktionary (wiktionary.org)

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Wiktionary Collection

Navajo

IMPERFECTIVE	singular	duoplural	plural
1st person	ashchį'	iichį'	da'iichį'
2nd person	íchį'	ohchį'	da'ohchį'
3rd person	achį'		da'achį'
4th person	ajichį'		da'jichį'
PERFECTIVE	**singular**	**duoplural**	**plural**
1st person	ashéchąą'	ashiichąą'	da'shiichąą'
2nd person	ashíníchąą'	ashoochąą'	da'shoochąą'
3rd person	azhchąą'		da'azhchąą'
4th person	ajizhchąą'		da'jizhchąą'

Lemma	Inflection	Features
achį’	iichį’	V;REAL;1;{DU/PL},{IPFV/PROG}
achį’	da’iichį’	V;REAL;1;PL,{IPFV/PROG}
achį’	ashchį’	V;REAL;1;SG,{IPFV/PROG}
…	…	…

Wiktionary Collection

- Current full parse available at unimorph.org
- Extraction/verification described in (Kirov et al. 2016. *Very large scale parsing and normalization of Wiktionary morphological paradigms*. LREC.)
- UniMorph feature format described in (Sylak-Glassman et al. 2015 *A language-independent feature schema for inflectional morphology*. ACL.)

Maltese

- Maltese: Ġabra Open Lexicon (Camilleri, 2013, http://mlrs.research.um.edu.mt/resources/gabra/)
  - Used as-is except for features remapped to UniMorph

marmar

Part of speech
Verb I
English gloss
to complain
to whine
Root
m-r-m-r[1]
Features
intrans.
Source(s)
Spagnol2011
Modified
2015-11-30 15:43 +0100

Word forms 1072

Show all forms

Surface form	Aspect	Subject	Direct Object	Indirect Object	Polarity
			Empty	Empty	Positive
marmart	Perfective	P1 Sg			Positive
marmart	Perfective	P2 Sg			Positive
marmar	Perfective	P3 Sg Masc			Positive
marmret	Perfective	P3 Sg Fem			Positive

Data Sampling and Presentation

- Subset of all available data used for shared task
  - Train/Dev/Test forms sampled according to λ-smoothed unigram distribution in Bonus Track corpus data (Wikipedia)
- All data presented using native orthography, except Arabic
  - Arabic used Wiktionary romanization (DIN 31635)
  - No phonological transcriptions provided

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Training Data Statistics

	Reinflection Pairs	Lemmas	Tags	Examples Per Tag Pair
Arabic	12616	2130	225	1.57
Finnish	12764	9855	95	5.70
Georgian	12390	4246	90	14.02
German	12689	6703	99	7.76
Hungarian	18206	1508	83	9.05
Maltese	19125	1453	**3607**	**1.00**
Navajo	10478	355	54	17.48
Russian	12663	7941	83	10.32
Spanish	12725	5872	84	3.24
Turkish	12645	2353	190	1.81

Meet Our Competitors

- For convenience, we categorized the submitted systems into three camps
- Camp 1: Align and Transduce
- Camp 2: Revenge of the RNN
- Camp 3: Time for Some Linguistics

Camp 1: Align and Transduce

- Drew inspiration from the work of Durrett and DeNero (2013)
- Heuristically extract a set of edit transformations
- Apply transformations with a semi-Markov model

EHU (Alegria and Etxeberria 2016)

- Argued that morphological reinfection is very similar to the grapheme-to-phoneme problem
- Extended the Phonetisaurus (Novak et al. 2012) toolkit, which is based on OpenFST (Allauzen et al. 2007)

Alberta (Nicolai et al. 2016)

- First run M2M-aligner (Jiampojamarn et al., 2007) — allows many-to-many alignments
- Train discriminative transduction algorithm DirectTL+ model (Jiampojamarn et al., 2008).
- Add a discriminative reranker on top!

Colorado (Liu and Mao 2016)

- Made use of baseline unsupervised alignment system
- Applied semi-CRF solution of Durrett and DeNero (2013)
- Unsupervised discovery of C/V segments for features

OSU (King 2016)

- Unsupervised alignments with Hirschberg's algorithm (Hirschberg 1975)
- Applied a 1st order semi-CRF to apply the edits
  - Very expensive compared to the 0th order model of Durrett and Denero (2013)

Camp 2: Revenge of the RNN

- Took inspiration from recent advances in neural MT
- Most frameworks based on the encoder-decoder model (Cho et al. 2014, *inter alia*)
- Rather than words, translate characters
- Achieved the best results

LMU (Kann and Schütze 2016)

- Builds off of the encoder-decoder model for machine translation
- Input word with source and target tag are formatted as a single string and fed to the network
- Won the shared task!

BIU-MIT (Aharoni et al. 2016)

- Extension of the encoder-decoder architecture
- Include extensions for templatic morphology
- Second place team (on average)

Helsinki (Östling 2016)

- Again, neural encoder-decoder architecture
- Added an additional convolutional layer over the characters
- Third place team!

Camp 3: Time for Some Linguistics

- Relied heavily on linguistic-inspired methods
- Reduces the problem to multi-way classification

Moscow State (Sorokin 2016)

- Uses longest common substring to compute an ‘abstract paradigm’
- In short, learn a joint set of rules for every slot in the paradigm (Ahlberg et al. 2015)
- Generated candidate set and used an SVM classifier

Columbia/NYUAD (Taji et al. 2016)

- The input words are first segmented into prefixes, stems, and suffixes
- Stems are further processed
- Sets of patterns are extracted and applied to the stems

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Results

	Standard			Restricted		
System	Task 1	Task 2	Task 3	Task 1	Task 2	Task 3
LMU-1	1.0 (95.56)	1.0 (96.35)	1.0 (95.83)	1.0 (95.56)	1.0 (95.34)	1.0 (90.95)
LMU-2	2.0 (95.56)	2.0 (96.23)	2.0 (95.83)	2.0 (95.56)	2.0 (95.27)	2.0 (90.95)
BIU/MIT-1	—	—	—	4.2 (92.65)	5.2 (77.70)	3.8 (76.39)
BIU/MIT-2	—	—	—	4.2 (93.00)	4.2 (81.29)	—
HEL	—	—	—	3.9 (92.89)	3.5 (86.30)	3.2 (86.48)
MSU	3.8 (84.06)	3.6 (86.06)	3.8 (84.87)	6.2 (84.06)	6.0 (79.68)	6.2 (62.16)
CU	4.6 (81.02)	5.0 (72.98)	5.0 (71.75)	7.3 (81.02)	6.9 (69.89)	5.5 (67.91)
EHU	5.5 (79.24)	—	—	8.0 (79.67)	—	—
COL/NYU	6.5 (67.86)	4.7 (75.59)	4.8 (67.61)	9.2 (67.86)	7.2 (77.34)	6.3 (53.56)
OSU	—	—	—	9.0 (72.71)	—	—
UA	4.6 (81.83)	4.7 (74.06)	4.4 (71.23)	—	—	—
ORACLE.E	97.49	98.15	97.97	98.32	97.84	95.80

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Neural Systems Results

System	Standard Task 1	Standard Task 2	Standard Task 3	Restricted Task 1	Restricted Task 2	Restricted Task 3
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ORACLE.E	97.49	98.15	97.97	98.32	97.84	95.80

Thank you

- Training/Dev/Test data available at
  - http://sigmorphon.org/sharedtask

Questions?
Suggestions?
Comments?