Advancing the study of endangered languages with computational tools for morphology

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ADVANCING THE STUDY OF ENDANGERED LANGUAGES WITH COMPUTATIONAL TOOLS FOR MORPHOLOGY

The case of Asama verb paradigms

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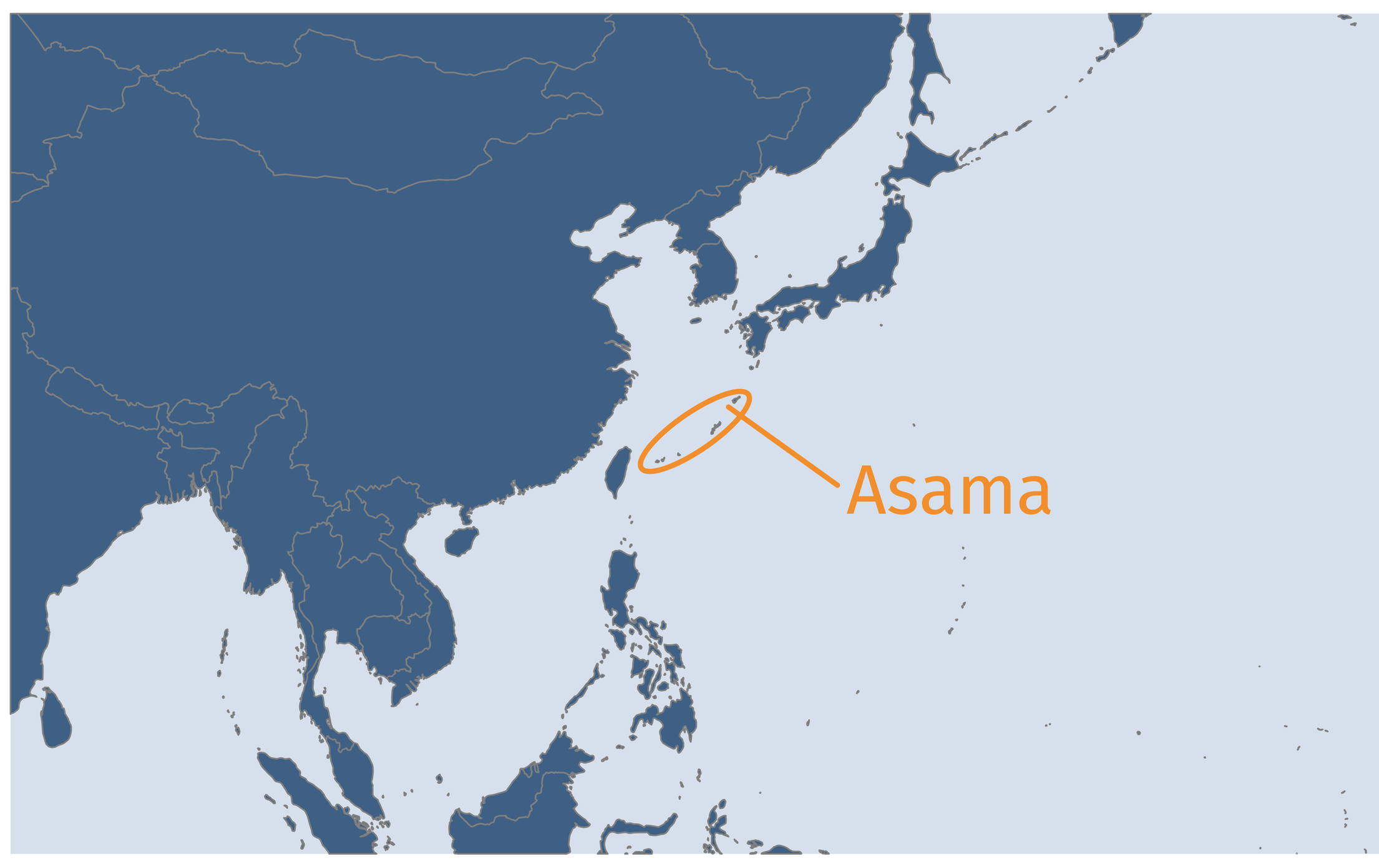
ASAMA



- Endangered Ryukuan language (Japonic family).
- Reference grammar project by D. Lévêque.
- 100 full + 400 near-full inflectional verb paradigms collected.
- Non-canonical phenomena (e.g. alternation of tones and vowel length) in verb inflection.

	'to sell'	'to knit'	'to go out'
NPST	*ujui* H	*amjui* H	*izjɨjui* LH
CVB2	*urugəəsɨ* H	*amjugəəsɨ* H	*izjɨrugəəsɨ* LH
NEG	*uran* H	*aman* H	*izjɨran* LH
DIMP	*uroo* H	*amoo* H	*izjɨroo* LH
IIMP	*urɨɨ* H	*aamɨ* HL	*izjɨɨrɨ* LH
CVB	*ui* H	*amii* H	*izjɨɨ* LH
DES	*uicjaahai* H	*amicjaahai* H	*izjɨcjaahai* LH
PST	*utan* H	*adan* H	*izjɨtan* LH
SEQ	*utɨɨ* H	*aadɨ* HL	*izjɨɨtɨ* LH
PROG	*utui* LHL	*aadui* HL	*izjɨɨtui* LHL

1 LINGUISTIC DOCUMENTATION

GOALS To **speed up and ease** the glossing of texts.

ISSUES Small amount of data, limited time, usual tools (Toolbox) not well-fitted to non-concatenative phenomena.

SOLUTION The transducer produces **complete paradigms** for all existing lexemes.

AMJUI LH →
- ⟨*aman* LH, NEG⟩
- ⟨*amoo* H, DIMP⟩
- ⟨*aamɨ* LH, IIMP⟩
- ⟨*aadɨ* H, SEQ⟩
- ...

```
tourner-IPFV-PART-PROH máwaj-u-N-na
tourner-IPFV-PST-PART máwaj-ut-a-N
```

RESULTS A simple Python script is used to format the output, which can then be directly imported into Toolbox and used in the process of interlinearisation.

```
\lx máwajunna
\mo máwaj-u-n-na
\ge tourner-IPFV-PART-PROH

\lx máwajutaN
\mo máwaj-ut-a-N
\ge tourner-IPFV-PST-PART
```

WHY COMPUTATIONAL TOOLS?

- "The insufficiency of paper-and-pencil linguistics" (Karttunen 2006).
- Finite-state transducers (Beesley & Karttunen 2003).
- Bidirectional:

  PRODUCTION lexeme/root → inflected form;
  RECOGNITION inflected form → lexeme/root.
- Syntax similar to that of phonological rewrite rules familiar to many linguists.

```
regex V -> 0 || V V _  ;
regex i -> ɨ || r _ ;
regex 0 -> j || s _ a ;
```

- FSTs have sufficient power to handle (almost) any morphological phenomena.
- Provide a maximally precise and explicit description.
- Free software implementations (Foma).

2 LINGUISTIC ANALYSIS

GOALS **Check** the accuracy of the description and test hypotheses on new lexemes.

ISSUES Non-canonical verb morphology, multiple classes.

DESCRIPTION Two orthogonal sets of rules associated with two sets of classes.

T_1	T_2	T_3	T_4	T_5
Xbj	-	Xb	Xb	Xd
Xmj	-	Xm	Xm	Xd
Xkj	-	Xk	Xk	Xcj
Xcj	-	Xc	Xt	Xccj
Xj	X	Xr	Xr	Xcj
Xj	X	Xr	Xr	Xccj
Xj	X	X	Xr	Xtt

Class	**NPST**	**IMP.DIR**	**SEQ**
I1	RT$_1$ui (H)	R:T$_4$ɨ (H)	RT$_5$ui (H)
I2	RT$_1$ui (H)	R:T$_4$ɨ (H)	RT$_5$ui (H)
II1	RT$_1$ui (H)	RT$_4$ɨɨ (H)	RT$_5$ui (LHL)
II2	RT$_1$ui (H)	R:T$_4$ɨ (H)	RT$_5$ui (LHL)
III	RT$_1$ui (LH)	R:T$_4$ɨ (HL)	R:T$_5$ui (HL)
IV	RT$_1$ui (LH)	R:T$_4$ɨ (LH)	R:T$_5$ui (LHL)
V	RT$_1$ui (HL)	RT$_4$ɨ (HL)	RT$_5$ui (HL)

SOLUTIONS FSTs allow to:
- Check the formal description on lexemes and highlight the problems (comparison between data and output);
- Test the results with the speaker (computation of the whole paradigm for lexemes with incomplete data and check with the speaker).

RESULTS Robustness of formal analysis is confirmed by the computational study, and lacks of data in the description are highlighted.

BENEFITS OF USING COMPUTATIONAL TOOLS

1. Test the accuracy and coverage of the analysis of the morphology.
2. Partially automate the glossing of texts.
3. Enable quantitative measures of morphological complexity.

⇒ Advance the study of endangered languages.

IMPLEMENTATION

- Content paradigm cell ⟨L, σ⟩ → realised cell w
  ⟨AMJUI LH, SEQ⟩ → *aadɨ* HL
- Unlabeled form w → all possible analyses ⟨L, σ⟩

aadɨ HL →
- ⟨AMJUI LH, SEQ⟩
- ⟨AAMJUI H, SEQ⟩
- ⟨ABJUI LH, SEQ⟩
- ⟨AABJUI H, SEQ⟩

- L → full realised paradigm, i.e. a set of cells $\{\langle w, \sigma\rangle, \langle w', \sigma'\rangle, \ldots\}$).
- Any realised form ⟨L, σ⟩ → list of all possible realised forms of any other paradigm cell.

3 THEORETICAL MORPHOLOGY

GOALS Exploring the **implicative structure** with complexity measures and Shannon **entropy** and solve the *Paradigm Cell Filling Problem* ("What licenses reliable inferences about the inflected (and derived) surface forms of a lexical item?", Ackerman et al. 2009: 54).

ISSUES Too few full paradigms, no pre-existing interactive database.

SOLUTION Composition of two FSTs in order to obtain for any given realized cell ⟨w, σ⟩ the list of all possible realized forms of any other paradigm cell.

omoorɨ LH SEQ →
- *omotui* LHL PROG.NPST
- *omocjui* LHL PROG.NPST
- *omootui* LHL PROG.NPST
- *omoocjui* LHL PROG.NPST
- ...

RESULTS Entropy measures help identifying the **sources of uncertainty** (unpredictable segmental alternations, neutralisation of vowel length and neutralisation of tone) and the **principal parts** of the system (Finkel & Stump 2007).

$H(C\|L)$	NPST	CONV	IIMP	SEQ	PROG.NPST
NPST		0.000	0.000	0.222	0.244
CONV	0.923		0.082	0.296	0.550
IIMP	0.950	0.211		0.222	0.525
SEQ	1.362	1.012	0.425		0.317
PROG.NPST	1.204	0.910	0.423	0.000	

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