Logical Metalanguage for Linguistic Description

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Motivation

- **Background**: Linguistics is the scientific description of language
- **Problem**: What metalanguage do you use to describe language?
- **Solution**: Develop a computational+logical metalanguage for linguistic description
- **Illustration:** Use it to describe Armenian
- **Implementation:** Develop software to run logical formula for linguistics (phonology & morphology)

What's linguistics for

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  - Theoretical linguists
  - Computational linguists
    1. Develop computational resources
    2. Industrial NLP applications

What's the problem?

- What do you need to share knowledge?
  - The right **metalanguage** which is:

1. **accurate**
2. **precise**
3. **human-readable**
4. **stable shelf-life**
5. **flexible**
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- But linguists often use prose+formalisms that don't fit all 6 needs

A linguistic problem in Armenian

- What's Armenian?
  - Indo-European language spoken in the Caucuses & Middle East
  - Under-studied & low-resource
  - Focus on morphology and phonology
- What's going in Armenian?
  - Orthography shows long sequences of consonants

Cons.	2	2	3	4	4	6
Meaning	'money'	'low'	'grand'	'to jabber'	'to find'	'to grumble'
Spelling	tram	stor	hsga	pndrel	tntrel	krtmnjal

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Pron.	təram	əstor	həsga	pəndrel	təntərel	kərtmənjal

  - But all are broken up by the vowel /ə/ 'puppet'

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- Research Answer?
  - Position of the vowel is predictable
  - Depends on #, type, and position of consonants

A linguistic problem in Armenian

- Two patterns:

1. Repeated Cs:

Meaning	'to be astonished'	'to jabber'	'to find'
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  - Theoretical linguistics:
    - Vaux 1998: Most complete description with a sketch of an algorithm
  - Computational linguistics:
    - Me: Implemented algorithm in Python
  - His knowledge+my implementation cover a lot of ground but...

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→ Original resource had good research quality but metalanguage problems

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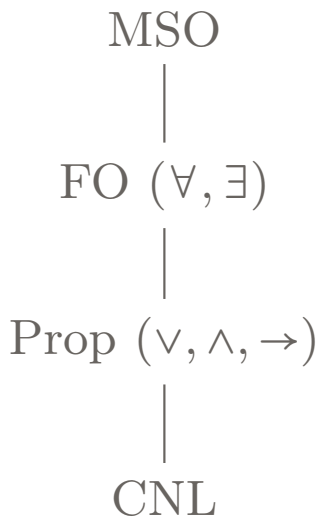
  - **Synthesize** work from theoretical linguistics, formal logic, and computational linguistics.
  - **Adapt** formal logic as a metalanguage for linguistics
  - **Develop** working software to convert formal logic into running code for linguistics

Formal logic

- What's logic?
  - Logic is the metalanguage used for describing complex patterns in mathematics (Courcelle, 1997; Engelfriet and Hoogeboom, 2001)
  - There are different types of logical languages with different degrees of power



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- Why not something else like FSM?
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  - Logic is higher-level language
  - Logic can be converted to FSMs to get its benefits

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  - Has been applied to sentence structure (Rogers, 1998)
  - Heinz & colleagues have partially adapted it for phonology
  - Looks like FO can handle bulk of phonology & morphology.
- What will I do?

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  - Heinz & colleagues have partially adapted it for phonology
  - Looks like FO can handle bulk of phonology & morphology.
- What will I do?
  - Describe a language's phonology with logic
  - Develop software to convert logic into code for linguistics (Python, Prolog, Haskell)

Armenian illustration

- Subpattern in pronouncing 4 consonants: Repeated Cs

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- Add /ə/ after 1st and 3rd if they're the same consonant; otherwise after just the 1st

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$$\texttt{RepeatedCs}(x, z) \stackrel{\text{def}}{=} \texttt{first}(x) \wedge \texttt{third}(z) \wedge \texttt{same}(x, z) \quad (4)$$

- Implement code in Python to check for these conditions or apply them

Plan for the year

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- **Output**: Develop software (Python, Prolog, Haskell) to run logical formula designed for phonology and morphology
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- Future work
  1. Collect more data on Armenian and related languages
  2. Improve metalanguage for phonology, morphology, and other linguistic fields
  3. Given proper metalanguage, develop more computational resources for Armenian
  4. Develop instructional material on how to use and implement logic for linguistics

Courcelle, B. (1997). The expression of graph properties and graph transformations in monadic second-order logic. In G. Rozenberg (Ed.), Handbook of Graph Grammars and Computing by Graph Transformations, pp. 313–400.

Engelfriet, J. and H. J. Hoogeboom (2001, April). MSO definable string transductions and two-way finite-state transducers. ACM Trans. Comput. Logic 2(2), 216–254.

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