Overview Nguni Natural Language Generation

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Outline

1 Motivation
   • A few application scenarios
   • NLG and knowledge management

2 isiZulu NLG

3 Part-whole relations and related aspects

4 Discussion

5 Conclusions
1 Motivation
   - A few application scenarios
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Natural language interfaces with some NLG

- Many tools, webpages, etc. with some natural language component
- Querying of information in natural language (cf. a query language SQL, SPARQL)
- Business rules typically specified in a natural language
- etc.
Example: iCal calendar entry with canned text
Example: Saadiq Moolla’s mobile healthcare app

Chest Pain

Have you had any recent pain in your chest? - Uke waba nobuhlungu esifubeni maduzane?

Does the pain radiate to your jaw, neck or arm? - Engabe ubuhlungu bakho bujikeleza emihlathini, emqaleni noma nasezingalweni?

Does anything precipitate or relieve the pain? - Ingabe ikhona into eyenza ubuhlungu buqhubekke noma eyehlisa ubuhlungu?

Dyspnoea

Are you breathless at any time? - Uke uphelelele umoya kwezinye izikhathi?
Example: Query formulation with Quelo
[Franconi et al. (2010)]

Pictures from: Quelo © The IESD Challenge 2012
Demo at: http://krdbapp.inf.unibz.it:8080/quelo/
Example: Business rules and conceptual data models

Each Course is taught by at least one Professor
Each Professor teaches at least one Course
NLG, principal approaches

- Canned text
- Templates
  - but also other languages [Jarrar et al.(2006)]
- Controlled Natural Language
- Grammar engines, such as [Kuhn(2013)], Grammatical Framework (http://www.grammaticalframework.org/)
Business rules/conceptual data models and logic reconstruction

**BR:** Each Course is taught by at least one Professor

**FOL:** $\forall x \ (\text{Course}(x) \rightarrow \exists y \ (\text{is\_taught\_by}(x, y) \land \text{Professor}(y)))$

**DL:** Course $\sqsubseteq \exists \ \text{is\_taught\_by}.\text{Professor}$
Example of templates

```xml
<Constraint xsi:type="Mandatory">
  <Text> - [Mandatory] Cada </Text>
  <Object index="0"/>
  <Text> debe </Text>
  <Role index="0"/>
  <Text> al menos un(a) </Text>
  <Object index="1"/>
</Constraint>

<Constraint xsi:type="Mandatory">
  <Text> - [Mandatory] Each </Text>
  <Object index="0"/>
  <Text> must </Text>
  <Role index="0"/>
  <Text> at least one </Text>
  <Object index="1"/>
</Constraint>
```

for a large fragment of ORM, and 11 languages [Jarrar et al.(2006)]
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NL Grammars, illustration

Sentence $\rightarrow$ NounPhrase $|$ VerbPhrase

NounPhrase $\rightarrow$ Adjective $|$ NounPhrase

NounPhrase $\rightarrow$ Noun

\[ \ldots \]

Noun $\rightarrow$ car $|$ train

Adjective $\rightarrow$ big $|$ broken

\[ \ldots \]

(and complexity of the grammar)
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Questions

- Can the template-based approach be used also for isiZulu NLG? (2014)
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  - No.
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  - No.
  - Need ‘patterns’
  - Needed a noun pluraliser [Byamugisha et al.(2016)]
  - [Keet and Khumalo(2014b), Keet and Khumalo(2014a)]
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  - Several part-whole relations [Keet and Khumalo(2016)]
  - Non-1:1 mappings with isiZulu’s ‘part of’ [Keet(2017)]
  - Language model to represent those components [Keet and Chirema(2016)]
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  - Verb grammar [Keet and Khumalo (2017)]
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- Grammar has been used to create and mark language learning exercises automatically
Logic foundation for isiZulu NLG

- Roughly OWL 2 EL
- OWL 2 EL is a W3C-standardised profile of OWL 2
- Tools, ontologies in OWL 2 (notably SNOMED CT)
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- OWL 2 EL is a W3C-standardised profile of OWL 2
- Tools, ontologies in OWL 2 (notably SNOMED CT)
- On the ‘roughly’: minus transitivity, but with negation, amounting to $\mathcal{ALC}$
  - of that, we have patterns for universal and existential quantification, subsumption, negation (disjointness), and conjunction
  - union not yet covered explicitly, but note $C \sqcup D \equiv \neg(\neg C \cap \neg D)$
  - more detail on the languages: see the Description Logics Handbook [Baader et al.(2008)] and OWL 2 Standard
Existential Quantification

- Common axiom type $C \sqsubseteq \exists R.D$ (named classes only)
- Example:

(E1) Giraffe $\sqsubseteq \exists$eats.Twig
- yonke indlulamithi idla ihlamvana elilodwa ('each giraffe eats at least one twig')
- zonke izindlulamithi zidla ihlamvana elilodwa ('all giraffes eat at least one twig')
- yonke indlulamithi idla noma yiliphi ihlamvana ('each giraffe eats some twig')
- zonke izindlulamithi zidla noma yiliphi ihlamvana ('all giraffes eat some twig')
- yonke indlulamithi idla ihlamvanathize ('each giraffe eats some twig')
Possible patterns for existential quantification

a. \(<\text{All-concord for NC}_x>\text{onke }<\text{pl. } N_1, \text{ is in NC}_x>\text{ conjugated verb} <N_2 \text{ of NC}_y> <\text{RC for NC}_y><\text{QC for NC}_y>dwa.\)

b. \(<\text{All-concord for NC}_x>\text{onke }<\text{pl. } N_1, \text{ is in NC}_x>\text{ conjugated verb} noma <\text{copulative } ng/y \text{ adjusted to first letter of } N_2><\text{EP of NC}_y>\text{phi }<N_2>\).

c. \(<\text{All-concord for NC}_x>\text{onke }<N_1 \text{ in NC}_x> <\text{conjugated verb} <N_2>\text{thize};\)
Example

- \( \forall x \ (\text{Professor}(x) \rightarrow \exists y \ (\text{teaches}(x, y) \land \text{Course}(y))) \)
- Professor \( \sqsubseteq \exists \text{teaches}.\text{Course} \)
- Each Professor teaches at least one Course
Example

- $\forall x \ (\text{uSolwazi}(x) \rightarrow \exists y \ (\text{ufundisa}(x, y) \land \text{Isifundo}(y)))$
- $\text{uSolwazi} \sqsubseteq \exists \text{ufundisa}.\text{Isifundo}$
- ?
∀x (uSolwazi(x) → ∃y (ufundisa(x, y) ∧ Isifundo(y)))

uSolwazi ⊆ ∃ ufundisa.Isifundo
### Motivation

#### isiZulu NLG

Part-whole relations and related aspects

#### Discussion

Conclusions

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<thead>
<tr>
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<th>AU</th>
<th>PRE</th>
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<td>m(u)-ba-</td>
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<td>1a</td>
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<td>-</td>
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<tr>
<td>2</td>
<td>a-</td>
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<tr>
<td>1</td>
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<td>m(u)-mi-</td>
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<td>17</td>
<td>ku-</td>
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<table>
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<th>x, (uSolwazi(x))</th>
<th>Isifundo(x)</th>
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</thead>
<tbody>
<tr>
<td>NC QCoral + onke</td>
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<tr>
<td>1</td>
<td>u-onke → wonke</td>
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<td>2</td>
<td>ba-onke → bonke</td>
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<tr>
<td>1</td>
<td>u-onke → wonke</td>
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<td>ba-onke → bonke</td>
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<td>u-onke → wonke</td>
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<td>u-onke → wonke</td>
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**Bonke oSolwazi**

- **look-up NC**
- **pluralise**
- **for-all**
∀x (uSolwazi(x) → ∃y (ufundisa(x, y) ∧ Isifundo(y)))

Bonke oSolwazi bafundisa

... for relevant NC. Here:

ngi-
u-
u-
si-
ni-
ba-
\forall x (uSolwazi(x) \rightarrow \exists y (ufundisa(x, y) \land Isifundo(y)))

uSolwazi \subseteq \exists ufundisa.Isifundo

Bonke oSolwazi bafundisa Isifundo
\[ \forall x \ (u\text{-}Solwazi(x) \rightarrow \exists y \ (y \text{-} fundisa)) \]

- look-up NC
- get RC
- get QC
- add -dwa

Bonke oSolwazi bafundisa Isifundo esisodwa
More details: ESWC’17 demo paper [Keet et al.(2017)]
http://www.meteck.org/files/geni/VerbaliserisiZuluScreencast.mov
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Common part-whole relations

Part-whole relation

- part-of
- s-part-of (objects)
- spatial-part-of (processes)
- involved-in (processes)
- stuff-part-of (different stuffs)
- located-in (2D objects)
- contained-in (3D objects)
- member-of (object/role-collective)
- portion-of (same stuff)
- participates-in (object-process)
- constitutes (stuff-object)
- mpart-of
Attempt at structuring part-whole relations in isiZulu

- **Less discriminating**: `ingxenye`/`SC+CONJ` used for parthood, involvement, membership, stuff parts, participation of individual objects (vs. collectives), containment (w-p only)
- **More discriminating**: portions, participation, and constitution
Context-dependent surface realisation (no single label)

- Common medical ontologies axioms type $C \sqsubseteq \exists R.D$
- Verbalisation pattern if $R = \text{‘has part’}$:
  $\text{QCall}_{ncx,pl} \ W_{ncx,pl} \ SC_{ncx,pl} - \text{CONJ} - P_{ncy} \ RC_{ncy} - QC_{ncy} - dwa$
- SC ‘conjugation’ dependent on noun class of head noun (that plays the Whole)
- CONJ ‘conjunction’ phonologically conditioned $na$-
- 6 SCs for plurals, 3 CONJ variants $= 18$ cases
Context-dependent surface realisation (no single label)

- Common medical ontologies axioms type $C \sqsubseteq \exists R.D$
- Verbalisation pattern if $R=\text{‘has part’}$:
  \[ \text{QCall}_{nc_x,pl} \text{ W}_{nc_x,pl} \text{ SC}_{nc_x,pl} \text{-CONJ-P}_{nc_y} \text{ RC}_{nc_y} \text{-QC}_{nc_y}-dwa \]
- SC ‘conjugation’ dependent on noun class of head noun (that plays the Whole)
- CONJ ‘conjunction’ phonologically conditioned \textit{na-}
- 6 SCs for plurals, 3 CONJ variants = 18 cases
- Examples:
  - \textit{bonke abantu banenhлизiyo eyodwa}
    ‘All humans have as part some heart’
    \textit{abantu nc=2, na+inhлизiyo=nenhлизiyo}
  - W=‘orchestra’ (nc5, SC=\textit{a-}) and P=‘musician’ \textit{isazi somnyuziki} $\rightarrow$ \textit{anesazi somnyuziki}
  - W=‘computer’ (nc5) and P=‘CPU’ \textit{umqondo womshini} $\rightarrow$ \textit{anomqondo womshini}
**Containment of objects**

**Whole->part**  
Qcall(nc(x,pl)) W(nc(x,pl)) SC(nc(x,pl)) CONJ-P(nc(y)) RC(nc(y))-QC(nc(y))-dwa

**Part->whole**  
Qcall(nc(x,pl)) P(nc(x,pl)) SC(nc(x,pl)) EP-LOC-W(nc(y)) -LOCSUF RC(nc(y))-QC(nc(y))-dwa

*Ex. W->p:* Zonke izisu zi-ne- ndilinga yokudla e-yo-dwa  
All stomachs have and bolus of food at least one

*Ex. P->w:* Zonke izindilinga zokudla zi-s-e- sis-wini esi-so-dwa  
All boluses of food are contained stomach in at least one
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- Template-based approach is not applicable to isiZulu (and, more generally: Bantu languages that have noun classes)
  - Or: grammar engine needed
- Devising the patterns hampered by outdated literature
- Several preferences for patterns
- Algorithms nontrivial; covering:
  - ‘simple’ existential and universal quantification
  - taxonomic subsumption
  - negation (class disjointness)
  - conjunction
- Essentially contributing to documenting the grammar
Some other potential use: machine translation

- Google’s “all giraffes eat twigs” is translated as “yonke izindlulamithi udle amahlumela” (d.d. 14-1-2014) and as wonke ama-giraffe adle amahlumela (d.d. 3-12-2017)
  - But izindlulamithi is in noun class 10, so it goes with zonke; correct with our algorithms
  - Concordial agreement zidla, not udle or adle; correct with our algorithms
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- Other issues that will be not easy for the statistical language approach: deep prepositions, part-whole relations, phonological conditioning, ...

- Some fun on the next page
(1) ‘swallowing is involved in eating’ → *ukugwinya kuhileleka ekudleni* → ‘swallowing involves eating’

(2) ‘all swallowing is involved in some eating’ → *konke ukugwinya kubandakanyeka ekudleni abanye* → ‘all swallowing is involved in eating others’

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2 https://bwisehealth.com/article/how-healthy-are-your-friendships?lang=zulu
3 https://steroidio.com/zu/steroids-list/
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1. ‘all doctors participate in some operation’ → bonke odokotela bahlanganyela ekusebenzeni okuthile → ‘all doctors participate in some work’
2. ‘all electorates participate in at least one election’ → bonke abakhethiweyo bahlanganyela okungenani ukhetho olulodwa → ‘all the candidates participate at least one option’

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(1) ‘All humans have as part some heart’ → *Bonke abantu banengxenye yenhliziyo* → ‘All people have a part of the heart’
(2) ‘All humans have as part at least one heart’ → *Bonke abantu banengxenye okungenani inhliziyo eyodwa* → ‘All people have at least one part’ (…)
(3) ‘All humans have part at least one heart’ → *Bonke abantu banenkani okungenani inhliziyo eyodwa* → ‘All people are stubborn at least one heart’

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(1) *Abangani esibagcinayo banengxenye abayidlalayo enkulu empilweni esiyiphilayo* → ‘The friends we care about have a major part of our life’ → *Abangane esibakhathalelayo banengxenye enkulu yokuphila kwethu*
(2) *Kwamanye, banengxenye izifo, kungenzeka isisindo somzimba, kanye nezinguquko isimo ngokomzwelo kuhlhanganise nemizwelo nguquguqukayo* → ‘In some cases, they have infections, possibly weight loss, and emotional changes as well as flexible emotions’ → *Kwezinye izimo, banezinkinga, mhlawumbe ukulahlekelwa isisindo, nezinguquko zomzwelo kanye nemizwelo nguquguqukayo*

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- Knowledge-based approach to NLG
- Novel verbalisation patterns and algorithms for simple subsumption, disjoint classes, conjunction, and basic options with quantification
- Verbalising formally represented knowledge in isiZulu requires a grammar engine even for the relatively basic language constructs
- Due to, principally: i) the system of noun classes, ii) the system of complex agreement, iii) phonological conditioned copulatives, and iv) verb conjugation
- Other basic language model for annotation of verbs and nouns with deep prepositions
- Part-whole relations
Future work

- More constructors
- Conjugation of verbs other tenses, and more prepositions (taught *by, works for*)
- Phonological conditioning in a structured fashion
- More systematic way for the ‘patterns’
- Interaction with data-driven approaches (learning and verification)
References

*The Description Logics Handbook – Theory and Applications.*  

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Thank you!

GeNi project details:
http://www.meteck.org/files/geni/

Questions?