Computational Modelling of Michif Verbal Morphology

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Abstract

This paper presents a finite-state computational model of the verbal morphology of Michif. Michif, the official language of the Métis people, is a uniquely mixed language with Algonquian and French origins. It is spoken across the Métis homelands in Canada and the US, but it is highly endangered with less than 100 speakers. The verbal morphology is remarkably complex, as the already polysynthetic Algonquian patterns are combined with French elements. Li Verb kaa-Ooshitahk di Michif handles this complexity by using a series of composed finite-state transducers to model the concatenative morphology and phonological rule alternations that occur in Michif. Such a rule-based approach is necessary as there is insufficient language data for an approach that uses machine learning. A language model such as Li Verb kaa-Ooshitahk di Michif furthers the goals of Canadian Indigenous computational linguistics while also supporting the creation of tools for documentation, education, and revitalization that are desired by the Métis community.

1 Introduction

In recent years there has been an increase in computational linguistic analysis of Canadian Indigenous languages, and in particular Algonquian languages such as East Cree (Arppe et al., 2017b), Plains Cree (Harrigan et al., 2017), and Odawa (Bowers et al., 2017). This paper adds Michif, a mixed language of Cree and French origin, to the list with a description of Li Verb kaa-Ooshitahk di Michif. Li Verb kaa-Ooshitahk di Michif, which translates as "The Michif verb maker", is a computational model of the verbal morphology of Michif, implemented in the xfst framework of Beesley and Karttunen (2003).

The output of such a model has many applications, including a smartphone application for conjugating verbs in Michif. Li Verb kaa-Ooshitahk di Michif represents a collaborative effort between linguists, computer scientists, and the Michif speech community, to further the goal of improving educational resources and tools for the documentation of Michif, and more broadly Canadian Indigenous languages.

2 Motivation

During the 19th century, marriage between French fur traders and Cree and Ojibwe women in the Métis homeland was common, and their descendants became known as the Métis people (Bakker, 1997; Rosen and Souter, 2009). Michif (ISO 639-3: crg), an Algonquian language, emerged as a mixed language which combined elements of French with the Indigenous Algonquian languages, Cree and Saulteaux (Bakker, 1997; Rosen and Souter, 2009). There are many varieties of the Michif language, however Li Verb kaa-Ooshitahk di Michif is based on a variety spoken mainly in Manitoba, Southern Saskatchewan, North Dakota, and Montana.

Today, Michif speakers of the various varieties are spread across Saskatchewan, Alberta, and Manitoba (Statistics Canada, 2017), although the number of speakers has decreased significantly. It is difficult to estimate true numbers of speakers of the "intertwin[ed]" language (Bakker, 1997), but Michif language activists estimate approximately 50-100 speakers with only a handful presently robust enough to

be involved in revitalization work (Souter, 2020). Current data suggests that Michif sits at an 8b, 'Nearly Extinct', on the Expanded Graded Intergenerational Disruption Scale, where a 1 is a healthy language and a 10 is extinct (Lewis et al., 2013). Languages ranked 8b typically have older speakers and have fewer opportunities to use the language and pass it on, and are therefore more at risk of extinction (Lewis et al., 2013).

Almost all Indigenous languages in Canada suffer from lack of linguistic documentation and analysis. This restricts the ability to create formalized teaching tools and technologies and hinders the efforts of language learners and activists in Indigenous communities in Canada. Michif is no different, and even lacks in comparison to other Algonquin languages, particularly in the domain of verbal morphology.

The Li Verb kaa-Ooshitahk di Michif computational model is a finite-state transducer (FST) which aims to create a complete model of the verbal morphology of Michif based on the current language data. The output of the FST can be the foundation for front facing language learning tools, such as a verb conjugation app or more advanced educational tools.

3 Michif linguistic background

The unique mixed origins of Michif are reflected in all linguistic domains. The phonological inventory of Michif is sourced from both French and Cree (with The "Saulteaux" or "Chippewa" dialect of Objibwe being a more minor source language). The pronominals are largely French based and verbal constructions are primarily Algonquian-derived (Sammons, 2019; Prichard and Shwayder, 2014; Rosen, 2007).

3.1 Verbal inflection in Michif

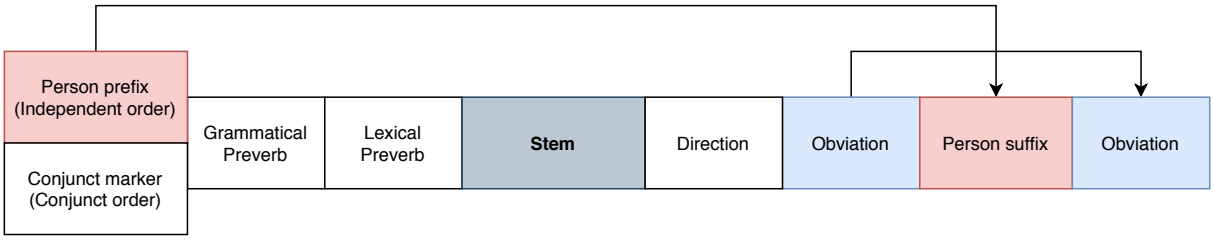

Figure 1: Verbal template of Michif

Michif, like other Algonquian languages, is highly polysynthetic. While a verb can minimally consist of a stem and a person/number suffix, verbs can be highly productive by concatenating morphemes containing many categories of syntactic information. Verbs in Michif can inflect for person, number, animacy, obviation, tense, aspect, and direction (Sammons, 2019; Rhodes, 2009).

(1) ayaaw

ayaa-w
IND.PRS.have.VAI-3SG

'He/she has.'

(2) ee-ka-kishkeetamiiyit

ee-ka-kishkeet-amii-yi-t
CONJ-FUT-know.VTI-3>3-OBV1-OBV2

'As/that he/she (OBV) knows it.'

Michif verbs can be broken down into four inflectional classes by transitivity and animacy: Animate Intransitive (VAI), Transitive Animate (VTA), Transitive Inanimate (VTI), and Inanimate Intransitive (VII) (Sammons, 2019). Animacy affects stem class as well as affix selection. There are also two minor classes, Animate Intransitive Transitive (VAIt) (Sammons, 2019) and Animate Intransitive Transitive animate/inanimate (VAIta/i) (Antonov, 2019).[1] Transitive verbs combine with the animacy of the object to create their inflectional classes (VTA & VTI), while intransitive verbs combine with the animacy of the subject (VAI & VII) (Wolvengrey, 2011). Person marking, obviation, and direction affixes vary according to the inflectional class.

[1]VAIta/i verbs are not accounted for in the current implementation. They inflect as VAI verbs but take either intransitive objects, or both animate and inanimate

All inflectional classes can be further broken down into two orders: independent and conjunct. The independent order marks person and number with long distance agreement between prefixes and suffixes, and is used to express the indicative mode. The conjunct order is typically marked with the '*ee-*' prefix, meaning 'while/as', which indicates a subordinate clause (Bakker, 2013)(with the exception of VII)[2]. The imperative, subjunctive (conjunct + complementizing suffix '*-i/-u/-o*'), and reflexive modes are not accounted for in the current implementation of Li Verb kaa-Ooshitahk di Michif.

Preverbs are prefixes that provide adverbial (inflectional and lexical) information before the stem of a verb, but occur *after* the person marking prefix in the independent order. Grammatical preverbs cover tense or relativization, while lexical preverbs are a closed class of prefixes that act like adverbs do in English (Sammons, 2019; Rhodes, 2009).

Preverbs are not required, and a verb can be modified by multiple preverbs, such as in the case of *ni-**ka-nohtee-maachi**-atoshkaanaan* 'We (EXCL) will want to begin to work', where **ka** indicates the future definite tense, **nohtee** means 'want/desire', and **maachi** means 'begin to/start to'.

VTA verbs in Michif are the only class which has direction, where actions are either direct or inverse depending on a hierarchy of actors much like in other Algonquian languages such as Plains Cree (Harrigan et al., 2017). Direct actions occur when the marked subject acts on the marked object, while inverse actions occur when the marked object acts on the marked subject. In the direct VTA forms, the 'ni-/ki-/∅-' prefix refers to the subject, while the person marking suffix refers to the object. In the inverse VTA forms, the 'ni-/ki-/∅-' prefix refers to the object, while the person marking suffix refers to the subject. This can be observed in the difference between the suffixes in ***ki**-miyeum-**in*** (2-PRS-like.VTA.IND-**DIR**2SG>1SG) 'You (SG) like me', and *ki-miyeum-**itin*** (IND.1.PRS-like.VTA-.**INV**.1SG>2SG) 'I like you (SG)'[3].

Obviation occurs across all inflectional classes in Michif and is triggered by obviative nouns (marked or unmarked) (Sammons, 2019). It only occurs in the third person, and number distinction is not specified, although the verb takes the 3SG person suffix (except for VII).

VAI verbs mark obviation in up to two places in a given verb form, relying on long distance dependencies. In every obviative form, the '*yi*' morpheme occurs immediately following the stem and preceding the person marking affix. In VAI verbs, the independent order will have an additional '*a*' morpheme following the person marking affix, while the conjunct order will not have any additional morphemes to mark obviation. Only obviative subjects are explicitly marked in VAI verbs.

(3) a. soñ namii kii-itohteeyiwa

soñ namii
3SG.MASC.POSS friend
kii-itohtee-yi-w-a
IND.PST-go.VAI-OBV1-3-OBV2

'His/her friend (OBV) went'

b. soñ namii kii-itohteeyit

soñ namii
3SG.MASC.POSS friend
kii-itohtee-yi-t
CONJ.PST-go.VAI-OBV1-3

'As his/her friend (OBV) went'

In the case of VII verbs, the placement of the '*yi*' morpheme sandwiched between the stem and the person marking affix is the same as in VAI verbs, however there is no additional morpheme added at the end of the verb. VII verbs only mark subject obviation.

(4) a. mii kriiyoñ ee-ka-ashaahtiniyiki

mii kriiyoñ ee-ka-ashaahtini-yi-ki
1PL.MASC.POSS pencil CONJ-FUT-be.sharp.VII-OBV-3PL

'As/that my pencils (OBV) will be dull'

[2]There are other prefixes which change the mode. The individuated complementizer prefix or "relativizer" '*kaa-*' 'who/that/the one who/that which', can refer to both prior and simultaneous actions (Bakker, 2013). The prefix '*chi-/shi-*' 'so that' is a future complementizer that marks subordinate clauses (Bakker, 2013). These prefixes are not part of the current implementation

[3]Note that speakers tend to omit the initial pronominal proverb if it is followed by the same consonant sound and the meaning is clear from context and the inflectional suffix.

The '*yi*' morpheme also occurs in VTI verbs, but instead it is concatenated following the person marking suffix. Independent order verbs then have the '*wa*' morpheme, while conjunct order verbs have the '*t*' morpheme to mark obviation.

(5) a. sa soer kii-tootamyiwa

sa soer kii-toot-am-yi-wa
3SG.FEM.POSS sister IND.PST-do.VTI-3>3-OBV1-OBV2

'Her sister (OBV) did it'

b. sa soer ee-kii-tootamiiyit

sa soer ee-kii-toot-amii-yi-t
3SG.FEM.POSS sister CONJ.PST-do.VTI-3>3-OBV1-OBV2

'As/that her sister (OBV) did it'

VTA verbs differ from the other verbal classes in their obviation due to the direction marking which occurs in the typical obviative position. One important difference from the other verbal classes, however, is that VTA verbs mark obviation for subject, objects and both subjects and objects of the same verb form. In the LI VERB KAA-OOSHITAHK DI MICHIFFST, obviation marking has been combined with the person marking suffixes as further research into the morpho-phonological interface is needed in order to provide a full breakdown of obviation.

Obviative marking of the subject only in a VTA verb.

(6) soñ nañfañ ee-ka-ayaawikot dañ la meezoñ ooma

soñ nañfañ ee-ka-ayaawee-ikot dañ la meezoñ ooma
3SG.MASC.POSS child CONJ-FUT-be.there.VTA-INV3.OBV>3SG PREP the.FEM house DEM.INAN.SG

'As/that her/his child (OBV) will live in the house here.'

Obviative marking of the object only in a VTA verb.

(7) awa zañfañ ka-ayaaweew dañ ta meezoñ ooma

awa zañfañ ka-ayaawee-eew dañ ta meezoñ ooma
DEM.ANIM.SG child IND.FUT-be.there.VTA-DIR.3SG>3.OBV PREP 2SG.FEM.POSS house DEM.INAN.SG

'This child will live in your house (OBV) here.'

Obviative marking of both subject and object in a VTA verb.

(8) soñ nañfañ ka-ayaaweeyiwa dañ ta meezoñ ooma

soñ nañfañ ka-ayaawee-eeyiwa dañ ta meezoñ ooma
3SG.MASC.POSS child IND.FUT-be.there.VTA-DIR.3OBV>3OBV PREP 2SG.FEM.POSS house DEM.INAN.SG

'His/her child (OBV) will live in your house (OBV) here.'

4 Finite-state computational modelling

Finite-state automata have been used to model the verbal morphology of a variety of languages (Schwartz et al., 2019; Bowers et al., 2017; Lachler et al., 2018; Grönroos et al., 2015; Arppe et al., 2017a; Harrigan et al., 2017). LI VERB KAA-OOSHITAHK DI MICHIF is a morphological analyzer, which is a series of composed finite-state transducers (FSTs) called a Lexical Transducer (Beesley and Karttunen, 2003). There are two primary components of a Lexical Transducer: the LEXICON finite-state network and the REWRITERULES finite-state network (Beesley and Karttunen, 2003). The LEXICON uses a set of labelled sub-LEXICONS whose declared content details the rules for morphological concatenation (Hulden, 2009). This is accomplished by using regular expressions (locally constrained) and flag diacritics (long distance

dependencies). Then, the RewriteRules further constrain the output of the FSTs by using regular expressions to apply phonological restrictions. Foma, a finite-state compiler, then takes the Lexicon and the RewriteRules and creates a unified finite state transducer: the Lexical Transducer, in this case Li Verb kaa-Ooshitahk di Michif (Hulden, 2009).

Using FSTs to model low-resource languages such as Michif is advantageous, as rule-based definitions of verbal paradigms do not rely on access to large, morphologically-tagged corpora which do not exist for Michif.

4.1 Morphological modelling in the Lexicon

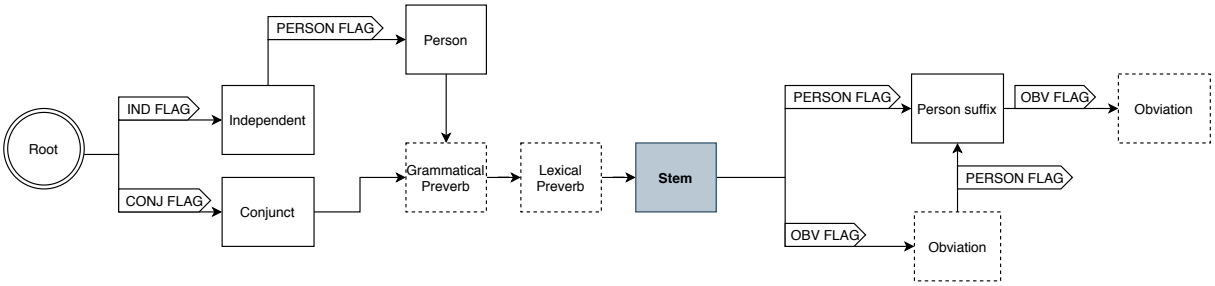

Figure 2: Schematic representation of paths through the Li Verb kaa-Ooshitahk di Michif FST

The Lexicon is written in a lexc file type, which allows for the linear concatenation of morphemes in the form of a continuation grammar. Each sub-Lexicon adds two components: morphological tags which provide syntactic information, and the actual morphemes themselves. Flag diacritics also occur in the sub-Lexicons as needed. The graphic above (Figure 2) illustrates the main sub-Lexicons of the Li Verb kaa-Ooshitahk di Michif FST. Most sub-Lexicons are further divided into each of the four verbal classes in Michif, but are not illustrated here for simplicity.

The long distance dependencies needed for patterns such as obviation are particularly challenging to model with continuation grammars, as they require knowledge of the previous states. Flag diacritics enable these long distance dependency checks between morphemes, so that phenomena such as obviation can be modelled (Hulden, 2009; Beesley and Karttunen, 2003). Li Verb kaa-Ooshitahk di Michif employs three types of flags: `P`: **P**ositive set; `R`: **R**equire feature/value; and `D`: **D**isallow feature/value. Each feature can be thought of as a set, and `P` and `D` flags add or remove possible verb forms to this set, while `R` flags require a verb form to be a member of a particular set in order to pass through the path.

As obviation in Michif only occurs with the third person, flag diacritics have to be used to avoid overapplication of the obviative concatenation rules. A 'person' feature is used, which distinguishes between first and second person forms. When this feature is disallowed, such as with a *@D.person@* flag diacritic, this ensures that only third person forms can pass through. In the example below, any forms set to first or second person will pass through the null path and continue to the VAIOrder sub-lexicon, while the third person, or 'disallowed' person, forms will receive obviative marking.

```
LEXICON VAIObviativeMarking
0 VAIPersonSuffix ;
@P.obv.yi@@D.person@:@P.obv.yi@@D.person@yi%< VAIPersonSuffix ;
```

Li Verb kaa-Ooshitahk di Michif FST treats obviative as a feature that is also set by a flag. The example above shows the *@P.obv.yi@* flag diacritic, which assigns any forms which pass through this path to the obviative set that uses the '*yi*' morpheme. Once the person suffix has been added, there is also the potential for a second obviative morpheme to occur. Typically, the second obviation marker varies by verbal order within each verbal class. For example, in VAI verbs, the independent order will have an additional '*-a*' morpheme following the person marking affix, while the conjunct order will not have any additional morphemes to mark obviation.

In the example below, the first sub-Lexicon ensures that only obviative forms receive the [OBV] tag. The *@D.obv@* flag accepts only those forms which have not previously been set to positive for the ob-

viative feature. The *@R.obv@* flag requires forms that are part of the obviative set to pass through, and simultaneously outputs the tag on the left side.

```
LEXICON VAIObviative1
@D.obv@                 EndVerb ;
@R.obv@[OBV]:@R.obv@    VAIObviative2 ;

LEXICON VAIObviative2
@R.order.indep@:@R.order.indep@%<a  EndVerb ;
@D.order.indep@:@D.order.indep@     EndVerb ;
```

The obviative forms then pass to the second sub-LEXICON, where they are sorted by order using flag diacritics. The @R.order.indep@ requires forms belonging to the set of the independent order to pass through this path, where the '*-a*' morpheme is added. All other forms, i.e. those belonging to the conjunct order, pass through the path with the @D.order.indep@ flag which has disallowed any independent forms. The path to EndVerb indicates that the morphological concatenation is complete.

The final output of the LEXICON is two-sided, where one side is the morphological breakdown of a given input stem and its inflectional morphemes, and the other side is the concatenated surface form. This will be the input for the REWRITERULES FST.

<achimostaaweew[VTA][IND][FUT][3][INV][3PL-OBJ][OBV]	<kii-achimostaaw<ikwak>
<ayamihaaw[VAI][IND][PRS][1SG]	<ni-ayamihaa<n>
<itohteew[VAI][IND][PRS][1PL][INCL]	<ki-itoht<aanaan>
<maachikipaheew[VTA][IND][FUT][1SG][DIR][3SG-OBJ]	<ni-ka-maachi-kipah<aaw>

Table 1: Sample output of the LI VERB KAA-OOSHITAHK DI MICHIF LEXICON

4.2 Morpho-phonological REWRITERULES

The LI VERB KAA-OOSHITAHK DI MICHIFFST only accounts for morpho-phonological rules which interact with the verbal morphology of Michif. When morphemes are concatenated, phonemes that would otherwise not co-occur become adjacent, creating the need for phonological rules which handle these issues. The REWRITERULES finite-state machine treats each phonological rule as an individual FST which is then concatenated to form one composed FST (Hulden, 2009; Beesley and Karttunen, 2003). Regular expressions are employed in theREWRITERULES, just as in the LEXICON.

The *'ni-/ki-'* prefixes host a multitude of morpho-phonological interactions. Following the *'ni-/ki-'* morphemes, [t] is epenthesized when followed by a vowel (Rosen, 2007). Voiceless consonants are voiced when preceded by the *'ni-'* prefix and followed by a vowel.The *'ni-'* prefix is then deleted following the voicing (Bakker, 1991). The REWRITERULES combine these two processes into one regular expression rule to avoid over application of both the voicing and deletion.

1. t-Insertion
   [..] -> t || [n i | k i] "-" _ Vowel ;

2. ni-Deletion
   n i "-" t (->) d "-" || _ Vowel ;
   n i "-" k (->) g "-" || _ Vowel ;
   n i "-" p (->) b "-" || _ Vowel ;
   n i "-" s (->) z "-" || _ Vowel ;

The Voicing rule creates the environment for ni-Deletion. t-Insertion also feeds Voicing when occurring with a *'ni-'* prefix, creating a cascading derivation of the three rules.

LEXICON Output	t-Insertion	ni-Deletion
ni-ayamihaan	ni-t-ayamihaan	d-ayamihaan
ki-itohtaanaan	ki-t-itohtaanaan	
ni-ka-maachi-kipahaaw		ga-maachi-kipahaaw

Table 2: Sample derivation of t-Insertion & ni-Deletion REWRITERULES

The *'ki-'* prefix is deleted when followed by [k] (Bakker, 1991).

3. ki-Deletion
   k i "-" (->) 0 || _ k ;

This process is common as the *'ki-'* person prefix is often followed by either the *'ka'* or *'kii'* tense marking morphemes.

LEXICON Output	ki-Deletion
ki-kii-maachi-kipahaanaan	kii-maachi-kipahaanaan
ki-ka-maachi-kipahitinaan	ka-maachi-kipahitinaan

Table 3: Sample derivation of the ki-Deletion REWRITERULE

4.3 Stems & Outputs

The latest version of the LI VERB KAA-OOSHITAHK DI MICHIF FST generates 56,235 verb forms. There is presently a total of 105 verb stems in the FST: 40 VAI, 35 VTA, 26 VTI, 2 VII, and 2 VAIt. Only 3 lexical preverbs are in the current implementation, while there are 4 grammatical preverbs.

5 Discussion

While much of the verbal morphology of Michif is accounted for, challenges around the lack of language data and inconsistencies in existing language data have yet to be overcome.

The imperative, subjunctive and reflexive modes are not currently part of the model. The VAIt verb class is not fully detailed, and the VAIta/i verbal class is not implemented at all. Furthermore, the "French-origin" verbal elements (modals, copula, etc.) need to be accounted for in some way if a complete account is to be made. The next implementation will also include additional lexical and grammatical preverbs.

The existing language data for Michif varies greatly from region to region, as well as by the age of the speaker. For this reason, further language data and linguistic analysis is needed.

6 Conclusion

Despite the development of LI VERB KAA-OOSHITAHK DI MICHIF, much more work remains to be done to create a complete account of the verbal morphology of Michif. Computational language modelling is an important foundational step towards creating language learning resources and making the creation of those resources more accessible to Indigenous language communities.

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Appendix I: Abbreviations

1	First person
2	Second person
3	Third person
3>3	Third person acting on third person
SG	Singular
PL	Plural
INCL	Inclusive
EXCL	Exclusive
DIR	Direct
INV	Inverse
OBV	Obviative
OBV1	First obviative morpheme
OBV2	Second obviative morpheme
OBJ	Object
IND	Independent order
CONJ	Conjunct order
PRS	Present tense
PST	Past tense
FUT	Future tense
MASC	Masculine
FEM	Feminine
INAN	Inanimate
ANIM	Animate
POSS	Possessive
DEM	Demonstrative
PREP	Preposition