Morphological Grammars to Generate and Annotate Verb Derivation in Quechua

Maximiliano Duran(✉)

Université de Franche-Comté, Besançon, France
duran_maximiliano@yahoo.fr

Abstract. In this paper we, study the morphology of Quechua verbs. In order to program their grammars, we first present the formalization of the agglutination laws of verbal suffixes in the form of NooJ morphological grammars. We isolate and study a class of highly productive bi and tri-suffixed agglutinations of interposed suffixes IPS. The derivations obtained, new atomic linguistic conjugable units ALUc's opens the way to favorably answer the challenging problem of translation of thousands of French verbs into Quechua, a language that contains less than 1 500 simple verbs.

Keywords: Quechua verb morphology · Suffix agglutination
Interposed suffix · NooJ grammars · Quechua verb derivation
Post posed suffixes · Verbalizers

1 Introduction

Quechua is the language of the Incas, an ancient civilization in South America. It's spoken by over 6 million people in Peru, Equator, Bolivia, and Argentina.

Concerning the verbs we notice two important characteristics: All the Quechua verbs are regular verbs, typologically speaking it is a SOV language.

We show in this paper how to generate new Quechua verbs through the derivation of simple verbs. We show also how to annotate them using certain morphological grammars programmed with the help of NooJ (Silberztein 2003, 2010). To reach this objective we should go through the following steps: first, we identify the basic canonical conjugated verbal form and isolate two classes of suffixes, the Inter positional suffixes IPS (Duran 2009, 2013), which will allow us to obtain new verbs and the post-posed suffixes PPS[1] which will present different modalities of a given verb without changing the part of speech. Parker calls it "modal suffix system" (Parker 1969). Then we describe in detail some of these generating paradigms in the NooJ environment (Silberztein 2016). We show some details of the programs that we have built to annotate the inflected verbs, then we describe how we can use this method to obtain the Quechua-French translation of these verbs with the help of automatically generated annotations.

[1] Parker (1969) unifies both sets in a single one and call it «modal suffix system». He considers only 16 suffixes.

S. Mbarki et al. (Eds.): NooJ 2017, CCIS 811, pp. 16–28, 2018.
https://doi.org/10.1007/978-3-319-73420-0_2

2 The Basic Canonical Conjugated Form

The main canonical conjugation form for any transitive verb follows the scheme

Subject + V STEM + ENDING

In which the person is marked but the time is not as is shown in the following table (Table 1):

Table 1. The unmarked-time basic conjugation of a verb

PRO QU	PRO EN	Verbal stem	PR ending
Ñuqa	I	Stem	+ NI
qam	You	Stem	+ NKI
pay	He, she	Stem	+ N
ñoqanchik	We	Stem	+ NCHIK
ñoqaiku	We (excl.)	Stem	+ NIKU
qamkuna	You	Stem	+ NKICHIK
paykuna	They	Stem	+ NKU

We will use the symbol PR for the set of these basic endings:
PR = (NI, NKI, N, NCHIK, NIKU, NKICHIK, NKU).

The general, non-future, verbal canonical form is:

V stem + IPS suffix+PR Ending+ PPS suffix

Where IPS symbolizes any interposed suffix and PPS symbolizes any postposed suffix: e.g.:

llamka-ri-ni	I begin to work	(1 IPS before the NI ending)
llamka-ni-raq	I first worked	(1 PPS after the NI ending)

A typical verbal form contains one to two agglutinated IPS preceding the ending and one to two PPS following the ending like in the following examples:

llamka-chi-ni-raq	I first made him work	(1IPS before, and 1 PPS after the NI ending)
llamka-na-nchik-raq-mi	We have to do the work putting everything aside	(1IPS before the NCHIK ending and 2 PPS after the NCHIK ending)

In the last two inflected forms *ni* and NCHIK act as fixed points.

As a matter of fact, a remarkable property during the inflection of any transitive verb is that the PR endings behave as fixed points around which IPS or PPS suffixes may be agglutinated to obtain a verbal form. The following table shows some more examples for the *ni* ending:

*Miku-**ni*** (I eat)
*Miku-chka-**ni*** (I am eating)
*Miku-chka-**ni**-raq* (I am eating before anything else)
*Miku-chi-chka-**ni**-raq-mi* ((I am eating before anything else indeed)
*Miku-chi-yku-chka-**ni**-lla-raq-mi* (I am carefully helping him to eat before anything else indeed

Fig. 1. The PR ending acts as a fixed point

The PR ending acts as a fixed point.

For the other endings, we may obtain their corresponding form replacing the NI ending by the one we want to use, leaving unchanged the rest of the form.

Thus if we represent by Fni the NI form: stem + IPS + ni + PPS.

And by Tnki the transformation that replaces the NI ending by the NKI ending. We will have:

Tnki(Fni)=Fnki, more explicitly
Tnki(stem+IPS+ni+PPS) = stem+IPS+nki+PPS

Where IPS[2] may be an agglutination of 1 to 4 interposition suffixes and PPS[3] may be an agglutination of 1 to 3 postposition suffixes.

3 Verbal Morphology

3.1 PPS Mono Suffixation

The mono suffixed inflection of a transitive verb including the future conjugation using 1 PPS or 1 FS[4] (future conjugation endings) are obtained applying the following NooJ grammar:

V_SPP1 = :SPP1_C| :SPP1_V |:SPP1_F;

Where

SPP1_V is the paradigm for the endings ending in a vowel and SPP1_C for those ending in a consonant

[2] IPS = (*chi, chka, ikacha, ikachi, ikamu, ikapu, ikari, iku, isi, kacha, kamu, kapu, ku, lla, mpu, mu, naya, pa, paya, pu, raya, ri, rpari, rqu,ru,tamu).*

[3] PPS = (ch, chá, chik, chiki, chu, chu(?), chusina, m, mi, má, man, ña, pas, puni, qa, raq, s, si, taq, yá).

[4] FS = (saq, nki,nqa, sun(nchik), saqku, nkichik, nqaku).

```
SPP1_V= ch |chiki |chu?  |chu |chusina |má  |m |ña |pas |puni  |qa |raq  |s |taq  |yá;
SPP1_C= chá |chiki |chu?  |chu |chusina  |má |mi  |ña |pas |puni |qa |raq |si |taq  |yá;
SPP1_F= SPP1_V_F| SPP1_C_F;
SPP1_V_F=(:F_V)(ch |chiki |chu?  |chu |chusina |má |m |ña |pas |puni |qa |raq |s |taq
|yá);
SPP1_C_F=(:F_C)(chá |chiki |chu?  |chu |chusina |má |mi |ña |pas |puni |qa |raq |si |taq
|yá);
SPP1_F=:SPP1_V_F | :SPP1_C_F;
F_V = <B>(nki/F+s+2 | nqa/F+s+3 | saqku/F+pex+1 | nqaku/F+p+3);
```

Giving a total of 210 inflected forms containing one postposition suffix as shown in the following Fig. 2.

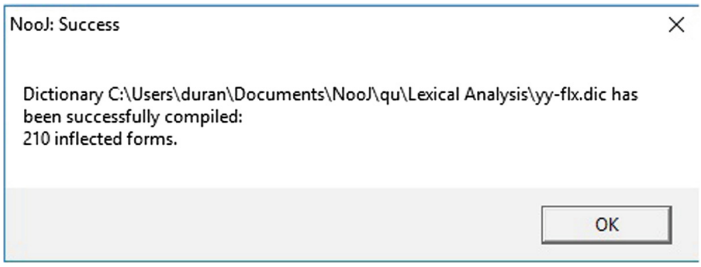

Fig. 2. Inflected forms bearing one interposed suffix

The following is a sample of these inflected forms:

```
rimaytaq,rimay,V+FR="parler"+FLX=V_SPP1+
rimayyá,rimay,V+FR="parler"+FLX=V_SPP1+
rimaychu?,rimay,V+FR="parler"+FLX=V_SPP1+
rimanqakuch,rimay,V+FR="parler"+FLX=V_SPP1+F+p+3
rimanqakuchiki,rimay,V+FR="parler"+FLX=V_SPP1+F+p+3
rimanqakuchu,rimay,V+FR="parler"+FLX=V_SPP1+F+p+3
rimanqakus,rimay,V+FR="parler"+FLX=V_SPP1+F+p+3
rimanqakumá,rimay,V+FR="parler"+FLX=V_SPP1+F+p+3
```

3.2 IPS Mono Suffixation

On the other hand, the mono suffixation of verb stems by IPS suffixes are very productive compared to the PPS derivations. They give rise to new verbs as in these examples:

asiy	«laugh»	> asi-ri-y	to smile
ripuy	«go away»	> ripu-ku-y	to move
rakiy	«to split»	> raki-naya-y	to feel like splitting

The resulting forms can be conjugated as if it were a simple verb. Figure 3 shows the NooJ grammar that generates them.

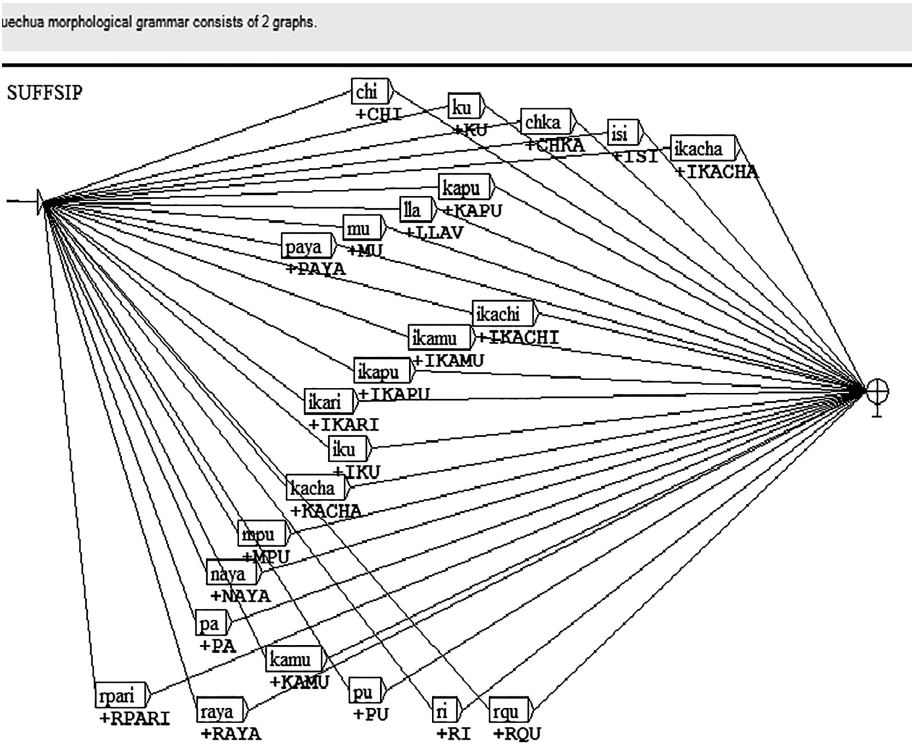

Fig. 3. The NooJ grammar that generates derived verbs using one suffix IPS

Below, we present an extract

rimaruy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + PRES + INF
rimarquy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + PAPT + INF
rimariy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + DYN + INF
rimarayay, rimay, V + FR = "parler" + FLX = V_SIP1_INF + DUR + INF
rimapuy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + APT + INF
rimapayay, rimay, V + FR = "parler" + FLX = V_SIP1_INF + FREQ + INF
rimanayay, rimay, V + FR = "parler" + FLX = V_SIP1_INF + ENV + INF
rimakuy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + AUBE + INF
rimakapuy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + RAS + INF
rimakachay, rimay, V + FR = "parler" + FLX = V_SIP1_INF + ARO + INF
rimaysiy, rimay, V + FR = "parler" + FLX = V_SIP1_INF + COLL + INF

The Quechua morphology allows certain agglutinations of two V_SIP2_INF and three V_SIP3_INF interposition suffixes. These new forms are also conjugable ones. They can be obtained by applying the following paradigms programmed in NooJ.

```
V_SIP2_INF =<B>(:CHICHI |:CHICHKA |:CHIIKACHI |:CHIIKAMU
|:CHIIKAPU |:CHIIKARI |:CHIIKU |:CHIISI |:CHIKAMU |:CHIKU |:CHILLAV
|:IKACHAKAMU |:IKACHAKU |:IKACHALLAV |:IKACHAMU |:IKACHAPU
|:IKACHARIV |:IKACHARQU |:IKACHICHKA |:IKACHIIKAMU
|:IKACHIIKAPU |:IKACHIIKARI |:IKACHIISI |:IKACHIKAMU |:IKACHIKAPU
|:IKACHIKU |:IKACHILLAV |:IKACHIMU |: … |:RIVRQU |:RPARICHI
|:RPARIIKACHI |:RPARIIKAMU |:RPARIIKAPU |:RPARIIKU|:RPARIISI
|:RPARIKAMU |:RPARIKAPU |:RPARIKU |:RPARILLAV |:RPARIMU |:RPARIPU
|:RPARIRQU
|:RQUCHKA |:RQUISI |:RQULLAV |:RUCHKA |:RULLAV |:TAMUCHI
|:TAMUCHKA |:TAMUIKACHA |:TAMUIKACHI |:TAMUIKAMU
|:TAMUIKAPU |:TAMURQU)y/INF;
```

It contains more than 240 valid agglutinations.

And for three IPS agglutinated suffixes

```
V_SIP3_INF =<B>(:CHAKUCHKAIKACHI |:CHAKUCHKAISI
|:CHAKUIKACHACHI |:CHAKUIKACHACHKA |:CHITAMURQU |:
|:CHKAIKACHIRIV |:CHKAIKACHITAMU |:CHKAISICHI |:CHKAISIIKARI
|:ISIMULLAV |:ISIMURQU |:KACHACHICHKA |:KACHACHIIKACHI
|:KACHACHIIKAMU |:KACHACHIIKAPU |:KACHACHIIKARI
|:KAMUIKAPUISI |:KAMUIKAPUKACHA |:KAMUIKAPULLAV |:KUIKUISI
|:KUIKULLAV |:KUIKURQU |:PAYAKAPUCHKA |:PAYAKAPUIKACHA
|:PAYAKAPUIKU |:PAYAKAPUISI |:…… …. |:RPARICHIMU |:RPARICHIPU
|:RPARICHITAMU |:RPARICHKAIKACHI |:RPARICHKAISI |:TAMUCHIKAMU
|:TAMUCHIKU |:TAMUCHILLAV |:TAMUCHIMU |:TAMUCHIPU
|:TAMUCHIRPARI |:TAMUCHKAIKACHI |:TAMURQUISI
|:TAMURQULLAV)y/INF;
```

Which contains more than 2470 valid agglutinations.

We present below some examples of ternary and more IPS suffix layer agglutinations:

na-ku-rqa rimanakurqanchik "we had talked about"
ra-ya-chi rimarayachinki "you have made him talk for a long time"
ra-ya-chi-spa rimarayachispayki "motivating him, you have made him talk for a long time"
ri-ku-lla-chka-pti rimarikullachkaptinchik "whereas we were talking very courteously one to each other"

3.3 The Mixed Inflections IPS + PPS

As we have seen in Fig. 1, an important property of Quechua grammar is that we can mix these two types of suffixation to generate current verbal forms. We have been able to program, with NooJ, the following paradigms of mixed agglutination:

```
V_MIX1=(:SIP1_PR_V) (:SPP1_V) | (:SIP1_PR_C)(:SPP1_C)
        | (:SIP1_PRM_V ) (:SPP1_V) | (:SIP1_PRM_C)(:SPP1_C);
```

e.g.: miku-chi-**ni**-raq

```
V_MIX12=:SIP1_PR_V)(:SPP2_V)|(:SIP1_PR_C)(:SPP2_C)  |(:SIP1_PRM_V  )
(:SPP2_V)|(:SIP1_PRM_C)(:SPP2_C);
```

e.g.: miku-chka-ni-raq-mi

```
V_MIX21= (:SIP2_PR_V)(:SPP1_V)|(:SIP2_PR_C)(:SPP1_C);
```

```
V_MIX22= (:SIP2_PR_V)(:SPP2_V)|(:SIP2_PR_C)(:SPP2_C);
```

e.g.: miku-chi-chka-ni-raq-mi

Where the symbols stand for V_MIX12: mixed verbal agglutination of 1 IPS and 2 SPP.

SIP1_PR_V: Agglutination with 1 IPS and conjugated following the PR scheme, etc.

We obtain, for the case of the verb *rimay*/to talk, 289 413 mixed and conjugated forms as shown in Fig. 4.

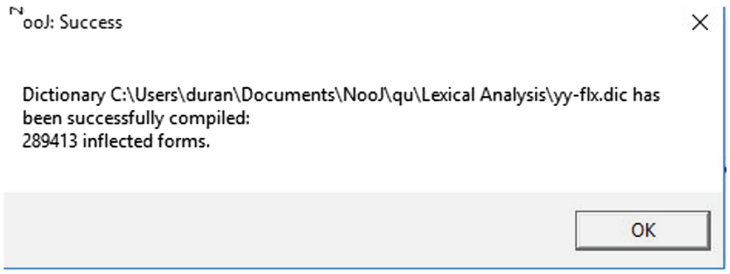

Fig. 4. Total of mixed and conjugated forms for the verb *rimay*

3.4 Verbalizers

An interesting strategy of Quechua is to generate verbs using a set of verbalizer suffixes. They may be added to nouns as well as to adjectives; these are:

The infinitive *–y*,
The transformative (creation or destruction) transitive *-chay*,

The transformative (to become) intransitive *–yay*.

Each one can be suffixed to certain classes of nouns or adjectives. Some nouns can be verbalized by only one of these suffixes and some nouns accept verbalization with two or all three of them: e.g.:

qipi	« parcel »	→ qipi-y	«to carry a parcel »
pirqa	« wall »	→ pirqa-y	« to build a wall »
machu	« old man »	→ machu-yay	« to age »
tuta	« night »	→ tuta-yay	« to get dark »
wasi	« house »	→ wasichay	« to build a house »
wasi	« maison, habitation »	→wasi-yay	« to become a house »
taksa	« petit »	→ taksa-yay	« to get small »

The following NooJ grammars may be utilized to generate verbs:

YAY = *yay*/V; # derives some type of nouns and adjectives into verbs *chukru* =>*chukruyay* to toughen
CHAY = *chay*/V; # derives some type of nouns and adjectives into verbs *puka* => *pukayay*/to become red
Y = y/V;

3.5 The Quechua-French Translation Problem

One of the objectives of our long-term project, of machine translation from French to Quechua, is to build bilingual French-Quechua dictionaries of each PoS (Nouns, Verbs, Adjectives, etc.).

Concerning the Quechua lexicon of simple verbs, it contains around 1500 entries. It is not enough to get the translation of the 25 000 French verbal senses contained in Dubois & Dubois-Charlier dictionary[5]. For instance, the verb "tourner"/to turn, has 27 meanings in LVF (Dubois and Dubois-Charlier 2007; François et al. 2007); how to find its translation knowing that the only possible equivalent simple verb in Quechua is *muyuy*.

4 Generation of ALUc

But, as we have just seen above, Quechua has a very productive strategy: Derivation V > V, by suffixation. We have programmed the following paradigms in NooJ and generated 43 394 new Quechua verbal senses (Fig. 5. *Total of mixed and conjugated forms for the verb* rimay), ALUc, that can be conjugated as a simple verb.

[5] See Dubois & Dubois-Charlier «Les verbes français LVF» This dictionary contains 25 609 verbal senses. It was finished in 1992 and thanks to Denis Le Pesant, who is in charge of its diffusion, it is available since 2007 in a formalized format through MoDyCo.

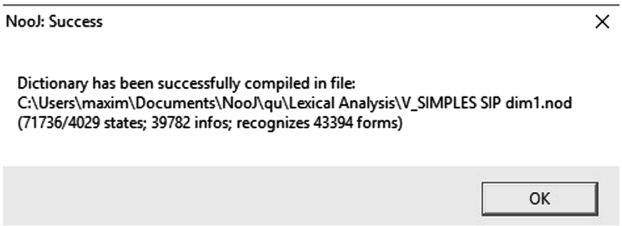

Fig. 5. Total of mixed and conjugated forms for the verb *rimay*

Total generated new verbal senses

An extract of which appear in the Fig. 6.

```
# NooJ V5
ichichiy,ichiy,V+TR+FR="marcher"+FLX=V_SIP1_INF+FACT+INF
ichirquy,ichiy,V+TR+FR="marcher"+FLX=V_SIP1_INF+PAPT+INF
ikiriy,ikiy,V+TR+FR="effleurer"+FLX=V_SIP1_INF+DYN+INF
iklliykuy,iklliy,V+TR+FR="bourgeonner"+FLX=V_SIP1_INF+COURT+INF
illariy,illay,V+TR+FR="absenter (s')"+FLX=V_SIP1_INF+DYN+INF
illapay,illay,V+TR+FR="absenter (s')"+FLX=V_SIP1_INF+PEAU+INF
illanayay,illay,V+TR+FR="absenter (s')"+FLX=V_SIP1_INF+ENV+INF
iñipay,iñiy,V+TR+FR="adhérer"+FLX=V_SIP1_INF+PEAU+INF
iñinayay,iñiy,V+TR+FR="adhérer"+FLX=V_SIP1_INF+ENV+INF
ipuykachay,ipuy,V+TR+FR="bruiner"+FLX=V_SIP1_INF+ARO+INF
ismuruy,ismuy,V+TR+FR="abïmer (s') (un fruit)"+FLX=V_SIP1_INF+PRES
kachamuy,kachay,V+TR+FR="envoyer"+FLX=V_SIP1_INF+ACENT+INF
kachiysiy,kachiy,V+TR+FR="saler"+FLX=V_SIP1_INF+COLL+INF
kachupay,kachuy,V+TR+FR="mâcher"+FLX=V_SIP1_INF+PEAU+INF
kakñakuy,kakñay,V+TR+FR="obstruer"+FLX=V_SIP1_INF+AUBE+INF
kallchariy,kallchay,V+TR+FR="moissonner"+FLX=V_SIP1_INF+DYN+INF
kamchachiy,kamchay,V+TR+FR="torréfier"+FLX=V_SIP1_INF+FACT+INF
kamiykuy,kamiy,V+TR+FR="admonester"+FLX=V_SIP1_INF+COURT+INF
```

Fig. 6. Extract of the generated new verbal senses

Do all of these ALUc have an actual meaning? In the affirmative case, the expected translation FR > QU of verbs of the Dubois & Dubois-Charlier dictionary seems to be feasible.

How to figure out the meaning of those derived forms which are not so familiar in everyday speaking or in the written corpus? When we apply the suffix *–chi-* to the verb *muyuy*/to turn we obtain *muyuchiy*/make it rotate, but is it possible to translate *muyu-chi-tamu-y* or *muyu-kapu-lla-y* avoiding long periphrases?

In order to aboard such a challenge, we have done the following steps: First we have identified and formalized the agglutination of IPS suffixes in the form of NooJ morphological grammars using one, two and three suffixes and applying some matrix methods to calculate the combinatorial. Second, we have inventoried the semantic characteristics of each IPS suffix and construct an indexed table. Third, we have constructed several NooJ grammars, like the ones appearing below, showing these modalities as annotations:

CHAKU_T=chaku/RID_1_de façon rificule_RID_2_ de façon diminuée_RID_3_de façon dépréciée;
CHI_T=chi/FACT_1_assiste_aide_FACT_2_invite_autorise_incite_FACT_3_pousse_l'objet_du_verbe_à_réaliser_l'action_FACT_4_commande_ordonne_pousse;
CHKA_T=chka/PROG1_en_train_deréaliser_l'action_PROG2_en_cours_d'accomplissement; # aspect progressif;
IKACHA_T=ykacha/DISP_1_en_désordre_DISP_2_réalise_l'action_desorienté_en_directions_multiples_DISP_3_dans_n'importe_quel_manière;
ISI_T=ysi/COLL_1_collabore_COLL_2_aide_à_réaliser_l'action
RI_T=ri/DYN_1_commence_à_DYN_2_l'action_se_fait_une_fois_DYN_3_l'action_commence_lentement_et_à_la_legère_DYN_4_avec_courtoisie_et_amitié;

4.1 Modalities of Enunciation of IPS Suffixes

We have made an inventory of all the main modal and aspectual meanings of the 27 inter positional derivational suffixes SIP. We show in Fig. 7 an extract of these descriptions.

	SIP	formulle	VSV1	VSV2	VSV3
2	chaku	chaku/RID	RID_1_de façon ridicule	RID2_de façon diminuée	RID_3_de façon dépréciée;
3	chi	chi/FACT	FACT_1_assiste_aide	FACT_2_invite_autorise_incite	FACT_3_pousse_l'objet_du_verbe_à_réal
4	chka	chka/PROG	PROG1_en_train_deréaliser_	PROG2_en_cours_d'accomplissement; # aspect progressif;	
5	ykacha	ikacha/DISP	DISP_1_le sujet réalise _acti	DISP_2_réalise_l'action_desorie	DISP_3_dans_n'importe_quel_manière;
6	ykachi	ikachi/POLI	POLI_1_poliment	POLI_2_concrètement	POLI_3_précisément
7	ykamu	ikamu/PREAT	PREAT_1_vers_le_sujet	PREAT_2_en_prévoyant	PREAT_3_attentionné
8	ykapu	ikapu/SOIN3	SOIN3_1_avec_attention	SOIN3_2_soigneusement	SOIN3_3_concernant_un_tiers
9	ykari	ikari/APRP	APRP_1_ponctuelle_et_rapi	APRP_2_à_la_hâte_mais_avec_précision_réalise_l'action;	
10	yku	iku/COURT	COURT_1_courtoisement_so	COURT_2_allant_vers_l'intérieur	COURT_3_réalise_l'action_à_fond_se_lâc
11	ysi	isi/COLL	COLL_1_collabore	COLL_2_aide_à_réaliser_l'action;	
12	kapu	kapu/RAS	RAS_1_retour au sujet	RAS_2_réalise_l'action-en_auto_bénéfice	
13	ku	ku/AUBE	AUBE_1_actance_se_respons	AUBE_2_réalise_l'action_à_son_	AUBE_3_s'impliquant_réalise_l'action
14	lla	lla/POL1	POLI_1_gentiment	POL1_2_poliment	POL1_3_doucement
15	mu	mu/ACT	ACT_1_actance_centripète_	ACT_2__actance_centrifuge_d'él	ACT_3_action_orienté_vers_un_point;
16	mpu	mpu/INSP	INSP_1_l'action_se_réalise_	INSP_2_rétrograder_de_retour_à_condition_antérieur;	
17	na	na/OBL	OBL-1_action_obligé	OBL_2_l'action_est_potentiellement_à_réaliser;	
18	naya	naya/ENV	envié_de_réaliser l action	ENV_2_bésoin_de_réaliser_l'action;	
19	pa	pa/PEAU	PEAU_1_peaufine_l'action	PEAU_2_réitère_l'action	PEAU_3_complète_l'action;
20	paya	paya/FREQ	FREQ_1_répétition_fréquen	FREQ_2_persiste_à_réaliser_l'ac	FREQ_3_action_prolongée_à_l'excés;
21	pu	pu/APT	APT_1_réalise_action_en_bé	APT_2_réalisé_en_préjudice_d'u	APT_3_action_s'écartant_du_sujet_et_de
22	ra	ra/PASS	RA_1: PRO V(PAS)	RA_2 : avoir_réalisée_l'action	
23	raya	raya/DUR	DUR_1_demeure_un_temps	DUR_2_permanence_dans_la_réalisation_de_l'action;	
24	ri	RIV=ri/DYN	DYN_1_commencer_à	DYN_2_l'action_se_fait_une_fois	DYN_3_l'action_commence_lentement_e
25	rpari	rpari/ASUR	ASUR_1_action_surprise_sar	ASUR_2_réalise_l'action_impulsi	ASUR_3_action_réalisé_complètement;
26	rqu	rqu/PAPT	PAPT_1_accompli_l'action_e	PAPT_2_action_centrifuge_réalis	PAPT_3_brusquement_soudainement_de

Fig. 7. Modalities of enunciation of IPS suffixes

Parsing these grammars gives us several propositions as possible translations of each derived ALUc (Fig. 8):

```
rimapamuy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_actio
rimapakuy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_actio
rimapaisiy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_acti
rimapaikuy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_acti
rimapaikariy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_ac
rimapaikapuy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_ac
rimapaikamuy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_ac
rimapaikachiy,rimay,V+FR="parler"+FLX=V_SIP2_INF+le_sujet_peaufine_PEAU_2_réitère_PEAU_3_réalise_l_a
```

Fig. 8. A glossed approach for the translation of derived verbs

For example: among the list of derivations of the verb *rimay*/to talk, it appears *rimaykuy*. It is the output of the inflection obtained when we apply to it the suffix –*yku*-. Its corresponding NooJ grammar has generated the following annotation in French:

```
rimaykuy,rimay,V+FR=« parler »+FLX=V_SIP1_INF_S+
le_sujet _courtoisement _COURT_2 soigneusement_
COURT_3_amicalement_ COURT_4_ réa-
lise_l_action_orienté_vers _le_sujet _+INF
```

We may use these automatic annotations in order to figure out the translation that feats better the ALUc.

We choose (manually): `(the subject) talks to someone courteously, carefully, friendly`,

Thus we'll have "to greet" as the nearest translation of *rimaykuy*.

Let's see an example in the sense French > Quechua. For one of the verbal senses of the verb "tourner"/to turn in French. We choose one of the 27 meanings of "tourner" appearing in the Dubois & Dubois-Charlier dictionary.

`Meaning 13: tourner «Il indique que l'action se réalise de façon persistante»`

To translate this verb, into Quechua, we search among the corresponding annotations in the output of inflections obtained when we apply the suffix –*paya*- to the verb *muyuy*, (that the modalities of *paya* appear in Fig. 7). Its corresponding NooJ grammar has generated, among 27 others, the following annotation in French:

```
muyupayay,muyuy,V+FR=« tourner »+FLX=V_SIP1_INF_S+
PAYA_1:  PRO V(PR) sans répit, répétition fréquente _
PAYA_2: persiste_à_réaliser _l'action _ PAYA_3 : ac-
tion_prolongée_à_l'excés _ PAYA_F : « PRO V(F) sans répit
+INF
```

We choose manually: `(the subject) "_tourne sans répit, répetition fréquente"`,

Which approaches better to meaning 13. Thus we'll have

`muyupaayay: tourner de façon persistante (rotation)`

We have mentioned before that the lexicon of simple verbs of Quechua contained around 1500 entries. We have found many derived verbs as translation of simple French verbs (like sourire/*asi-ri-y* coming from *asiy*/rire "to laugh"; bougonner/*rima-pa-ku-y* coming from *rimay*/parler "to talk", etc.). Many others come from

verbalizations of nouns or adjectives like: aplanir/*pampa-cha-y* coming from the noun *pampa*/plane; appauvrir/*wakcha-ya-y/"to become poor"* coming from the adjectif *wakcha*/orphelin, pauvre "poor". However, for the translation of several thousands of French verbs we have utilized our annotation method described above. In Fig. 9 we present an extract of our newly constructed electronic French-Quechua verb dictionary containing more than 8600 entries (Duran 2017).

	A	B	C	D	E	F	G
1	V fr	V qu	Domaine	Phrase	CONJUGA	Constructior	Lexique
2	aimer 01	kuyay	psycholo	On a~ P. Tous deux s'a~. On a~ sans être paye	1bZ	T1100 - P1	1
3	aimer 02	kuyaykuy	psycholo	On a~ ses amis pour leur franchise.	1bZ	T1100	5
4	aimer 03	kuyay	psycholo	On a~ manger des bonbons. On a~ le chocolat	1bZ	T1400	5
5	aimer 04	waylluy	psycholo	On a~ cette rencontre, que tu réussisses, venir	1bZ	T1400	5
6	aimer 05	munay	psycholo	On a~ à taquiner sa soeur.	1bZ	N1a	5
7	aimer 06	munarpariy	physiolog	On a~ le soleil. Cette plante a~ l'ombre.	1bZ	T1306	5
8	ajouter 01	yapaykuy	littérature	On a~ un chapitre au livre.	1aZ	T13a0 - P3	1
9	ajouter 04	mirachiy	quantitati	Ces cris a~ à la panique.	1aZ	N3a	5
10	ajuster 01	matipay	mécaniqu	On a~ un tuyau au robinet. La robe s'a~ bien à	1aZ	T13a8 - P3	2
11	ajuster 02	allchapariy	habilleme	On a~ sa cravate, sa coiffure.	1aZ	T1306	5
12	ajuster 04	tinkupachiy	mécaniqu	L'ajusteur a~ les pièces de métal. La pièce est	1aZ	T1308 - P3	5
13	ajuster 05	tinkupay	habilleme	On a~ les salaires au coût de la vie.	1aZ	T13a0 - P3	5
14	ajuster 06	tinkuchiy	armemer	On a~ son fusil avant de tirer.	1aZ	T1306 - P3	5
15	ajouter	yapaykuy	mécaniqu	On a~ un embout à une canalisation.	1aZ	T13a8 - P3	6
16	aligner 01	qayllascha	objet	On a~ des plants. Les chaises s'a~ devant l'es	1aZ	T1801 - P8	2
17	aligner 02	yupaychay	littérature	On a~ des nombres, des phrases vides.	1aZ	T1800	5
18	aligner 07 (s')	hayllaschal	locatif, lie	Les gens s'a~ sur les trottoirs pour regarder le	1aZ	P7001	5
19	aligner 08 (s')	qawarikap	psycholo	On s'a~ sur les positions de P.	1aZ	P10g0	5
20	aligner 09	sqischay	locatif, lie	On a~ des enfants devant l'entrée de la classe	1aZ	T1701 - P7	5
21	alimenter 01	mikuy	cuisine, p	On a~ un malade de légumes. On s'a~ de fruits	1aZ	T11b0 - P1	2
22	alimenter 02	mikuchiy	industrie	On a~ en gaz la ville par une conduite. La ville s	1aZ	T19j0 - P9	5
23	alimenter 03	huntapay	littérature	On a~ les conversations d'anecdotes.	1aZ	T13b6 - P3	5
24	alimenter 04	huntapay	psycholo	On a~ sa haine de tels propos. Sa haine s'a~ c	1aZ	T1308 - P3	5
25	aliter 02 (s')	siririy	médecine	Le malade s'a~, on est a~ avec la grippe. La g	1aZ	P1001 - T9	5
26	aller 01	hamuy	locatif, lie	On a~ à Paris, dans un musée.	1zA	A12	1
27	aller 02	riy	locatif, lie	On a~ pour chasser. On a~ à la chasse, à la re	1zA	A12	5
28	aller 03	riykuy	commerc	On a~ chez le boucher, le médecin, le coiffeur.	1zA	A12	5
29	aller 04	riy	véhicule	Ce train a~ à Paris.	1zA	N3g	5

Feuil1 Feuil2 Feuil3

Fig. 9. Extract from Electronic French-Quechua (See Duran (2017).) verb dictionary

5 Conclusion and Perspectives

We have constructed several thousands of morpho syntactic paradigms for the inflection and derivation of verbs,

We have obtained the annotated verbal inflexions which serves as a database for the translation of several thousand french verbal senses into Quechua,

We plan to enhance the number of paradigms containing multi suffixed derivations to enlarge the FR-QU dictionary.

References

Dubois, J., Duboir-Charlier: Dictionnaire Linguistique et Sciences du langage. Editions Larousse, Paris (2007)

Duran, M.: Dictionnaire Quechua-Français-Quechua. Editions HC, Paris (2009)

Duran, M.: Formalizing quechua verbs inflexion. In: Proceedings of the NooJ 2013 International Conference, Saarbrücken (2013)

Duran, M.: Dictionnaire électronique français-quechua des verbes pour le TAL. Université Franche-Comté, Besançon-Paris. Thèse doctoral soutenu en mars, 600 p. (2017)

François, J., Le Pesant, D., Leeman, D.: Le classement syntaxico-sémantique des verbes français, Langue française, Armand Colin, Paris, no. 153 (2007)

Parker, G.J.: Ayacucho Quechua Grammar and Dictionary. University of Hawaii, Mouton, The Hague, Paris (1969)

Silberztein, M.: NooJ Manual (220 p., updated regularly) (2003). http://www.nooj4nlp.net

Silberztein, M.: La formalisation du dictionnaire LVF avec NooJ et ses applications pour l'analyse automatique de corpus. Langages 3/2010 (no. 179–180), pp. 221–241 (2010)

Silberztein, M.: Language Formalization: The NooJ's Approach. Wiley Eds. (2016)