Building stemmers for Information Retrieval and related domains

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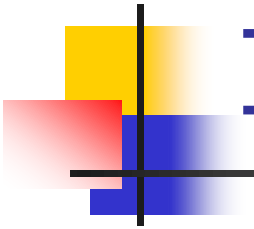
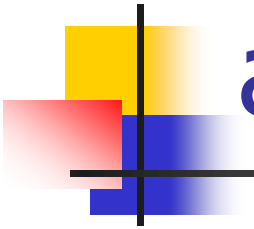


Introduction



about stemmers

- They are used in various text processing tasks: search engines, document/text summarizers, document/text classifiers, etc,
- Stemmers produce normalized forms of words in order to handle as one attribute all the inflected word-forms existing in documents for the same word,
- Alternative solution is the usage of lemmatizers that conflate a set of words in their etymological root.

Stemmer's and Lemmatizer's examples

Greek

- Τράπεζα (Bank),
- Τράπεζες (Banks),
- Τραπεζικές (Banking),
- Τραπεζική (Banking)

- Stemmer's result: ΤΡΑΠ,
- Lemmatizer's result: ΤΡΑΠΕΖΑ

Albanian

- PROVË
- PROVOHEJ
- PROVONTE
- PROVUAR

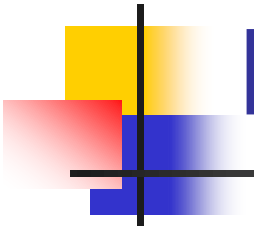
- Stemmer's result: PROV,
- Lemmatizer's result: PROVË

Stemming example for Serbian

	singular	plural
nominative	вòда	вòде
genitive	вòде	вóдā
dative	води	водама
accusative	воду	воде
vocative	водо	воде
locative	води	водама
instrumental	водом	водама

To complicate more: водица

The stem could be **вод**

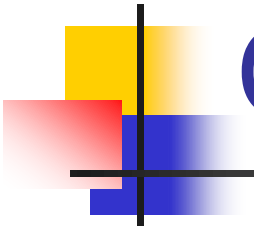


Rule based stemmers

- Porter's stemmer uses five levels (granularity, different rules in each level)
- Lovin's stemmer uses 2 steps (suffix elimination and recording step)
- Paice's stemmer is an iterating algorithm using the same rules in each step

The purpose of research

- The domain of interest is the creation of a stemmer, when the development team does not have knowledge of the target language of stemmer.
- Our approach requires two resources:
  - a list of available suffixes used in the target language and
  - a training set of words in the target language with their translations in the native language of the experts.
- Both resources can be easily constructed by speakers of both languages (target and experts' native language).
- Speakers of both languages are needed to have a secondary or high school level (no university degree).



Overview of Approach

- The approach assumes a very simple (primary or bootstrapping) stemmer that provides stems by simply removing the longer suffix that match with a given word.
- Experts express their arguments regarding the results of the primary stemmer.
- The final step is a trial and error approach that permits to an IR (information retrieval) expert to dynamically construct a better stemmer, without coding even a single line of code.

Approach in Data Flow Diagram

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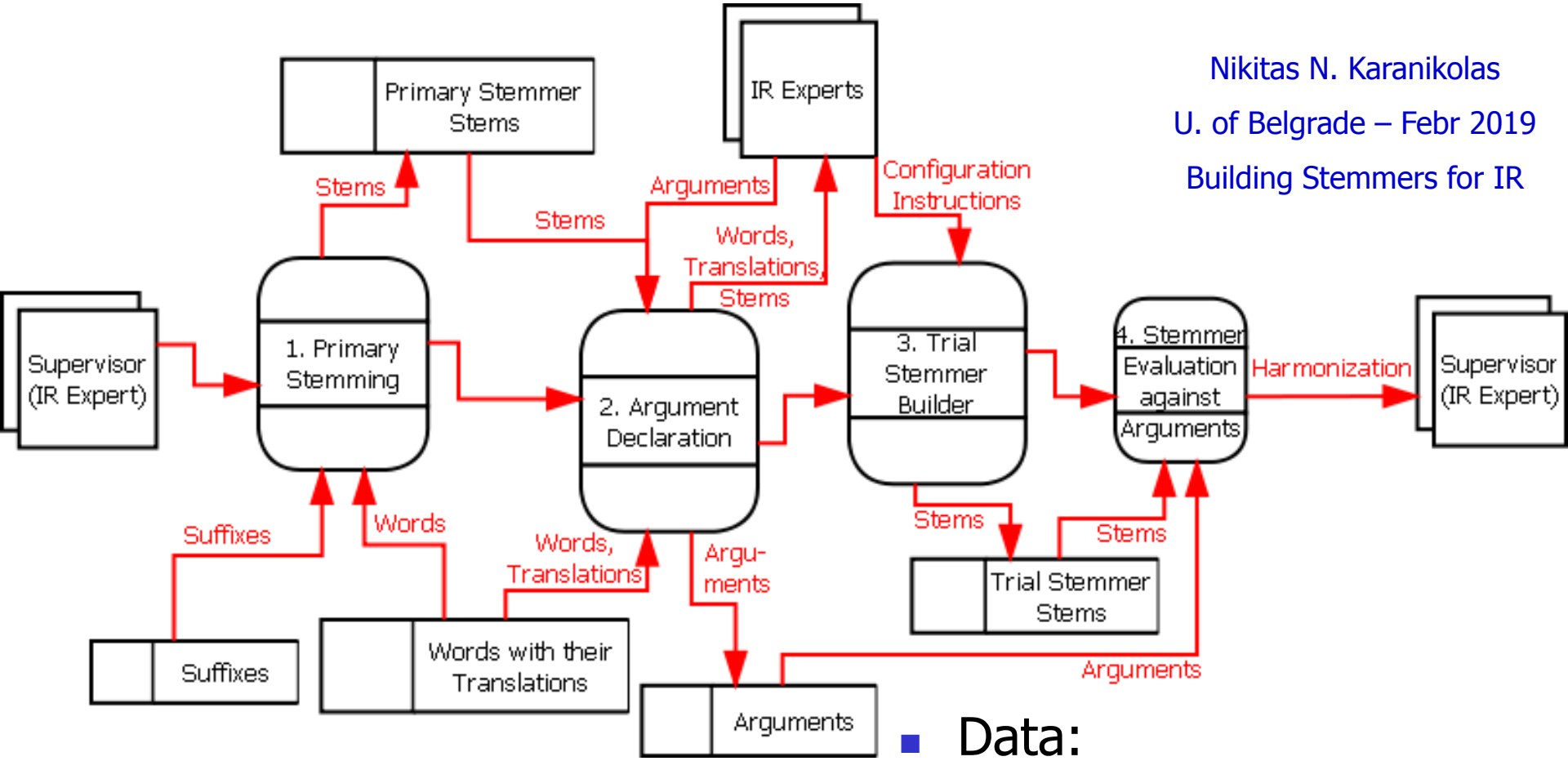
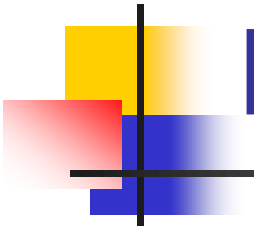
Building Stemmers for IR



- Processes:
  - 1. Primary Stemmer
  - 2. Argument Declaration
  - 3. Stemmer Builder
  - 4. Evaluator
- Data:
  - Suffixes
  - Words with Translations
  - Arguments
  - Primary Stemmer's Stems
  - Trial Stemmer Stems



Experts' Arguments

Examples of Experts' argumentation (1/3)

Ref. num	Word	Stem	Translation	Argument
1489	HIMARË	HIM	οι ύμνοι	CS (HIM)
1490	HIMNET	HIMN	των υμνών	
1491	HIMNI	HIM	ο ύμνος	
1492	HIMNIN	HIM	τον ύμνο	
1493	HIMNIT	HIM	του ύμνου	

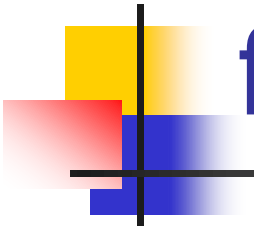
Examples of Experts' argumentation (2/3)

Ref. num	Word	Stem	Translation	Argument
1963	KOSTA	KOST	όνομα ανθρώπου	DS
1964	KOSTON	KOST	κοστίζει	

Examples of Experts' argumentation (3/3)

Ref. num	Word	Stem	Translation	Argument	
3172	PËRBEHEJ	PËRBE	αποτελείται	DS	CS_1
3173	PËRBËJNË	PËRBË	αποτελούνται		
3174	PËRBËN	PËRB	αποτελεί		
3175	PËRBËNTE	PËRBË	αποτελούσε		
3176	PËRBËRË	PËRBËR	αποτελείται		
3177	PËRBËRJE	PËRBËR	σύνθεση		CS_2
3178	PËRBËRJEN	PËRBËR	η σύνθεση		

Kinds of arguments and facilities



- Kinds
  - Complaints
  - Verifications
  - Why expressing verifications
- Facilities
  - Movements
  - Rules for x in CS(x)

Complaints - CS

Ref.Num.	Word	Stem	Translation	Argument
3562	PRONARET	PRONAR	Ιδιοκτήτες	CS (PRON)
3563	PRONAREVE	PRONAR	των ιδιοκτητών	
3564	PRONAVE	PRON	των ιδιοκτησιών	
3565	PRONË	PRO	ιδιοκτησία	
3566	PRONES	PRON	της ιδιοκτησίας	

Complaints – DS/CS

Ref.Num.	Word	Stem	Translation	Argument	
2049	KUKËS	KUK	πόλη της Αλβανίας	DS	CS_1
2050	KUKËSIT	KUK	της πόλης αυτής		
2051	KUKULL	KUK	κούκλα		CS_2

Complaints – DS/CS

Ref.Num.	Word	Stem	Translation	Argument	
1059	FILL	FILL			CS_1
1060	FILLIM	FILL		DS	CS_2
1061	FILLIMI	FILL			
1062	FILLIMIN	FILL			
1063	FILLIMISHT	FILL			
1064	FILLIMIT	FILL			
1065	FILLOI	FILL			
1066	FILLOJ	FILL			
1067	FILLOJMË	FILL			
1068	FILLOVA	FILL			
1069	FILLUA	FILL			
1070	FILLUAN	FILL			
1071	FILLUAR	FILL			

Verifications - CS

Ref.Num.	Word	Stem	Translation	Argument
1073	FILOZOFËT	FILOZOF	οι φιλόσοφοι	CS (FILOZOF)
1074	FILOZOFINË	FILOZOF	τον φιλοσοφισμό	
1075	FILOZOFISË	FILOZOF	της φιλοσοφίας	

Verifications – DS/CS

Ref.Num.	Word	Stem	Translation	Argument	
176	ARMATA	ARMAT	στρατός	DS	CS_1
177	ARMATËS	ARMAT	του στρατού		
178	ARMATOSUR	ARMATOS	οπλισμένος		CS_2
179	ARMATOSURA	ARMATOS	οπλισμένα		
180	ARMË	ARM	όπλα		CS_3
181	ARMËT	ARM	τα όπλα		
182	ARMËVE	ARM	των όπλων		

Why expressing verifications

- The need to emphasize or verify the results of the primary stemmer comes from the algorithm used to compare the harmonization of a given stemmer with the expert's arguments.
- The matching factor (in an off hand simplification) is calculated as the number of experts arguments (CS and DS/CS) that are verified by the stemmer's results (stems), normalized by the number of arguments.
- The rest stemmer's results (stems that correspond to words which are outside the experts' arguments) contribute only slightly to the matching factor.
- The criterion for a stem outside the experts' arguments to contribute (increase slightly the matching factor) is that it differs from its adjacent ones.
- This requirement/criterion is the only difference against some earlier version.

Reordering & Complaints – CS

Ref.Num.	Word	Stem	Translation	Argument
1554	IDENTIFIKUARA	IDENTIFIK	προσδιορισμένα	∅
1552	IDEJA	IDE	η ιδέα	CS(IDE)
1553	IDENË	ID	την ιδέα	
1555	IDEVE	ID	των ιδεών	

Reordering & Complaints– DS/CS

Ref.Num.	Word	Stem	Translation	Argument	
3511	PRILL	PRI	Απρίλιος	DS	CS_1
3523	PRISJA	PRIS	περίμενα		CS_2
3524	PRISNIN	PRIS	περίμεναν		
3525	PRITËN	PRIT	περίμεναν		
3526	PRITET	PRI	αναμένεται		
3527	PRITJEN	PRIT	την αναμονή		
3528	PRITUR	PRIT	φιλόξενος		

Reordering & Verifications – CS

Ref.Num.	Word	Stem	Translation	Argument
3576	PROVINCË	PROVINC	επαρχία κράτους	∅
3575	PROVË	PROV	δοκιμή	CS(PROV)
3577	PROVOHEJ	PROV	δοκιμάζονταν	
3578	PROVONTE	PROV	δοκίμαζε	
3579	PROVUAR	PROV	δοκιμασμένο	

x in CS(x) – example

Ref.Num.	Word	Stem	Translation	Argument
2014	KRYER	KR	εκτελεσμένος	CS (KRYER)
2015	KRYERA	KRYE	το εκτελεσμένο	
2016	KRYERJEN	KRYER	την εκτέλεση	

X can be one of the available stems in set, but which one?

KRYER:
exist in every
longest
most frequent

x in CS(x) – example

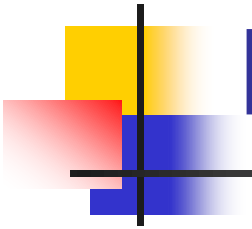
Ref.Num.	Word	Stem	Translation	Argument
2063	KUNDER	KUND	κατά	CS (KUND)
2064	KUNDËRSHTIM	KUNDËRSHT	ένσταση	
2065	KUNDËRSHTIVE	KUNDËRSHT	εναντιώθηκες	
2066	KUNDËRSHTUAN	KUNDËRSHT	εναντιώθηκαν	

KUND:
exist in every
longest
most frequent

Relax the rule, give priority to the left (up)

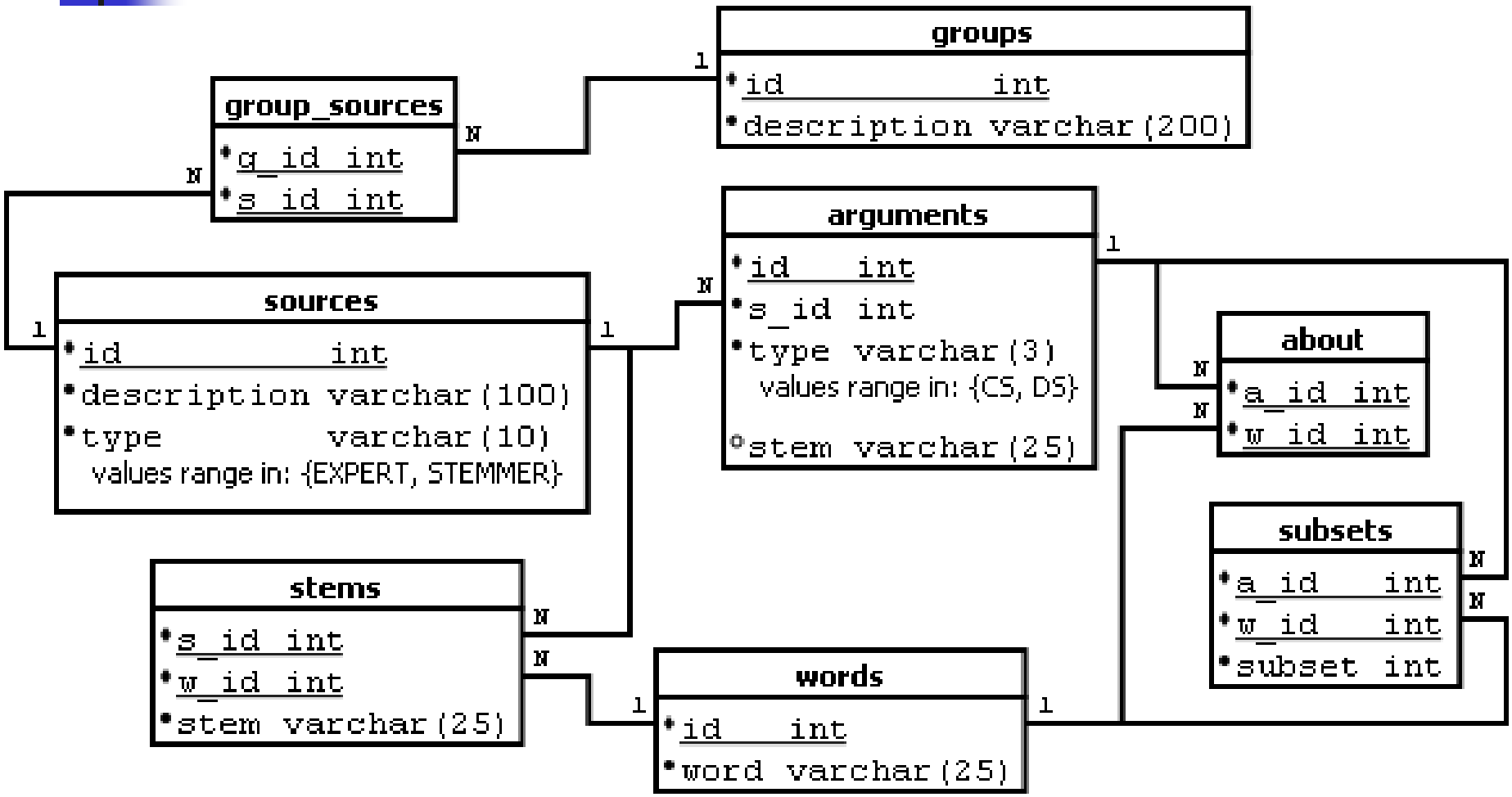
x in CS(x) – requirements

- Requirement to select a stem that exists in every word of the set. It comes from the need to get the stem with simple suffix removal (no replacements).
- Requirement to be the longest one. It comes from the need to not over-conflate (conflate with neighbour words which have other meanings).
- The requirement to be the most frequent. It is because it leaves fewer cases that impose adaptation of stemmer.



Database

Database structure



Database codified expert's CS argument

Ref. num	Word	Stem	Translation	Argument
1489	HIMARË	HIM	οι ύμνοι	CS (HIM)
1490	HIMNET	HIMN	των υμνών	
1491	HIMNI	HIM	ο ύμνος	
1492	HIMNIN	HIM	τον ύμνο	
1493	HIMNIT	HIM	του ύμνου	

```
INSERT INTO arguments values (29, 3, 'CS', 'HIM');
INSERT INTO about values (29,1489);
INSERT INTO about values (29,1490);
INSERT INTO about values (29,1491);
INSERT INTO about values (29,1492);
INSERT INTO about values (29,1493);
```

Database codified expert's DS/CS argument

Ref. num	Word	Stem	Translation	Argument	
3172	PËRBEHEJ	PËRBE	αποτελείται	DS	CS_1
3173	PËRBËJNË	PËRBË	αποτελούνται		
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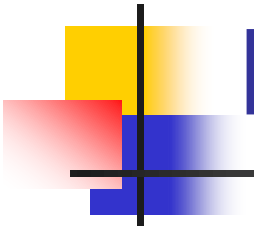
3177	PËRBËRJE	PËRBËR	σύνθεση		CS_2
3178	PËRBËRJEN	PËRBËR	η σύνθεση		

INSERT INTO **arguments** values (123, 4, 'DS', null);

INSERT INTO subsets values (123,3172,1);
INSERT INTO subsets values (123,3173,1);
INSERT INTO subsets values (123,3174,1);
INSERT INTO subsets values (123,3175,1);
INSERT INTO subsets values (123,3176,1);

INSERT INTO subsets values (123,3177,2);
INSERT INTO subsets values (123,3178,2);

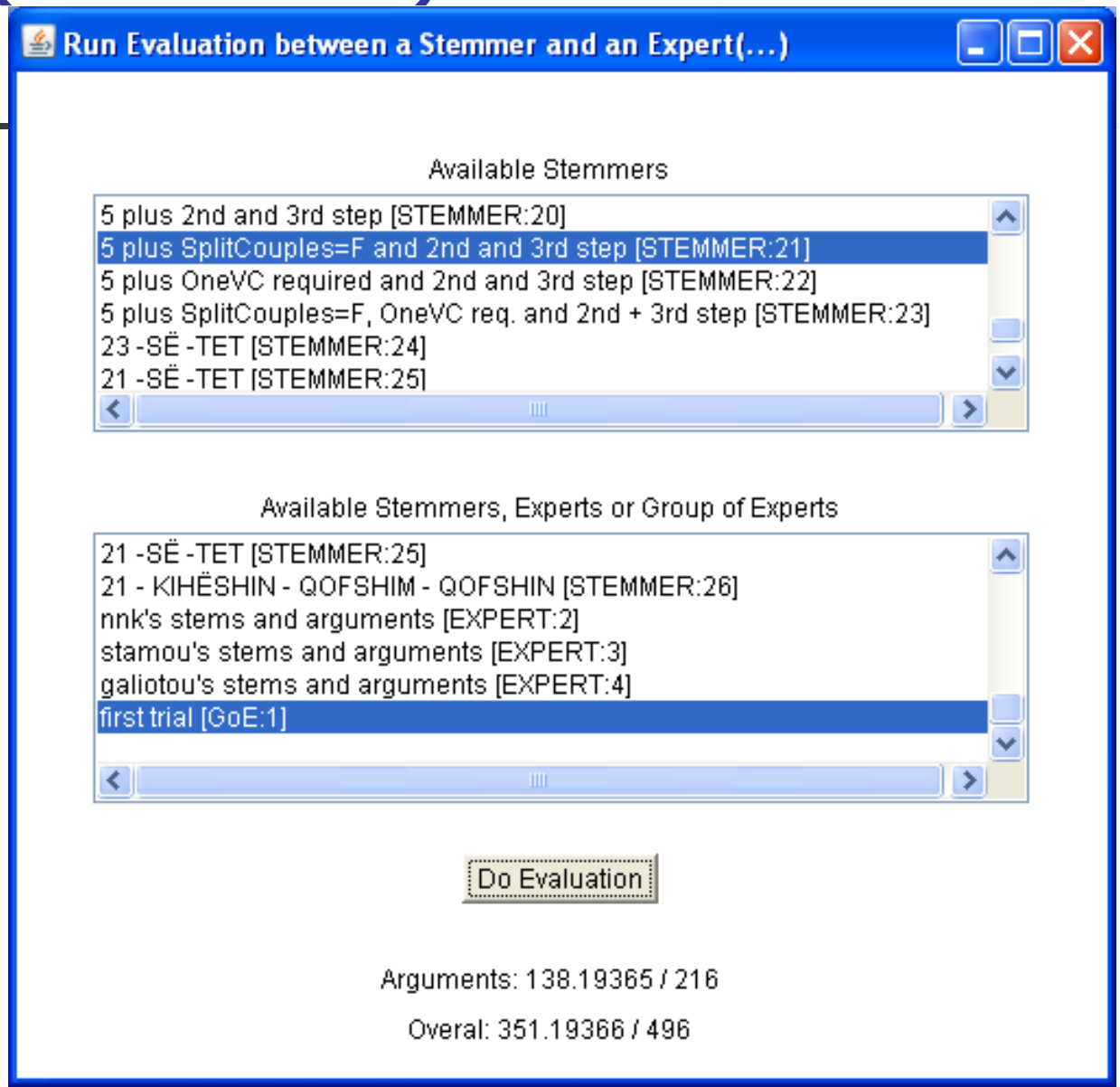


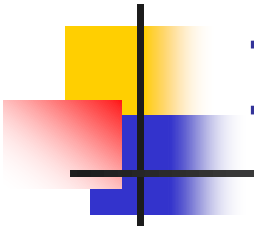
Evaluator

Matching Algorithm

- **Intra subset uniformity (**how much uniform are the stemmer's results intra subsets**)**
- **Inter subsets unevenness (**how much unevenness are the stemmer's results inter subsets**)**
- **Factors combination (**relative contribution between previous factors**)**

Interface for evaluating stemmers (Evaluator)





1st Builder

1st Builder: 1st step – Remove the longest suffix under 4 (optional) conditions

- *Active Suffix* condition (per suffix). Suffixes marked as inactive are not checked and consequently are not candidate for removal.
- *At Least Remain Letters* arithmetic parameter. A suffix removal is permitted only when the remaining word part contains a number of letters which is equal or greater than the parameter's value.
- *One VC* optional condition. If enabled, a suffix removal is permitted only when the remaining word part contains at least one VC pattern (where V is a sequence of one or more vowels and C is a sequence of one or more consonants). Otherwise, it doesn't matter if no one VC remains after suffix removal.
- *Split Couples* optional condition. If disabled, a suffix removal is permitted only when the last letter of the remaining word part followed by the first letter of the suffix being removed do not constitute a Couple. Otherwise, the suffix is removed without checking if a Couple is split.

1st Builder: 2nd step – Remove the longest suffix under 3 optional and 1 mandatory condition

- *Active Suffix* optional condition (per suffix).
- *At Least Remain Letters* optional arithmetic parameter.
- *Split Couples* optional condition.
- *VCVCVC* mandatory condition. The suffix removal is permitted only when the remaining word part contains at least the VCVCVC pattern.

1st Builder: 3rd step – Remove ending consonants under 1 optional and 1 mandatory condition

- *At Least Remain Letters* optional arithmetic parameter.
- *Do not Split Couples* mandatory condition. The ending consonant is removed if the previous letter is also a consonant and together they do not constitute a Couple.

- Removal is repeated in case of multiple ending consonants.

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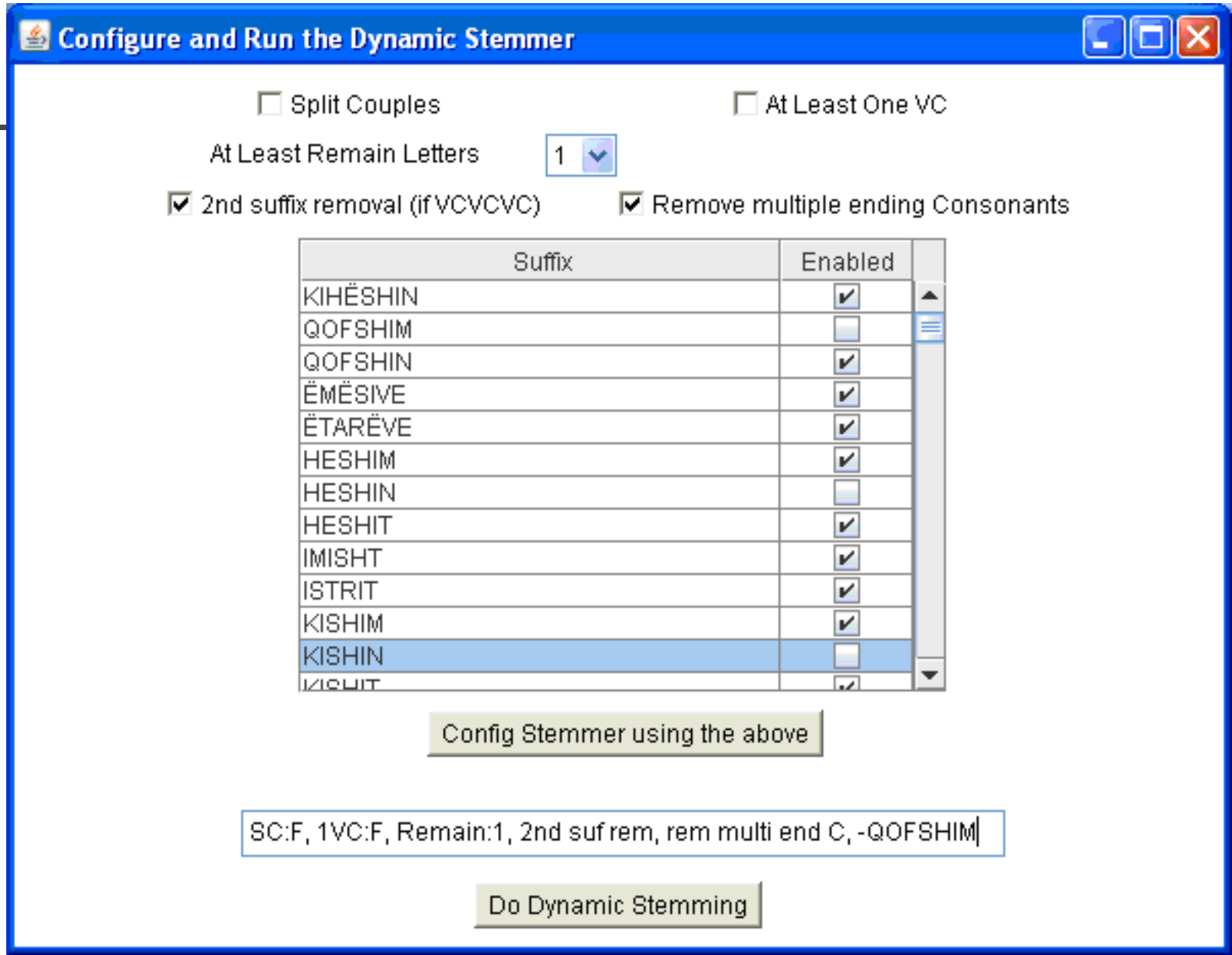
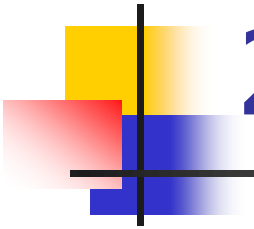
1st Builder: Interface



1st Builder: Overview

- So far, our approach for building stemmers was based in one set of suffixes that were used in both of the first two steps.
- The application of the second step was optional and this was one of the user's interventions in order to create/define alternative trial stemmers.
- Enabling the second step was guidance to a Paice like stemmer. There were also other available configuration options (split or do not split couples; number of remaining letters after suffix removal; etc) that the user could use in order to create/define alternative trial stemmers.
- There was also a third (optional) step for removing multiple ending consonants. The later was guidance to a Lovins like stemmer.
- However, the set of (selected by user) active suffixes was the same in both (first and second) steps, while the operation of the third step was not affected by the set of active suffixes.

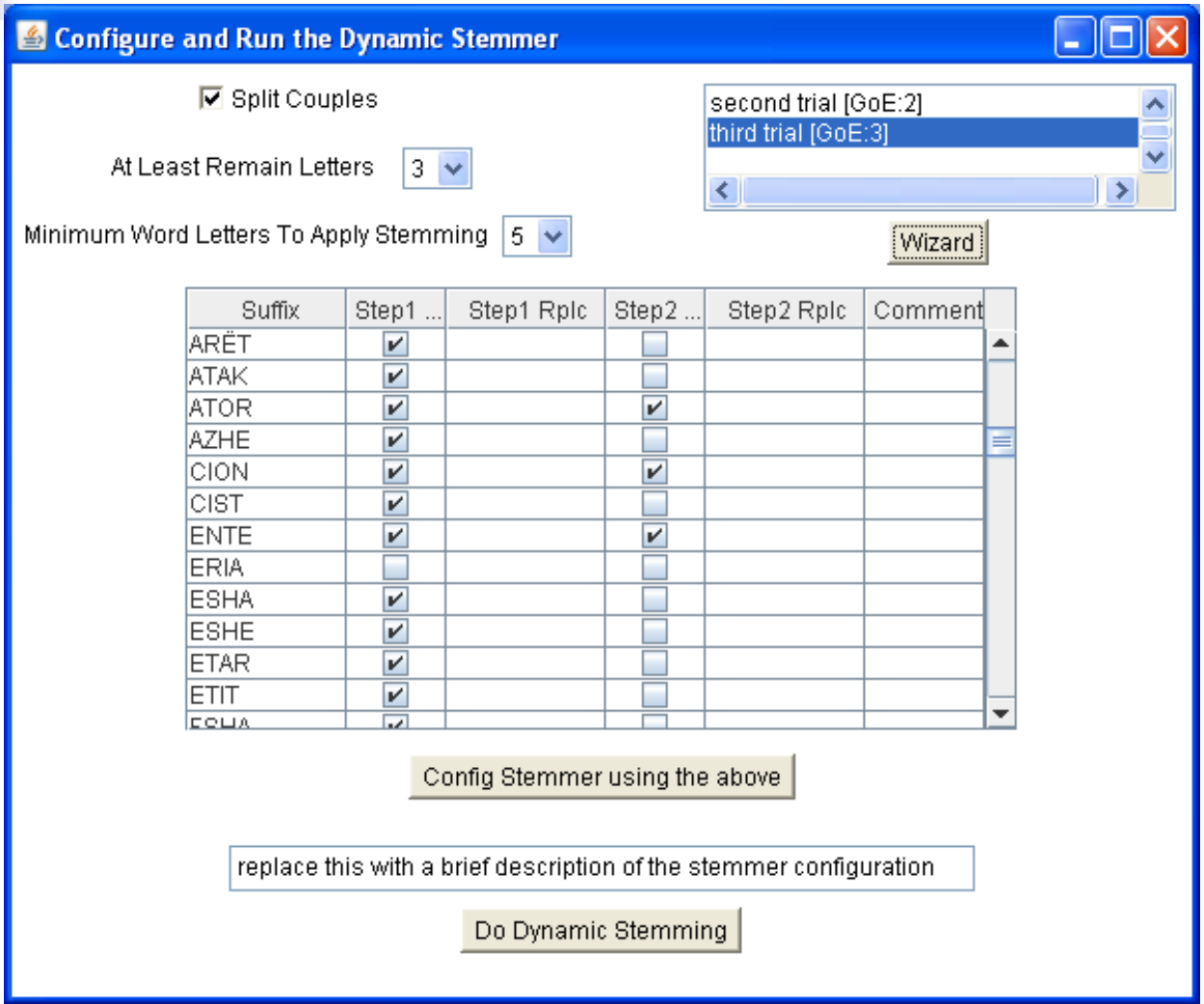


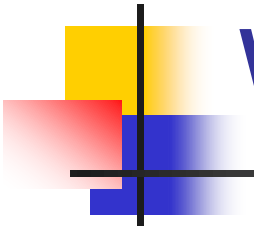
2nd Builder

Different suffixes for each step

- The available classical solutions for stemming words (e.g. Porter's) gave us another paradigm where the suffixes (endings) removed in each step are not same.
- Since many researchers still use the Porter's stemmer, we decided to adopt this paradigm and provide to the user the ability to enable/disable different suffixes for each step
- As we will see the builder uses a table with six columns. Columns two (*Step1*) and four (*Step2*) provide the user the abilities to:
  - disable Suffix (provided in the first column) in both steps;
  - disable Suffix in first step and enable it in the second step;
  - enable Suffix in first step and disable it in the second step;
  - enable Suffix in both steps.

2nd Builder: Interface





Wizard in 2nd Builder

The idea behind the Builder's Wizard

Training Set			
Ref.Num	Word	Stem	Argument

	Counters			
Suffix	1-PU	1-NU	2-PU	2-NU

- Only explicit CS and implicit (passive) CS arguments are considered. The DS/CS arguments are not considered.
- For each line of the examined arguments the algorithm tries to adapt the (primary) stemmer's result with the x of the CS(x) argument.
- For this adaptation some suffixes should enabled/disabled for the first or the second step. The relevant counter of each suffix participating in the adaptation is increased by one

2 examples of Wizard's operations (quadruples and relevant suffixes)

RefNum	Word	Stem	Argument
3562	PRONARET	PRONAR	PRON

Suffix	1-PU	1-NU	2-PU	2-NU
AR			+1	
ET	+1			

RefNum	Word	Stem	Argument
2015	KRYERA	KRYE	KRYER

Suffix	1-PU	1-NU	2-PU	2-NU
RA		+1		
A	+1			

Wizard's filters that activate / deactivate suffixes

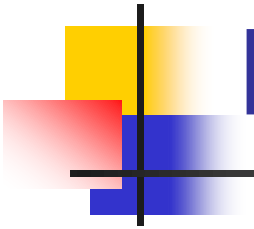
if (Step1-NU > Step1-PU)

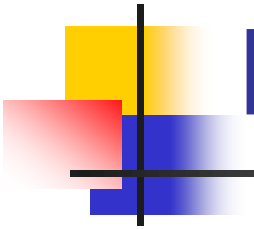
Disable Suffix on 1st step

if (Step2-PU > Step2-NU)

Enable Suffix on 2nd step

Improvements of the Matching Algorithm





Evaluation

Evaluation – dimensions

- by 5000 distinct words
- 2100 quadruples of the form (<Ref.Num.>, <Word>, <Stem>, <Argument>)
- 470 stopwords (adj, prep, aux.verbs, etc)
- 380 suffixes
- 5 IR experts
- 4 Builder configurations

4 builder configurations Evaluation results for expert V

Wizard's configuration	Harmonization rates
V ¬SC RL:3 MWL:5	300.40 / 405 = 74.2%
V ¬SC RL:1 MWL:5	295.40 / 405 = 72.9%
V SC RL:3 MWL:5	298.65 / 405 = 73.7%
V SC RL:1 MWL:5	292.65 / 404 = 72.3%

SC = split couples
RL = remain letters
MWL = minimum word letters to apply stemming

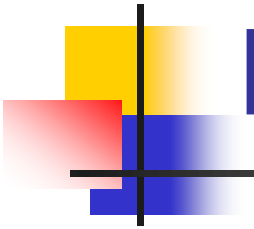
Best evaluation result per Expert

Expert	harmonization with primary stemmer	harmonization with best wizard's stemmer	Improvement
V	66,4%	74,2%	11,7%
F	66,1%	69,5%	5,1%
A	61,1%	69,8%	14,2%
S	69,8%	81,3%	16,5%
K	73,6%	80,7%	9,6%

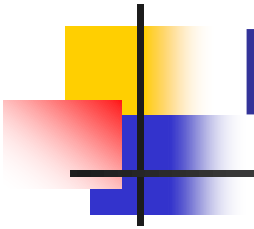
Average improvement 11.4%

Evaluation Results – Best Stemmer configuration

- VFASK ¬SC RL:3 MWL:5
- Overal improvement is 9.6% (74.1/67.6 = 1.096),
- Slightly less than the average improvement.
- This is an expected reduction since the more arguments there are, the more the conflicts there are by activation/deactivation of suffixes

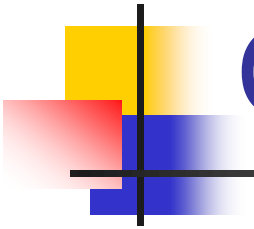


Lessons Learned

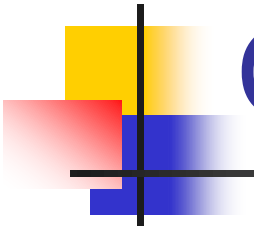


Lessons Learned

- It is not so easy to explain to Experts the rules of how to express their arguments using Excel.
- Even, if they say that they have understood, they do not follow the rules.
- It is very laborious to convert experts' arguments into SQL statements.
- We have to always emphasize and remind experts that verification arguments are very important.



Couples



Couples

- We use the term couples for digraph vowels, digraph consonants, and diphthongs.

Couples in Polish language

- Polish language has 32 letters and 7 digraphs.
- Each Polish digraph corresponds to a single sound and actually to a single consonant (digraph consonants).
- Couples (consonant digraphs) in Polish: ch cz dz dź dż rz sz

Couples in Albanian language

- Couples (consonant digraphs) in Albanian are:
  dh gj ll nj rr sh th xh zh
- dh → Greek δ
- nj → Serbian Њ
- th → Greek θ
- xh → Serbian Ћ or Џ

Couples in Greek language

- Couples can be vowel digraphs and diphthongs in Greek. Some examples are:

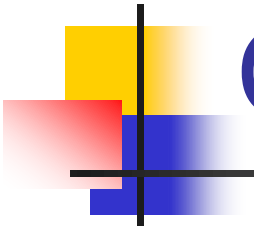
  ει οι αυ ευ αη …
- εί → κλείνω
- οι → άνθρωποι
- ευ → εύλογο
- αη → αηδόνι

Couples in Serbian language

- Serbian/Cyrillic not having ???
- Serbian/Latin official
  - Dž (Џ)
  - Nj (Њ)
  - Lj (Љ)
- Serbian/Latin unofficial
  - Dj (Ђ, Ђ)

Split couples

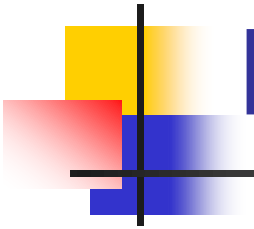
- Our system offers the “split couples” as a configurable parameter.
- This did not be useful in previous experiments (Albanian language). Albanian language do not permit splitting digraphs during the application of inflectional rules that produce words.
- However, the Polish language justified our choice. The Polish words “koszony” (participle, passive, present perfect, male, singular, nominative) and “kosić” (verb, active, present, subjunctive, singular, second person) are inflected forms of verb barber (to cut someone’s hairs).
- The first one contains the digraph “sz” while the second one has only the letter “s”.



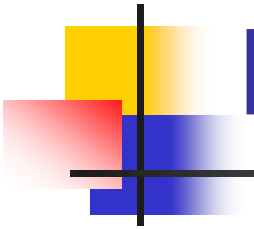
Conclusions

Conclusions

- It seems that our methodology offers the proper facilities for building stemmers for various languages.
- We have managed to create stemmers for
  - The Polish language,
  - The Albanian language.
- We need only basic knowledge for the target language:
  - Alphabet,
  - Couples (digraphs, diphthongs, etc),
  - a list of suffixes,
  - few documents to extract words.
- Optional we need also:
  - Translations of words into Experts' native language,
  - A list of stopwords.



Future Work



Future work

- extend the Wizard in order to also consider the DS/CS arguments
- An internal to the system Alphabet Reduction should be very interesting. In such case not any accent or diacritics removals should be conducted outside the system (before data insertion).
- to build a stemmer for Serbian, Bulgarian, Romanian, Croatian, etc.

Our previous work in this domain

- **Nikitas N. Karanikolas**, Bootstrapping the Albanian Information Retrieval, 4th Balkan Conference in Informatics, September 17-19, 2009, Thessalonica, Greece, IEEE Computer Society's Conference Publishing Services and IEEE Xplore
- **Nikitas N. Karanikolas**, A methodology for building simple but robust stemmers without language knowledge: Overview, data model and ranking algorithm. CompSysTech'2013: 14th International Conference on Computer Systems and Technologies, June 2013, Ruse, Bulgaria. ACM ICPS, doi:10.1145/2516775.2516783
- **Nikitas N. Karanikolas**, A methodology for building simple but robust stemmers without language knowledge: Stemmer configuration. Procedia, Social and Behavioral Sciences, vol. 147, pp. 370-375, 2014, doi:10.1016/j.sbspro.2014.07.113
- **Nikitas N. Karanikolas**, Supervised learning for building stemmers. Journal of Information Science, Vol. 41 (3), pp. 315-328, 2015, doi:10.1177/0165551515572528
- **Nikitas N. Karanikolas**, "Building Stemmers for the Polish Language". PCI 2016, November 10 - 12, 2016, Patras, Greece

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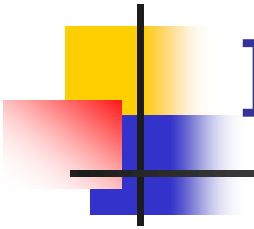

- Thank you for your attention,
- I will try to answer Questions.

Building stemmers for Information Retrieval …

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