YaMTG: An Open-Source Heavily Multilingual Translation Graph 
Extracted from Wiktionaries and Parallel Corpora

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Abstract
This paper describes YaMTG (Yet another Multilingual Translation Graph), a new open-source heavily multilingual translation database (over 664 languages represented) built using several sources, namely various wiktionaries and the OPUS parallel corpora (Tiedemann, 2009). We detail the translation extraction process for 21 wiktionary language editions, and provide an evaluation of the translations contained in YaMTG.

Keywords: Translation Graph, Multilingual Lexicon, Wiktionary

1. Introduction
Large-scale general-purpose multilingual translation databases are useful in a wide range of Natural Languages Processing (NLP) tasks. This is especially true for research efforts targeted to under-resourced languages. Translation databases can be used for adapting existing resources in other languages. This has been applied for example for the development of wordnets in languages other than English (see e.g., de Melo and Weikum (2009)). There is thus a real need in NLP for open-source multilingual lexical databases that compile as many translations as can be found on any freely available resource in any language.

In this paper, we introduce YaMTG (Yet another Multilingual Translation Graph), a new open-source heavily multilingual translation database (over 664 languages represented). While developing YaMTG, we have put the emphasis on the three following features:

1. Our resource is intended for general purpose;
2. We tried to to find a right balance between ‘large-scale’ and ‘quality’, thus leaving a limited amount of noise in the data;
3. No information is inferred from the data in order to avoid noise propagation.
4. The resource is easily accessible, usable and extensible.

The remainder of this paper is organised as follows. We first overview the literature on related work (Section 2). Next, we describe in Section 3 how we extracted automatically a preliminary large-scale set of translation and synonym pairs from 21 wiktionary language editions and from the OPUS parallel corpora (Tiedemann, 2009). We detail the translation extraction process for 21 wiktionary language editions, and provide an evaluation of the extracted translation and synonym pairs. Sections 4 and 5 are then respectively dedicated to the construction of the translation and synonym graph proper and to its filtering, in order to reduce the level of noise in the graph. Finally, we provide in Section 6 quantitative data about the final (filtered) graph YaMTG, together with an overall evaluation of YaMTG and an assessment of the quality of our filtering step.

2. Related work
Research focused on the creation of heavily multilingual word-based translation databases tends to use collaboratively constructed lexicons such as wiktionaries. By doing so, the community is taking advantage of the ‘the wisdom of crowds,’ thus overcoming the lack of expert-built lexicons for some languages (Meyer and Gurevych, 2012). Etzioni et al. (2007) built TransGraph, a multilingual sense-distinguished dictionary extracted from wiktionaries and other dictionaries. It covers 100 languages, with 3 languages having over 100,000 words. This translation graph was later reshaped by Mausam et al. (2009) with the creation of the PanDictionary. It covers over 1000 languages, whose translations are still emanating from wiktionaries and other dictionaries. It covers 100 languages, with 3 languages having over 100,000 words. This translation graph was later reshaped by Mausam et al. (2009) with the creation of the PanDictionary. It covers over 1000 languages, whose translations are still emanating from wiktionaries and other dictionaries. Yet, the resource doesn’t seem to be openly available as we write. The PanLex project (Baldwin et al., 2010) is a lemmatic translation resource which combines a large number of multilingual, bilingual, and monolingual lexical resources. It includes many inferred translations links, less accurate than directly extracted ones. As we write, it covers 1353 language varieties and 12M expressions extracted from more than 4000 different resources, including wiktionaries in many languages.1 It is still under development. The data is available on the PanLex website.2 To our knowledge, it is the most complete heavily multilingual translation database. However, we were not able to find an evaluation of the quality of the data.

Some researchers have produced multilingual translation data as a side effect of other goals. The success of the Princeton WordNet (Fellbaum, 1998) as a generic language resource spurred the creation of similar resources in other languages. Many researchers in non-English speak-
ing countries launched various projects, sometimes involving several teams and languages, all aimed at creating new wordnets in their respective languages (Hamp and Feldweg, 1997; Farreres et al., 1998; Pianta et al., 2002; Diab, 2004; Sagot and Fišer, 2008). A list of resources which follows the wordnet design can be found on the Global WordNet Association website. Researchers undertook several actions to establish relationships between wordnets in different languages. The EuroWordNet project (Vossen, 1998) devolved the manual creation and linkage of new wordnets in 8 European languages upon several institutions over many years. Atserias et al. (2004) merged lexico-semantic information contained in local wordnets into the EuroWordNet framework. Similar initiatives have been taken for the design and development of multilingual WordNets in other geographic areas, such as BalkaNet (6 languages, (Stamou et al., 2002)) or IndoNet (18 languages, (Bhat et al., 2013)). Their development was manually carried out by experts, event if some tasks were automated. Yet the quality of the lexico-semantic information provided by these resources prevail over the multilingual aspect. Half-way between large multilingual lexical databases and wordnet-like ontologies, some researchers aimed at unifying multilingual data from various sources into unique knowledge graphs.

De Melo and Weikum (2009) introduced, and further extended (de Melo, 2012), their Universal WordNet, covering concepts in a language-independent fashion. To do so, they used wordnets in many languages, freely available translation dictionaries, wiktionnaries in different language editions, monolingual and multilingual thesauri and ontologies, and parallel corpora (de Melo, 2012, p.35-37). The resulting resource covers over 200 languages, whose translations were extracted from open-source dictionaries, wiktionaries and parallel corpora. The '201012' dump downloaded on February 2014 contains more than 85,000 meanings instantiated by nearly 1.5 million (1,481,412) lexical items. While lexemes in 419 languages are displayed, 46 languages have more than 10,000 instances. This Universal Wordnet is freely available under a Creative Commons license.

Navigli and Ponzetto (2010, 2012) developed BabelNet, a wide-coverage multilingual knowledge resource. They mapped encyclopedic and onto-lexical data (namely Wikipedia and Wordnet). Concepts thus obtained were supplemented with linguistic information encoded in different wiktionary languages editions. In each language edition, a wiki page corresponds to a character string which can represent one or more lexical items. These items can either be in the edition's language, in other languages or both. Language edition dumps are made available by the Wikimedia Foundation at http://dumps.wikimedia.org/. We extracted translations from the dumps available in September 2013. Wiktionaries are organised as a set of formatted pages, whose title may correspond to an article describing one or more lexical entries. The page content of the different language editions displays different structures for the linguistic information of the lexical entries. Sérasset (2012) plans to build and provide open-source access to an a language-independent automatic extractor for a comprehensive set of linguistic information encoded in different wiktionary language editions.

It is possible to custom a set of language specific triggers (Figure 1) for the identification and extraction of translations and synonyms from wiktionary pages. These triggers are instantiated by regular expressions. For instance, English edition triggers are:

- Translation ON: {{trans-top.*}}
- Translation OFF: {{trans-bottom}}
- Synonyms ON: ====Synonyms====
- Synonyms OFF: {{checksyns}}
- All_swiches OFF: ^\$+$
- Ignore: {{trans-[^tb].+}}

Compared to these works, YaMTG contains less lexical items (900,000 vs. 1.5M for UWN, 12M for PanLex and 44M for BabelNet 2.0; see Table 1 for details). This is because it was designed using fewer sources, keeping its development cost low. We plan to include more translations to YaMTG in order to increase it's coverage soon. However, only PanLex covers more languages than YaMTG.

### Table 1: Comparison of the basic figures for the main multilingual translation resources and YaMTG

| Multilingual Resource | # Lexical Entries | # Languages |
|-----------------------|-------------------|-------------|
| YaMTG                 | 881,643           | 664         |
| UWN                   | 1,481,412         | 419         |
| PanLex                | 12,000,000        | 1353        |
| BabelNet 2.0          | 44,490,880        | 50          |

3. Translation Extraction

3.1. Wiktionaries

3.1.1. Extraction

As described by (Meyer and Gurevych, 2012), Wiktionary is a multilingual online dictionary encoding linguistic knowledge in multiple languages. There exists independent wiktionaries for each language. Those are called language editions. In each language edition, a wiki page corresponds to a character string which can represent one or more lexical items. These items can either be in the editions' language, in other languages or both. Language editions dumps are made available by the Wikimedia Foundation at http://dumps.wikimedia.org/. We extracted translations from the dumps available in September 2013.

They can be downloaded directly at http://dumps.wikimedia.org/*L*/wiktionary/latest/*L*/wiktionary-latest-pages-articles.xml.bz2, replacing the ‘*L*’ part in the URL by the ISO-639-1 language code of the desired language edition.
Figure 1: Language independent set of triggers, switches and side effects for translation and synonymy extraction from wiktionaries.

- **Source Language:** `^\[^>+?!==(`[^=]+)==$`
- **Implicit translations:** `^\="#.*\]\]%.*$`

For the Hindi edition, we instantiated the triggers as follows:

- **Translation ON:** `^\(\{\{-trans-\}\)|\( *==* *\अनु वाङ एः *==*\)\( *==* *अनु वाङ एः *==*\)`
- **Translation OFF:** `^\( *\{-.*\}\)|\( *==* *\अनु वाङ एः *==*\)`
- **Synonyms ON:** `^ *==* *समानार्थी! *==*`
- **Synonyms OFF:** `^\[\[.*` `^\]` `^\]` `^\]`
- **All switches OFF:** `^=`
- **Ignore:**
- **Source Language:** `"[^\]*">?!==\{(==+)==$`
- **Implicit translations:** `"\#\*a\*\[\[.*\]\]`.`

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- **Translation ON:** `^\(\{\{-trans-\}\})\( \( *==* *अनु वाङ एः *==*\)\( *==* *अनु वाङ एः *==*\)`
- **Translation OFF:** `^\( *\{-.*\}\)|\( *==* *अनु वाङ एः *==*\)`
- **Synonyms ON:** `^ *==* *समानार्थी! *==*`
- **Synonyms OFF:** `^\[\[.*` `^\]` `^\]`
- **All switches OFF:** `^=`
- **Ignore:**
- **Source Language:** `"[^\]*">?!==\{(==+)==$`
- **Implicit translations:** `"\#\*a\*\[\[.*\]\]`.`

Using this customized triggers for every article page in a wiktionary edition enable the extraction of raw translation data. Figure 2 shows an example of raw data extracted from the Hindi edition with the set of Hindi triggers presented above.

Noisy elements (e.g., punctuation characters) are then removed. Languages names (e.g., 'हिन्दी') and language codes (e.g., 'en' for English, 'gu' for Gujarati) are converted into ISO 639-2 (alpha-3) language codes. The information is put in a normalised format (Table 2), keeping track of the origin of the translation at the end of each line (e.g., #WY_hi stands for Hindi wiktionary; see Table 2).

Table 2: Fragment of the normalized translation extracted from the Hindi wiktionary.

| Source language | Target language | Wiktionary edition (lang.) |
|-----------------|-----------------|---------------------------|
| hin आसमान | hin अम्बर | hi |
| hin आसमान | hin आकाश | hi |
| hin आसमान | hin गगन | hi |
| hin आसमान | hin नभ | hi |
| hin आसमान | eng sky | hi |
| hin आसमान | guj आकाश | hi |
| hin आसमान | ben आकाश | hi |
| hin आसमान | spa firmamento | hi |
| hin आसमान | fra ciel | hi |
| hin आसमान | fas اسمان | hi |

3.1.2. Evaluation of the extraction process

Table 3 presents the proportion of wikipedia entries from which translations or synonyms have been extracted for 21 languages edition, together with the number of raw (unfiltered) translation pairs extracted.

The biggest wiktionary editions (English and French) have an extraction for roughly a quarter of their non-empty entries (respectively 18.4% and 17.8%). The best extraction rates (90.1% and 80.9%) have been achieved for the Portuguese and Romanian editions. Greek and Polish are the two edition having worst extraction rates (11.7% and 11.4%). For Greek, that poor score seem to be mainly due to implicit translations which are not extracted from articles in another language. More precisely, we retain only one trigger for implicit translations (`^\="#\[\[.*\]\]%.*$`). Yet many implicit translations are marked by the pattern `^\="#\[\[.*\]\]%.*$`. We chose not to identify this trigger because, as it is also used to mark related terms (συγγενικά). Therefore, it would bring much noise in the data.

We evaluated the wiktionary extraction process for the 21 languages edition we processed by randomly selecting 3150 translation pairs (150 extracted from each language edition) and manually checking their adequacy against the corresponding wiktionary.

Table 4 presents the result of this evaluation with an error analysis. Accuracy scores range from 78% (Spanish) to 97.3% (Dutch). We identified 4 major error classes:

1. translations whose source or target language hasn’t been successfully identified;
2. definitions mistaken for translations;
3. translation containing residual ‘noise’ (mainly non-alphanumeric characters);

4. miscellaneous errors.

Most instances of class 1 to 3 errors will be discarded by the filtering step described in Section 5. Type 4 (‘miscellaneous’) errors are the most detrimental, as most of them will remain in the data. Table 4 indicates a mean score of 87.6% for the unfiltered extraction. However, this score is biased because smallest languages edition are overrepresented. Weighting the scores by the size of the extraction (Table 3) leads to a more reliable score of 89.4%.

3.2. Opus

OPUS (Tiedemann, 2009) is a collection of translated texts from the web aimed at providing the community with a publicly available parallel corpus in a wide variety of languages. We used the word alignments issued on October 9, 2013 to add new translations links in the graph, retaining only alignments with a frequency at least 10. With this threshold, we retained 576131 terms (or lexical items) for 31 languages from OPUS translations. As OPUS translations are prone to alignment errors, their quality may not be as good as desired. Yet they contain a substantial amount of inflected forms which are not necessarily present in other sources. We rely on the filtering steps (Section 5) to avoid retaining the worst translations.

4. Building the Translation Graph

Previous steps resulted in more than 18M translations or synonyms in 4,324 languages. Note that while wiktionary translations are mainly lemmas, OPUS translations consists in a lot of inflected terms’ translations. We kept them in the graph, but it is easy to get rid of them as we kept translations origins in the data. Discarding translations originating from OPUS only thus removes inflected terms. All these translations contains a lot of noise such as errors identified in Section 3.1.2 plus alignment flaws arising in OPUS data.

5. Filtering

Unfiltered translations gathered in previous steps need to be filtered in order to decrease the noise. We removed many translations matching one of the following criteria:

- They are ‘too long’ (usually Section’s 3.1.2 class 3 errors, i.e., definitions mistaken for translations) or ‘too short’ (usually stopwords);
- They contain punctuations and/or numbers;
- Their charset does not correspond to their declared language;
- They appear in less than X other translations;
- They appear in more than Y other translations (when too many translations are available for the same word, it turns out it is very often the result of an error).

The first three filtering criteria are designed to avoid errors from class 1 to 3 as identified in Section 3.1.2. The two last criteria were rather designed to get rid of types 4 errors (miscellaneous errors) and OPUS misalignment. We empirically chose $X = 3$. Concerning $Y$, we assumed that it may be somehow related to the number of languages present in the graph. After applying the first filtering criteria, the graph displays terms (lexical items) in 3,739 languages. For those languages, only 468 appears 100 times or more. We assumed that a term should reasonably not have more than an average of 2 translations for all of these 468 languages. In other words, we decided that a term should not be involved in more than $Y = 936$ translations.

6. Results and evaluation

6.1. Graph properties

The filtered graph retains nearly a tenth of the terms and 15% of the languages present in the unfiltered graph. Yet, 32.3% of the translation/synonym links, or edges, are retained (cf. Table 6). 51.2% of these remaining translations are extracted solely from OPUS, 42.1% from wiktionaries only, whereas 3.2% were extracted from both OPUS and at least one of the 21 wiktionaries we processed.

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7As a standard of comparison, the Ethnologue association states living languages number more than 7,105 (http://www.ethnologue.com/).

8This filter does only concern less than 3 letters words written in Cyrillic, Greek and Latin script.
Before Filtering | After Filtering
---|---
**Lang. edition** | **Erroneous** | **Good** | **Erroneous** | **Good** | **Kept**
bg | 8 | 1 | 1 | 4 | 136 | 90.7 | 3 | 0 | 1 | 0 | 93 | 95.9 | 64.7
es | 4 | 0 | 19 | 5 | 122 | 81.3 | 0 | 0 | 2 | 1 | 16 | 84.2 | 12.7
da | 2 | 0 | 3 | 2 | 143 | 95.3 | 1 | 0 | 0 | 0 | 65 | 98.5 | 44
de | 4 | 1 | 0 | 2 | 143 | 95.3 | 1 | 0 | 0 | 0 | 46 | 97.9 | 31.3
el | 4 | 0 | 5 | 2 | 139 | 92.7 | 1 | 0 | 2 | 1 | 65 | 94.2 | 46
en | 1 | 5 | 0 | 4 | 140 | 93.3 | 1 | 1 | 0 | 0 | 111 | 97.4 | 76
es | 5 | 0 | 15 | 13 | 117 | 78 | 0 | 0 | 0 | 1 | 46 | 97.9 | 31.3
fr | 4 | 0 | 8 | 0 | 138 | 92 | 2 | 0 | 3 | 0 | 95 | 95 | 66.7
hi | 9 | 3 | 3 | 4 | 131 | 87.3 | 1 | 0 | 0 | 0 | 42 | 97.7 | 28.7
hu | 3 | 9 | 1 | 1 | 136 | 90.7 | 1 | 2 | 0 | 0 | 56 | 91.8 | 40.7
it | 0 | 4 | 14 | 2 | 130 | 86.7 | 0 | 1 | 0 | 0 | 58 | 96.7 | 40
ja | 2 | 10 | 26 | 15 | 97 | 64.7 | 1 | 3 | 8 | 0 | 38 | 71.7 | 35.3
nl | 0 | 0 | 0 | 4 | 146 | 97.3 | 0 | 0 | 0 | 0 | 68 | 100 | 45.3
pl | 3 | 3 | 0 | 2 | 142 | 94.7 | 0 | 0 | 0 | 0 | 68 | 100 | 45.3
pt | 5 | 3 | 18 | 4 | 120 | 80 | 2 | 0 | 0 | 0 | 89 | 97.8 | 60.7
ro | 0 | 0 | 13 | 3 | 134 | 89.3 | 0 | 0 | 0 | 0 | 116 | 100 | 77.3
ru | 10 | 1 | 4 | 2 | 133 | 88.7 | 1 | 1 | 0 | 0 | 95 | 99 | 64
sk | 5 | 7 | 12 | 0 | 126 | 84 | 2 | 0 | 0 | 0 | 39 | 95.1 | 27.3
sv | 4 | 4 | 9 | 0 | 133 | 88.7 | 2 | 3 | 0 | 0 | 69 | 89.6 | 51.3
tr | 2 | 11 | 4 | 0 | 133 | 88.7 | 0 | 1 | 1 | 0 | 83 | 96.5 | 57.3
vi | 9 | 0 | 20 | 0 | 121 | 80.7 | 0 | 0 | 0 | 0 | 31 | 100 | 20.7
Total | 84 | 62 | 175 | 69 | 2760 | — | 19 | 11 | 17 | 3 | 1389 | — | —
% | 2.7 | 1.9 | 5.6 | 2.2 | 87.6 | — | 1.3 | 0.8 | 1.2 | 0.2 | 96.5 | — | —

Table 4: Evaluation figures for the unfiltered extraction of translations/synonymy from 21 wiktionary editions (sample size for each language: 150), and for the filtered graph.

| Wiktionaries | OPUS | Union |
|---|---|---|
| Terms | 5,246,987 | 487,251 | 7,903,646 |
| Transl./Syn. links | 14,449,087 | 3,631,229 | 18,080,316 |
| Languages | 4,324 | 32 | 4,324 |

Table 5: Number of unfiltered translations and synonyms links in wiktionaries and OPUS and the union of both

| Before filtering | After Filtering (YaMTG) |
|---|---|
| Terms | 7,903,646 | 881,643 |
| Transl./Syn. | 18,080,316 | 5,842,279 |
| Languages | 4,324 | 664 |

Table 6: Number of terms, translations and synonyms before and after applying filters.

Figure 3 displays the degree distribution in the graph. This distribution resembles that of a small-world graph, a type of graph often encountered when modeling real-world data. Small-world graphs have tightly interconnected node clusters, and a shortest mean path length that is similar to that of a random graph that has the same number of nodes and the same number of edges. We checked the ‘small-world-ness’ of our translation graph against the definition of that notion as presented by Humphries and Gurney (2008). It turns out that our translation graph indeed qualifies as a small-world graph.

Figure 4 illustrates the distribution of translation or synonymy pairs w.r.t. the languages at both ends of the pair.

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9Humphries and Gurney (2008) define a graph $G$ as being small-world by constrast with an Erdős-Rényi random graph $G_{\text{rand}}$ that has the same number of nodes and edges than $G$ in the following way. Let us call $L_G$ (resp. $L_{G_{\text{rand}}}$) the average shortest path length in $G$ (resp. $G_{\text{rand}}$). Moreover, let $n_G^3$ the number of triangles in $G$ and $n_G^2$ the number of paths of length 2 in $G$. We then define the transitivity-based clustering coefficient in $G$ as $C^3_G = 3n_G^3/n_G^2$. The same definition holds for $G_{\text{rand}}$. Then, $G$
Table 7: Evaluation figures for the final (filtered) translation/synonymy graph, i.e., YaMGT based on a randomly selected sample of 200 edges.

| Source | total | Misc. | Erroneous | Good |
|--------|-------|-------|-----------|------|
|        |       | lang. | def.      | noise|      |
| OPUS   | 99    | 10    | 0         | 0    | 89   | 90%  |
| Wiktionaries | 85    | 2     | 4         | 0    | 77   | 91%  |
| Both   | 16    | 0     | 0         | 0    | 16   | 100% |

Total	200	12	4	0	2	182	91%

Figure 4: Language matrix for the 25 most frequent languages in the graph (darker means more translation or synonymy pairs).

We evaluated the quality of the final graph by looking over 1,639 edges selected as follows:

- 1,439 edges which were evaluated in Section 3.1.2 and still present in the final graph. This will allow us to evaluate the reliability of the filtering described in Section 5;
- 200 more edges randomly chosen in the translation graph, in order to assess its overall accuracy in a non-biased way.

These edges cover 3,332 terms in 72 languages.

6.2. Overall evaluation

We estimated the overall accuracy of the links in the filtered graph based on a manual evaluation of the 200 randomly selected pairs. The overall accuracy result is 91% (see Table 7). Amongst the 18 incorrect links in this random evaluation dataset (9%), 4 are incorrect because one of the terms have been assigned a wrong language, 2 still contain noise and 13 are miscellaneous errors (mostly alignment errors from OPUS). Note that all wikipedia definitions mistaken for translations were successfully removed by the filter.

6.3. Filter’s accuracy

Amongst the 3,150 translation links evaluated in Section 3.1.2, 1,439 (45.3%) were still present in the final graph. Table 4, restricted to links extracted from wiktionaries, compares the figures before and after filtering. It displays an average accuracy score of 95.8% for the filtered extraction. Weighting the scores by the proportion of translations/synonyms from the different language editions present in the final graph (Table 8) gives us a final accuracy score of 97.2% for translations extracted from wiktionaries. On average, the filter managed to improve accuracy scores by nearly 8 points the (raw and weighted).

7. Conclusions

YaMTG is an Open-Source Heavily Multilingual Translation Graph, freely available online. Its aim is mainly to provide a ready-to-use translation graph. Further versions including other translation sources are under development and will be released soon. The version of YaMTG presented in this paper contains 5.8 million translation or synonymy pairs (edges in the graph) covering 664 languages. Those translations were extracted from 21 wiktionary language editions and from the OPUS Parallel Corpora, and then filtered using generic and graph-based heuristics. We evaluated the quality of the initial set of translations extracted from our various source, the precision of our filtering step and the accuracy of its output, namely YaMTG. We estimated overall quality of the translation/synonymy links within YaMTG as approximately 91%. If one only considers translation/synonymy links extracted from wiktionaries, this figure reach as much as 97.2%.

In the future, these scores could be improved with a two-fold strategy:

- Adding new translations to the unfiltered graph. The filtering step removes lexical items which are not present in at least $X$ other translations. Thus, satisfying translations which tend to occur less in translation databases are more likely to be removed by the filter. More pairs in the unfiltered graph should lead to less overfiltering.

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http://alpage.inria.fr/~hanoka/yamgt.html
Table 8: Number of translations and synonyms by number of distinct sources it was extracted from (subtable a). Note that a same translation link (or edge) may have been extracted from more than one sources (e.g., wiktionary language editions) and can be therefore counted more than once (see subtable b).

- Similarly, playing with the thresholds $X$ and $Y$ (see section 5) may improve the quality of the graph. But increasing $X$ requires to have a sufficient amount of translations.

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