ArtsSemNet: From Bilingual Dictionary to Bilingual Semantic Network

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Abstract: *The paper presents two bilingual lexicographical resources for the terminology of fine arts: the ArtsDict electronic dictionary and the ArtsSemNet semantic network, and describes the process of transformation of the former into the latter. ArtsDict combines a broad range of information sources and is currently the most complete dictionary of fine arts terminology for both Bulgarian and Russian: not only electronic, but also in general. It contains 2,900 Bulgarian and 2,644 Russian terms, each annotated with complete dictionary definitions. These are further augmented with various terminological relations (polysemy, synonymy, homonymy, antonymy and hyponymy) and organised into a bilingual semantic network similar to WordNet. In addition, a specialised hypertext browser is implemented in order to enable intuitive query and navigation through the network.*

Keywords: semantic network, terminology, polysemy, homonymy, hyponymy, antonymy, synonymy**.**

1. Introduction

The contemporary dictionary development has been deeply affected by the wide spread of personal computers. Nowadays, a fast growing number of users already forgot the annoying lookups in huge paper-based dictionaries and started using their computer equivalents. Although the first computer dictionaries were often worse than the traditional ones their potential was out of question. As early as in 1992 the creators of the *Oxford English Dictionary* [*OED*] invested $13.5 millions in a five years project to enable the development of an electronic version. It soon became clear that the computer dictionaries could potentially provide by far richer capabilities. In the mean time, some other resources, such as *thesauri*, arose (e.g. the *Roget's thesaurus* [*RT*]), which provided the users with synonymy information. Soon, the lexicographers started combining dictionaries and thesauri, which resulted in *semantic networks* (e.g. *WordNet* [*Fellbaum,1998*; *Miller&al.,1990*; *WordNet*]), including not just term glosses and synonyms lists, but also links to antonyms, hyponyms etc.

The work presented below progressed in a similar fashion: we started with electronic dictionaries and later transformed them into semantic networks with various terminological relations. We concentrated on the fine arts terminology for two closely related and easy-to-combine Slavonic languages suitable for a comparative research: Bulgarian and Russian. Although initially we focused on Bulgarian, Russian support has been added for two reasons: to illustrate the multilingual support (at present the dictionary interface is bilingual, while the semantic network allows several languages to be used in parallel) and to make use of the rich language material for Russian we already had. Adding other Balkan languages in combination/instead of Bulgarian/Russian would be attractive, once the necessary data is collected and made available.

2. ARTSDICT: Bilingual Terminological Dictionary

ArtsDict has been created in order to allow for easy creation and usage of parallel bilingual terminological dictionaries for the purpose of lexicographical research. The dictionary data consists of a set of navigable dictionary entries: a term (*single-word term*, *SWT* or *multi-word term*, *MWT*) and one or more glosses describing its sense(es). The main screen of *ArtsDict* is split both horizontally (between the dictionaries) and vertically: the SWT and MWT, including doublets and variants, appear on the left in alphabetical order, while their glosses are listed on the right. Although the user interface imposes no such restrictions, we enforced strict rules for the contents of the separate fields. For example, after the term we add in brackets its origin, when it is a foreign word, and the form for singular, when it is presented in plural. The doublets[1]

[1] We consider the *doublets* and the *variants* as absolute synonyms, the difference being that the former share the same root, while the latter do not.

Аквамарин (нем. Aquamarin, по лат. aqua 'вода' + marinus 'морски')	Минерал, разновидност на берила, силикат на берилия и алуминия, скъпоценен камък, с цвят от светлозелен до небесносин, използван като материал за художествени изделия.
Акварел (рус. акварель, фр. aquarelle, от ит. acquarello, от лат. aqua 'вода')	1. Акварелни бои - бои, състоящи се от пигмент и свързващо вещество (растително лепило с примеси на мед, захар, глицерин); 2. Акварелна техника - живописна техника, използваща акварелни бои; 3. Произведение на живописта, изпълнено с акварелна техника.
Акварелен портрет	Разновидност на портретния жанр, включваща портрети, изпълнени в акварелна техника.
Акварелист (от ит. acquarello)	вж. Художник-акварелист
Акварелистка (от акварелист, от ит. acquarello)	вж. Художничка-акварелистка.
Акварелна техника	вж. Акварел във 2 знач.
Акварелни бои, Водни бои	вж. Акварел в 1 знач.

Table 1. Extract from the Bulgarian dictionary contents.

Аквамарин (нем. Aquamarin, по лат. aqua marina 'морская вода')	Минерал, прозрачная разновидность берилла, синевато-зеленой или голубой окраски, драгоценный камень, применяемый как материал для художественных изделий.
Акварелист (ит. acquarello)	см. Художник-акварелист.
Акварелистка (от акварелист, от ит. acquarello)	см. Художница-акварелистка.
Акварель (фр. aquarelle, ит. acquarello, от лат. aqua 'вода')	1. Красочный материал, предназначенный для акварельной живописи, состоящий из пигмента и большого процента клеящих веществ в качестве связующего (которым служит растительный клей с примесью меда, сахара, глицерина); 2. Техника живописи, выполняемая акварельными красками; 3. Произведение искусства, выполненное акварельными красками в соответствующей технике.
Акварельная живопись	см. Акварельная техника.
Акварельная техника, Акварельная живопись, Живопись акварелью, Живопись водяными красками	см. Акварель во 2 знач.
Акварельные краски (ед. ч. краска), Водяные краски	см. Акварель в 1 знач.

Table 2. Extract from the Russian dictionary contents.

Олово (Bulgarian)	Тежък мек ковък метал със сивосинкав цвят, използван като материал за художествени произведения.
Олово (Russian)	Химический элемент, мягкий, ковкий, серебристо-белый металл, применяемый в изобразительном искусстве как материал для художественных изделий. На български се превежда калай.

Table 3. Example of translingual homonymy (Russian).

and variants[2] appear horizontally comma separated after the term. Similarly, after a neutral term its stylistic relative synonyms are listed, since they represent the same notion (again comma separated).

The presented arrangement of variants, doublets and stylistic synonyms allows equivalent terms in the two dictionaries (i.e. the two languages) to be examined in parallel, for the short entries, and sequentially, for the longer ones (see Tables 1, 2). The parallel exploration simplifies not only the unification of the dictionaries (by means of addition the corresponding equivalent: see Table 5) but also the search for translingual homonyms (see Table 3).

[2] In fact the phonetic and orthographic variants are lexico-grammatical variants of the same word (allolexes), not distinct words (synonyms). We treat them as separate words (i.e. synonyms) for two reasons: 1. to preserve the unified approach to all groups of *variant*, which represent distinct words or terminological collocations; 2. because the phonetic and graphemic variants could be stylistic relative synonyms. It is not possible for the lexico-grammatical variants of a word to be related to different styles, e.g. in the fine arts terminology*: б. зограф – изограф* (the dialect for *зографа*).

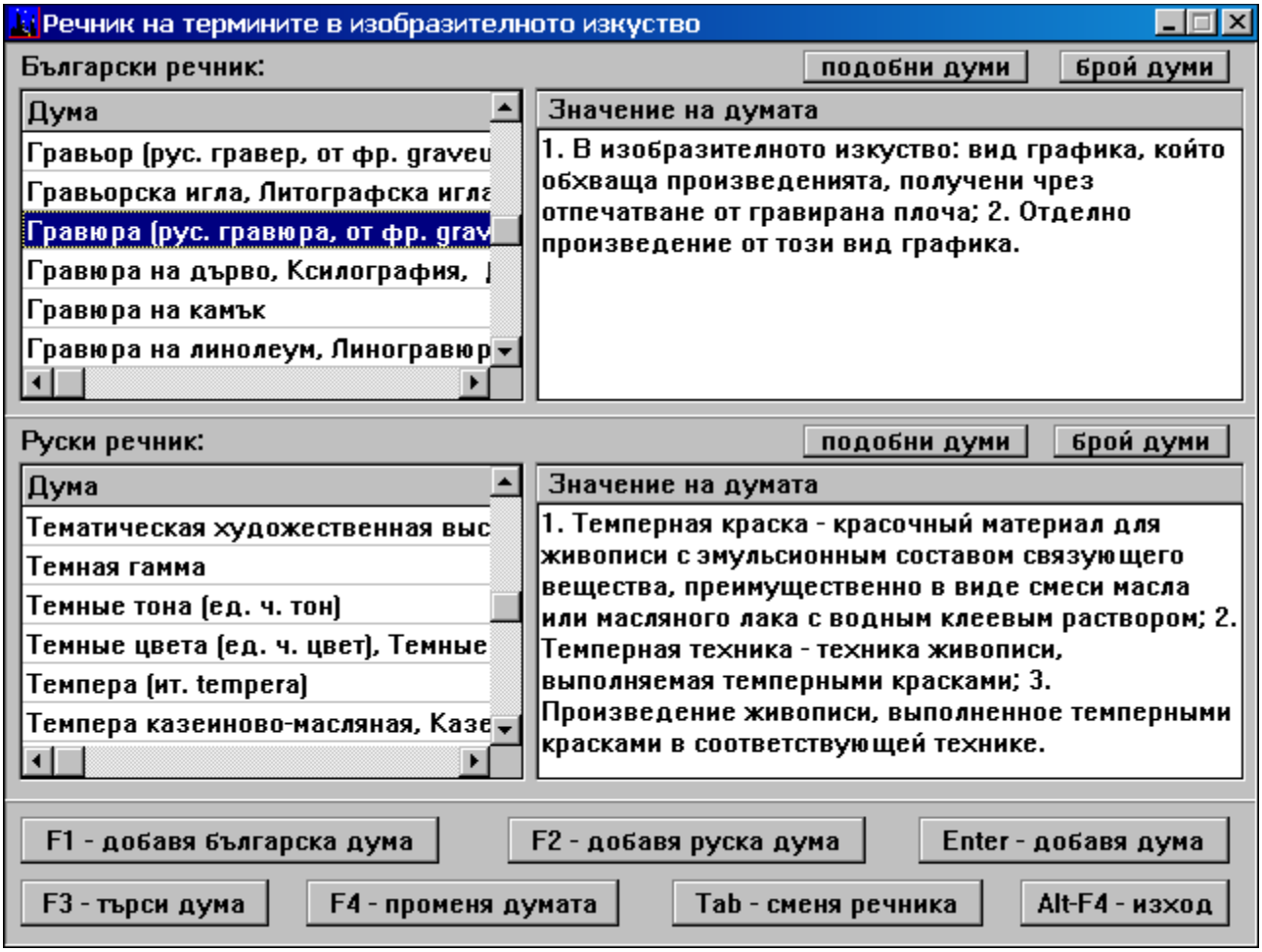

Figure 1. Screenshot from *ArtsDict*.

We would like to note that the dictionaries presented here are the most complete fine arts terminological ones for both Bulgarian and Russian and have been built using a broad range of resources: scientific, popular-scientific, fine arts, publicist, social-political and other (journals, specialised scientific and popular-scientific literature, catalogues, etc., [*Flerov,1981*; *Odnoralova,1982*; *Pavlovsky, 1975*; *Tsonev,1957*; *Vinner,1954*]). In addition, Russian and Bulgarian dictionaries have been used: terminological (e.g. [*SDFAT,1965*; *SDFAT,1970*]), encyclopaedic (e.g. [*EFAB,1987*]), orthographical, etymological, dictionaries of foreign words, terms lists of fine arts sources etc. Terminological terms, professional slang and nomenclatures are grouped together and considered within a unified terminological framework (for details: [*Atanasova,2003*]).

3. ARTSSEMNET: Semantic Network

3.1. Creation

The *ArtsSemNet* semantic network was built around the *ArtsDict* dictionaries contents. For the purpose, we investigated and completely annotated (manually, but with a partial computer automation using a formal and a semantic techniques; see below) several important terminological relations: polysemy, homonymy, synonymy, antonymy and hyponymy. As a result a semantic network of the type of *WordNet*, hierarchically organised around the hyponymy relation, was obtained. At the moment of preparation of the present paper it contained:

- lexemes: 2,900 Bulgarian and 2,644 Russian;
- hyponyms chains: 276 Bulgarian and 283 Russian;
- antonyms chains: 157 Bulgarian and 134 Russian;
- absolute synonyms chains: 483 Bulgarian and 458 Russian;
- relative synonyms chains: 136 Bulgarian and 114 Russian;
- homonyms: 14 Bulgarian and 6 Russian;
- polysemous words: see Table 4.

The direct extraction of *homonyms*, *synonyms* (*stylistic* and *relative*) and *polysemous terms* from the dictionary entries was simplified because of the rules enforced during its creation. The *hyponyms* and *antonyms* posed a problem though. For the extraction of hyponyms sharing a common term-ele-

ment (root/stem, affix, word as a component of MWT or another complex word, MWT), not necessarily shared also by the hypernym, a formal technique was used. *ArtsDict* was given a hyponym/hypernym, expressed through SWT or MWT, and it produced chains of SWT and MWT containing the target term-element. These were further investigated and the hyponyms were sieved by the lexicological researcher [*Atanassova&al.,2002*]. A similar technique was used to facilitate the extraction of *antonyms* sharing a common term-element as well as for *shared-root synonyms* (also with common suffix or prefix).

Senses count	1	2	3	4	5	6	7
Bulgarian	2,571	273	49	4	2	1	0
Russian	2,313	263	56	9	2	0	1

Table 4. Terms polysemy.

For the extraction of hyponyms sharing no term-element a semantic technique based on *latent semantic analysis* (*LSA*) was used (for an introduction to LSA see [*Landauer,1998*]). The LSA engine was given hyponym or hypernym, expressed as SWT or MWT, and a ranked list of SWT and MWT was produced as a result, this time sorted according to the semantic proximity to the target term. The result was again manually investigated by the lexicographer and only the true hyponyms were kept. Note that the list can possibly contain hyponyms with *common term-element* as well, as long as they are considered semantically close enough by the LSA engine (see [*Nakov&Atanassova,2001*]). The dualistic nature of LSA (see [*Landauer,1998*]) allowed us to measure the proximity not only between terms (SWT or MWT) but also between their glosses (see [*Atanassova&Nakov,2001b*]). Several different variants of LSA were used in combination: the target being the *glosses* of the hypernym (or the *glosses* of some of its known hyponyms) or the hypernym *itself* (or some of its known hyponyms – *itself*). Each of these techniques has been tried both with and without segmentation (see [*Atanassova&Nakov,2001a*]).

3.2. Functionality

The primary purpose of *ArtsSemNet* is to assist the lexicographer with his work by providing him with a tool for fast and easy access to rich fine arts terminology (see [*Atanassova&al.,2003*]). When a search for a particular term is performed *ArtsSemNet* displays its glosses, homonyms, synonyms (both absolute and relative) and synonyms chains, antonyms and antonyms chains, as well as hyponyms chains the target term is part of (both as hyponym or hypernym). *ArtsSemNet* offers a clean and intuitive interface. The user can input a term to be explored, change the language being explored as well as specify different search criteria. The information displayed for a given term includes:

- term glosses list;
- homonyms list;
- absolute synonyms chains;
- relative synonyms chains;
- antonyms chains;
- hyponyms chains with the target term as a hypernym;
- hyponyms chains with the target term as a co-hyponym.

The system offers several options: whether the term is to be searched exactly or partial matches should be considered as well (e.g. root or prefix); whether the homonyms, synonyms and synonyms chains, antonyms and antonyms chains, and hyponyms and hyponym chains should be displayed.

Glosses are presented as plain text one per line and have numbers added in front, in case there is more than one gloss for the target term. *Homonyms* are listed one per line. *Absolute synonyms*, *relative synonyms* and *antonyms* are hyphen-separated. If a relative synonym of the target term has some absolute synonyms these are listed after it comma-separated. So are the absolute synonyms of the antonyms.

Hyponyms chains are listed as terms lists where the hypernym is displayed first, followed by its hyponyms. Again, if a term has absolute synonyms, these are shown along with it separated by commas. If a polysemous term is the hypernym of more than one hyponyms chain the corresponding gloss is shown in brackets for each of them. This is similar to the *synsets* in *WordNet*. The user interface allows also displaying separately each hyponym, which is the hypernym of hyponyms chains of its own as well as showing these chains.

In any case, when the terms lists are displayed each distinct one is presented as a hyperlink. When the latter is followed the target term changes and the corresponding information about the new one is displayed (it in turn contains hyperlinks to other terms and so on). The navigation mechanism is similar to the one provided by a standard Web browser: even the standard forward and backward buttons are present, visualised as left and right arrows, so that the user can navigate back to the already visited terms and then can go forth. Figure 2 shows *ArtsSemNet* after a successful search for the Bulgarian term *надлъжна гравюра*.

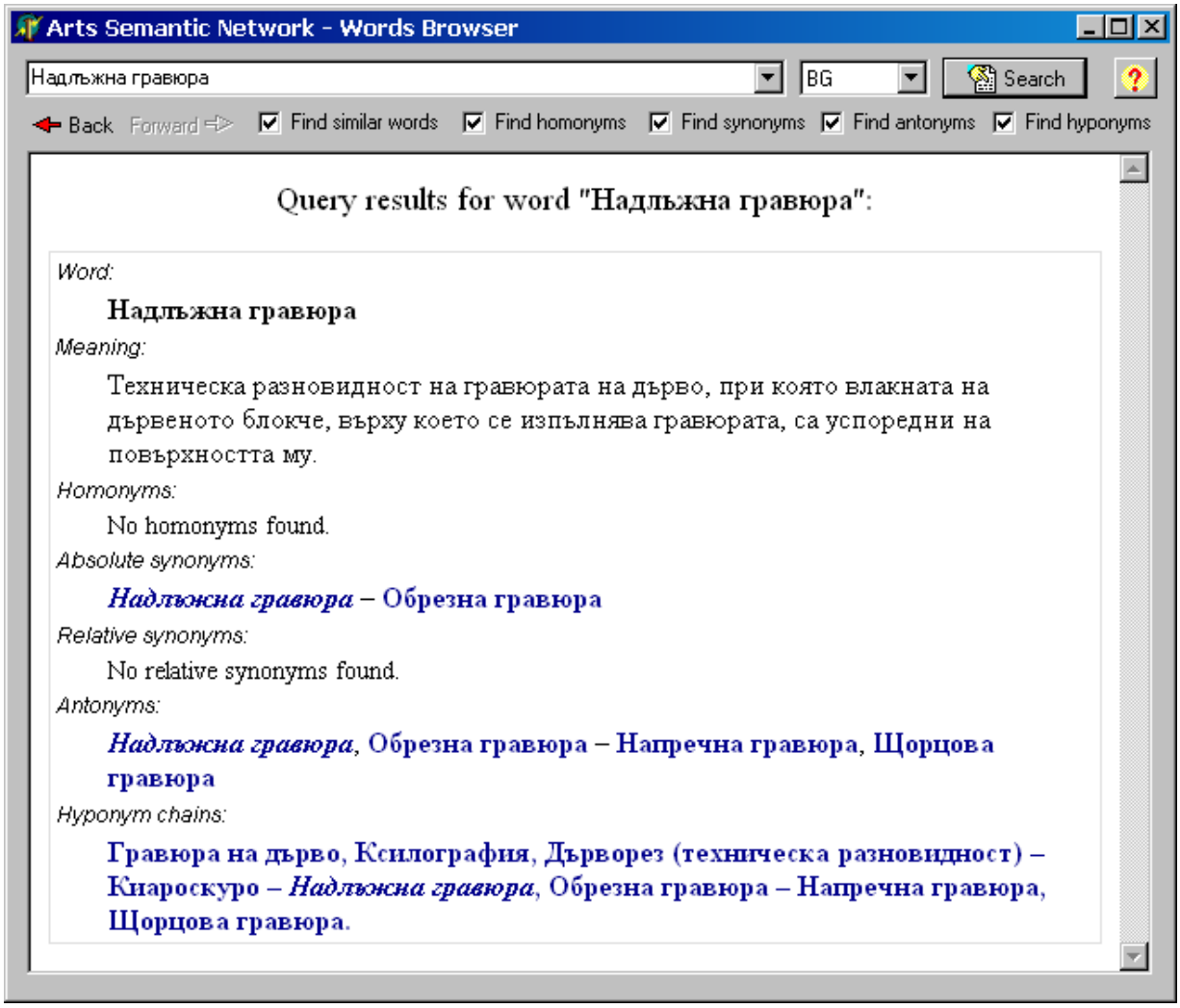

Figure 2. Screenshot from *ArtsSemNet*.

ArtsSemNet is implemented in *Borland Delphi* using the relational database management system *Microsoft Access 2002* for the storage and retrieval of the fine arts terminological terms, designed in a way to ensure efficient processing for the kinds of queries needed.

4. Related Work

WordNet. *WordNet* has been developed by psycholinguists from the Cognitive Science Laboratory of the Princeton University as a computational model of the human lexical memory. Since then the project evaluated into a general lexical reference system comprising thousands of words and their corresponding glosses, organised into a semantic network. The terms (lexemes) in *WordNet* are represented as one or more *synsets* (i.e. *synonym sets*). A synset groups a term with some of its synonyms, which taken as a whole represent a particular lexical sense of that term (see [*Fellbaum,-1998*; *Miller&al.,1990*]). A lexically ambiguous term is included in more than one synsets: one for each of its senses (according to the sense granularity level chosen by the network). The synsets are hierarchically interconnected according to the hyponymy and the meronymy (part-whole) relations and are further distinguished by more specific properties. The work on the project continues and the latest version 2.0 of *WordNet* includes 115,424 synsets – 79,689 nouns, 13,508 verbs, 18,563 adjectives and 3,664 adverbs [*WordNet*]. Nowadays, *WordNet* is among the most important resources for natural language processing, machine translation, word sense disambiguation, information extraction, information retrieval etc.

EuroWordNet. The success of *WordNet* provoked interest in the development of similar resources for other languages. In 1996 the European Commission funded the *EuroWordNet* project, covering 7 European languages in parallel (see [*EuroWordNet*; *Vossen,1998*]): Czech, Dutch, Estonian, French, German, Italian and Spanish. Each part of *EuroWordNet* uses its own language-specific synsets but all are interconnected by means of a common index based on *WordNet*, so that the navigation between the similar words in different languages is possible in all directions. While the *EuroWordNet* project was finished in 1999 (as opposed to *Word-*

Натюрморт (Bulgarian)	1. Един от жанровете на изобразителното изкуство, който изобразява битови предмети, зеленчуци, плодове, убит дивеч, цветя и др.; 2. Отделно произведение от този жанр.
Натюрморт (Russian)	1. Один из жанров изобразительного искусства, посвященный воспроизведению предметов обихода, снеди (овощи, мясо, битая дичь, фрукты), цветов и пр.; 2. Отдельное произведение этого жанра.

Table 5. Parallel notions in Bulgarian and Russian.

Net which has always been active) the work on other European languages continues. There are already *WordNet*s available for Basque, Portuguese and Swedish. Under development are ones for Bulgarian, Danish, Greek, Icelandic, Latvian, Moldavian, Norwegian, Romanian, Russian (see [*RWN*]), Serbian, Slovenian, Swedish and Turkish. Several non-European languages have projects under development, see the Web page of the *Global WordNet Association* for details (see [*GWA*]).

BalkaNet. This is an ongoing project whose aim is the creation of a multilingual lexical database consisting of *WordNets* for the following mostly Balkan languages: Greek, Turkish, Romanian, Bulgarian, Czech and Serbian (in fact Czech is not a Balkan language, but is Slavonic like Bulgarian and Serbian). The objective is to collect some 15,000 comparable synsets (around 30,000 literals) in each language, covering generic vocabulary, distributed into the following POS categories: 65% nouns, 25% verbs, 5% adjectives and 5% adverbs (see [*BalkaNet*]). The data will be later incorporated into *EuroWordNet*.

The first attempts to build a Bulgarian *WordNet* focused on automatic construction from English-Bulgarian and Bulgarian-English electronic dictionaries (see [*Nikolov&Petrova,2001*]). For the *BalkaNet* project though, everything has been created from scratch. At the moment of preparation of the present paper the Bulgarian *WordNet* contained about 8,000 synsets (see [*BWN*]).

5. ARTSSEMNET and WORDNET

WordNet and *ArtsSemNet* have similar functionality but there are also some important differences. As we mentioned above, the terms in *WordNet* are represented not as entities of their own but as synsets. Although this is a clean way to express the lexical relations as holding between *senses* and not between the terms themselves, it is also partly due to the fact that *WordNet* was designed for English where the same word could often belong to several different parts of speech (e.g. noun, adjective and verb), which implies different senses according to *WordNet*. This is highly unlikely for Slavonic languages. In addition, at present *ArtsSemNet* focuses on nouns only.

The synset organisation of *WordNet* implies also some interface differences. When the user enters a query word, *WordNet* displays all synsets it is included in along with their glosses. In addition, the synonyms, co-hyponyms, hyponyms and hyponyms chains, meronyms/holonyms, antonyms and coordinated words can be shown. All this information is related to the corresponding *synsets* of the target. A summary of the major differences between *ArtsSemNet* and *WordNet* follows:

- *ArtsSemNet* is term-centred, while *WordNet* is built on synsets (senses). *ArtsSemNet* includes some internal organisation similar to synsets as well but only when it is really needed to split the term for a particular *relation* (e.g. hyponymy, see Tables 6, 7). The synsets do not necessarily correspond to different glosses. Even when a term has different glosses (i.e. senses) this does not imply that this will make difference for *all* the relations it is involved in (e.g. because of systematic relations). If one followed the *WordNet* approach for a focused terminological network this would result in several *parallel* sense-sense relations (see Tables 6, 7), which we wanted to avoid.
- *WordNet* does not distinguish between *absolute* and *relative* synonyms as *ArtsSemNet* does, which, in our opinion, is an important distinction. Examples of absolute synonyms: Bulgarian (*готически стил – готика*; *изумруд – смарагд*; *историческо платно – историческа картина*; *накити – бижу*; *торсо – торс*; *морски пейзаж – марина*; *разяждане – ецване*) and Russian (*мушта-бель – палка*; *арабеска – арабеск*; *барбы – заусенцы*; *восковая живопись – энкаустика*; *гематит – кровавик*; *отпечаток – оттиск*; *оклад – басма*; *мягкий кракелюр – плывучий кракелюр*). Examples of relative synonyms: Bulgarian (*бристол – ватман – торшон*; *кукери – бабугери*; *мартеница – китица – гадалушка*; *пафти – чапрази – куки*; *златарство – куюмджийство*; *ножарство – бучакчийство*) and Russian (*мастихин – шпатель*; *картинная галерея – пинакотека*; *гиацинт – жёлтый яхонт*; *рубин – красный яхонт*).

Пейзаж, Ландшафт (жанр)	Градски пейзаж – Исторически пейзаж – **Морски пейзаж, Марина** – Парков пейзаж
Пейзаж, Ландшафт (произведение)	Ведута – **Морски пейзаж, Марина**
Портрет (жанр)	**Автопортрет** – Акварелен портрет – **Бюст, Бюстов портрет** – Групов портрет – Кавалетен портрет – Камерен портрет – Ктиторски портрети – Параден портрет – Психологически портрет – Скулптурен портрет – Социален портрет – Фаюмски портрет – **Херма**
Портрет (произведение)	**Автопортрет** – **Бюст, Бюстов портрет** – **Херма**

Table 6. Pseudosynsets and parallel homonymy in Bulgarian.

Перо (инструмент)	**Гусиное перо** – Рейсфедер – Рондо – **Тростниковое перо, Калам**
Перо (техника)	**Гусиное перо** – **Тростниковое перо, Калам**

Table 7. Pseudosynsets and parallel homonymy in Russian.

- *WordNet* does not explicitly distinguish between *homonymy* and *polysemy*, which has been shown important for some applications, e.g. information retrieval (see [*Krovetz,1993*]).
- *ArtsSemNet* does not support the meronymy/holonymy relation ("*X* is part of *Y*"), present in *WordNet*. This is because we follow the Bulgarian and Russian linguistics tradition, where meronymy is considered as a special kind of hyponymy/hypernymy and not a separate relation.
- The user interface of *WordNet* does not provide automated hyperlink-based navigation between terms (as *ArtsSemNet* does), but has a programming interface. *ArtsSemNet* is kept in a relational database, which allows a simple programming access, although a specialised interface is not supported at the moment.
- *ArtsSemNet* supports both Bulgarian and Russian, while the original *WordNet* is for English only (and *EuroWordNet* supports another set of 7 European languages, but at the moment – neither Bulgarian nor Russian).

We would like to point out that we have two separate networks though *without* links between them. Although they are accessed via the same interface, so that a term can be looked up in either language (a lot of the terms are present in both, but do not necessarily represent parallel notions /Table 5/, but also translingual homonyms /Table 3/ etc.), there is no common index. This is because of problems due to language-specific terminology (crafts, materials, instruments, techniques) originating from differences of culture, traditions, climate etc. Examples for Russian terms with no analogues in Bulgarian are: *клееварка* (*клеянка*), *портретная* (room for portraits), *резьба по газопенобетону*, *резьба по ганчу*, *хохломская роспись* (*хохлома*), *палехская миниатюра*, *сграффито с инкрустацией цветных штукатурок*. Some terms specific to Bulgarian include: *каменина*, *ковано желязо*, *пастирска резба* (*овчарска резба*), *чипровски килим*. Another source of differences is the language-specific deficiency of whole classes of terms, e.g. particular female professionals: Bulgarian-only (*графичка*, *декораторка*, *дизайнерка*, *експресионистка*, *калиграфка*, *керамичка*, *маринистка*, *натуралистка*, *реставраторка*) and Russian only (*лепщица*, *медальерка*, *миниатюристка*, *силуэтистка*, *юмористка*). Unlike *EuroWordNet*, which is a *general* semantic network, we wanted to build one that is both *specialised* and as *complete* as possible. We were not willing to sacrifice coverage in some language, for the sake of cross-language index.

6. Availability and Usage

Both *ArtsDict* and *ArtsSemNet* are freely available for research purposes and their latest versions can be found on the Web (both the applications and the fine arts database for Bulgarian and Russian): http://www.cs.berkeley.edu/~nakov/artssemnet.

There are two variants of distribution: 1) Microsoft Access .mdb file; and 2) SQL-script to create the database schema and populate the data. The first one is oriented to Windows applications and is suitable even for users that are not familiar with relational databases. The second variant could be used by a software developer to import the data into a standard RDBMS (e.g. *MySQL*, *Oracle*, *SQL Server*) and then access it using his/her favourite programming language (e.g. *Java*, *Perl*, *C++*, *C#*).

Technically, the software part of *ArtsSemNet* (both the application and the database) is not limited in any way neither to Bulgarian/Russian nor to fine arts terminology. It can be used with any terminology in any language (except when the alphabet used may be a concern, e.g. Chinese) as long as information about the terms, glosses and relations is available. Since the data is currently stored in a format compatible with MS Access, it can be used

as an alternative way to explore and edit the data, to add a new term, gloss or relation, even a new language. The changes will be then automatically recognised and ready to use by the *ArtsSemNet* interface presented above.

7. Future Work

There are several directions for further improvement and development of *ArtsSemNet*. First of all, some minor functional additions are possible: e.g. enable direct search for co-hyponyms. Second, it would be good to provide a more intuitive navigation: e.g. display the hyponymy hierarchy in the form of tree/graph(s) thus providing a better visual idea of the relations holding between the different terms. Other relations, e.g. holonymy can also benefit from a hierarchical visualisation. A suitable graphical representation similar to the one used in the QuickGO browser (see [*QuickGO*]) for the Gene Ontology Web interface is another interesting option. It would be good to allow for editing/adding/deleting terms, glosses and relations directly from the browser interface. It would be also nice to try to interconnect (maybe partially) the two languages similarly to *EuroWordNet*. Adding more languages is another possibility.

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