Analysis of rhetorical structures in technical manuals and their multilingual generation

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Abstract

In this paper we discuss characteristic features of consumer-oriented technical manuals in several European languages (English, French, German and Russian). We investigated multilingual parallelism of functional structures found in these manuals and the possibility to represent them in a hierarchy of rhetorical relations. We also discuss differences in realization of several rhetorical relations in the languages under investigation. A combination of a language-independent representation of the text content and language-dependent methods for its realization provides the basis for multilingual generation of technical manuals.

1 Introduction

Production of technical documents in multiple languages becomes an actual problem if we take into account the growing localization market. The quality of machine translation is unsatisfactory for practical needs. On the other hand, human translation of a large number of manuals into a large number of languages is very expensive while its quality is often far from the desired one. Another important task is to keep correspondence between the content of a manual and changes in the design of the device that is described by this manual. By this reason, experiments in the field of multilingual generation of technical manuals from their language-independent representation are promising. Multilingual generation of technical documents as an alternative to their machine translation was proposed in [0]. Our investigations follow the direction of research on the TECHDOC system [0], which is an attempt to apply notions from the systemic-functional grammar (SFG) [0 and 0] and rhetorical structure theory (RST) [0] for representing the content of technical manuals.

2 The register of consumer-oriented manuals

Even though RST representations are declared as independent from a natural language they are expressed in, their set and ways for expression depend on a sub-language (a register), which is specific for a given problem domain. In its turn, a register is determined by the communicative situation between the writer and the reader, functional structures expressed in texts and cultural traditions of this genre. Technical manuals form a special register (or a set of registers) having following characteristic features. Technical manuals describe human-made artifacts, so the writer (who is usually a person with technical education) understands and somehow expresses all the device properties that are relevant for its manual. Rhetorical structures in this register are not rhetorical ones according to classical rhetoric. Instead, they reflect the intention of the writer to compose the text so that it conveys information for the user in a concise and adequate way. For this reason, in texts of this register the set of functional structures is restricted in comparison to other registers of technical documents, in particular, registers that involve investigation,

tentative statements or experimental setup require quite different structures for their representation. On the other hand, texts of the register of technical manuals are intended to influence the reader, so they contain modalities and special lexical resources that are irrelevant for technical descriptions in general.

The limited set of functional structures entails the usage of a limited number of lexical, syntactic and semantic resources, while these resources are tightly linked to corresponding communicative goals: expressing a warning, prohibition, condition, advice, description of a sequence of operations, etc. In other words, the way communicative goals are expressed is highly regular. In addition, the structure of a manual is regular too. It is divided into subsections describing operations with various subsystems of the device. These subsections are often arranged in a manual according to a type of operations: maintenance, tuning and the use of a device. The flow of information in each subsection is often developed as “process–its steps”.

An interesting feature of original Russian manuals is that they do not address the reader directly, for example, impersonal constructions are actively used, even direct warnings are written in an impersonal form. Russian technical manuals often look like descriptions of laws of an artificial world related to the device, rather than instructions for its use. As a result, these manuals lack (or do not express directly) the rhetorical structure. For example, it is impossible to build the hierarchical structure (except several fragments) of the following text taken from the manual for the hydraulic system of the aircraft TU-204:

В начале работы после запуска двигателя на земле при охлажденной жидкости до температуры ниже -35°С, необходимо произвести разогрев жидкости гидросистемы до температуры выше -35°С, включив кран кольцевания выключателем КК на панели наземной подготовки на щитке ГИДРОСИСТЕМА. Электрическая схема включения крана кольцевания представлена на рисунке.

(*In the beginning of operations after starting the jet engine of the aircraft on the ground, cooling of the liquid in hydraulic system to temperature below -35°C should result in its heating to temperature above -35°C by turning on the circulation mode switch CM which is placed on the "ground operations" board of the HYDRAULIC SYSTEM panel. The electric circuit for turning the circulation mode on is shown on the drawing.*)

This text violates the requirement for adjacency of spans connected by rhetorical relations [0, p. 8]. However, we can keep all the propositions of this text and reformulate it as follows:

Если [температура жидкости гидросистемы ниже -35°С]$_1$ [необходимо произвести ее разогрев]$_2$ до [температуры выше -35°С]$_3$. Для этого [в начале работы]$_{4a}$ [после запуска двигателя]$_{4b}$ [на земле]$_{4c}$ [включить кран кольцевания выключателем КК]$_5$, [находящимся на панели наземной подготовки на щитке ГИДРОСИСТЕМА]$_6$. [Электрическая схема включения крана кольцевания представлена на рисунке]$_7$.

(If [temperature of the liquid in the hydraulic system is below -35°C]$_1$, [it should be heated]$_2$ to [temperature above -35°C]$_3$. To achieve this, [after starting operations]$_{4a}$ [after starting the jet engine]$_{4b}$ [on the ground]$_{4c}$ [turn the circulation mode on using switch CM]$_5$ [which is placed on the "ground operations" board of the HYDRAULIC SYSTEM panel]$_6$. [The electric circuit for turning the circulation mode on is shown on the drawing]$_7$.)

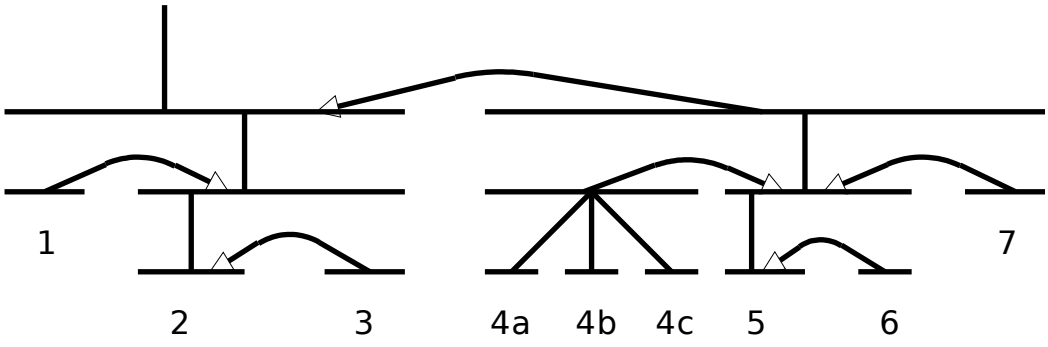

Figure 0.

In this text all the intended communicative goals are expressed directly in hierarchy of RST-relations (figure 0). Rigorous definitions of rhetorical relations which are used in our paper are provided in [0]. The CONDITION relation connects proposition 1 and span 2-3 which is organized from propositions connected by the UNTIL relation. Text span 4-7 is connected to the resulting span 1-3 by the ENABLEMENT relation. The sequence of propositions 4 is connected by the SEQUENCE multinuclear relation, the whole text span 4 serves as a PRECONDITION (defined in paper [0]) for span 5-6, which is formed by the CIRCUMSTANCE relation connecting two propositions 5 and 6*. Additional information from proposition 7 is also connected to span 5-6 by the ELABORATION relation. This structure is language-independent (at least for Russian and English).

However, in some cases it is impossible to express the communicative goals through a hierarchical structure of rhetorical relations. Authors of [0] provide examples of non-adjacent text spans that cannot be joined without breaking constituency of other ones. This situation reflects a general conflict between multiple dimensions of several types of structures (both in syntax and knowledge representation) and a single dimension of linear arrangement of linguistic units.

We think that efforts that the writer made for the composition of the text is a decisive factor for the possibility of its analysis in terms of rhetorical organization, i.e. for the construction of RST-tree that covers the entire text from minimal units upwards for analyzing it up to its large spans. A similar fact is mentioned by L. Iordanskaya: “The more organized the text is logically and rhetorically, the more predictable the choice of the theme proper” [4, p. 18]. Advertisements or messages in newspapers are generally well-composed and devoted to a single communicative goal. So they exhibit hierarchical rhetorical structure of all their spans more frequently. In contrast, just fragments of rhetorical structure can be found in fragments of a text that has been composed less accurately way or is not devoted to a single communicative goal. The possibility of this fact was noticed in [0, p. 20]. Even if a certain type of texts is hard to analyze in terms of RST, this is not a problem for generation, because we *produce* a tree of rhetorical relations and a generated text (hopefully) somehow expresses all the intended communicative goals. In addition, every text of technical manuals (whether it has an RST-analysis or not) contains language-independent functional structures which will be described below.

* Though this participial clause in Russian is similar to restrictive subordinate clauses that are not usually detected as units for RST analysis [0, p. 6], it is useful for the generation purposes to consider all the propositions in text as minimal spans which are connected by rhetorical relations.

3 Functional structures in technical manuals

We have already mentioned that a typical subsection of a technical manual is developed as “process–its steps”. This is expressed by a sequence of actional predicates designating operations with objects. In addition, a sequence of predicates is often interrupted by fragments of the following types: conditions for actions, information about parametric values and modal expressions (warning, prohibition, advice). Below we are going to discuss these text structures in a greater detail. Conditions are represented by means of rhetorical relations, by this reason, they are described in subsection “Expression of rhetorical relations”.

4 Resources for the expression of structures: process-its steps

These structures have two text spans where a span containing “process steps” follows a span with a process. E.g., a process is “changing motor oil”; process steps are “remove oil filler cap”, “drain oil”, “replace oil filler cap with a new washer”, etc. The flow of information expressed in a span “process steps” is determined by the mechanism design (i.e. in the ideational stratum), while textual resources (for example, alternations in theme-rheme) are not used for this task. From the viewpoint of the text structure, this span is organized as a single text fragment containing a sequence of rhemes—predicates with objects and their attributes. In terms of RST it is represented by a sequence of propositions, connected by the SEQUENCE relation. The unity of a fragment can be emphasized by such language resources as coordinative reduction and pronominalization. These resources are common for different languages, though their realization differs from one to another. A text span designating a process expresses a single proposition, it can be realized in several ways: by a sentence, syntactic construction referring to a secondary action or by a verbal noun.

Both spans (process and its steps) are connected into a single span according to traditions of this genre, stylistic rules and language-dependent resources. We found two basic and two complicated ways for this realization.

A. The united span is expressed as a topic and its explication, so that the whole unit is structured as a subsection. Name of the process is shown in the heading, process steps are described in the content of this subsection. In this case, a topic is developed by a sudden switch, because this is done via the table of content and not by language resources. By this reason, RST representations usually do not use a relation between a heading and a content [0, pp. 13, 61]. If a text span “process steps” has only a few simple propositions, organization of a subsection is wasteful. So, the whole structure is often united by the ELABORATION relation which connects propositions developed as “general/specific”:

Remove cap by turning it counterclockwise

Снять крышку, повернув ее против часовой стрелки.

B. The whole structure is united by the PURPOSE relation. In this case, a “process” span is organized as a sentence or syntactic construction having a functional word referring to the purpose, e.g., in a manual for an automatic washer in French (text span 1 is a satellite and text span 2 is a nucleus):

Pour [nettoyer le reservoire d'eventuels residus]$_1$, [ouvrir le portillion, ..]$_2$

It is possible that both ways are combined. In this case, a topic indicated in the heading is repeated as a purpose-oriented construction in the first sentence of the current subsection. In this case the PURPOSE relation provides a smooth development of a theme which starts in satellite and continues in the nucleus. For example, a heading is “*Cleaning detergent residue from the soap dispenser*,” then its content is developed as “*In order to clean... open...*”

Both ways of realization can be complicated by additional rhetorical structure that emphasizes the constituency of the second span. This is done by introduced abstract processes and modifiers.

A'. Way A is complicated by reduction of the text span “process” from a sentence to a word, usually a verbal noun coupled to an abstract predicate with an abstract circumstance (*is performed as follows*). This results in tightening predicate-argument relations in the proposition that contains this abstract predicate. The text span “process steps” is naturally linked to this predicate by the ELABORATION relation as a method of development “abstract/concrete”. For example, the content of the above-mentioned French sentence can be expressed in English as A':

[Cleaning of the dispenser is performed as follows]$_1$: [open...]$_2$

A topic, which is expressed in the heading on the level of text structure according to way A, is represented as a theme expressed on the clause level (in this sentence the theme is expressed by the grammatical subject). This clause constitutes the first text span while its abstract part is explicated further in the second text span.

B'. Way B is complicated by introduction of an abstract predicate which serves as a nucleus of the PURPOSE relation. This proposition with the introduced abstract predicate has number 3 in the following example in English, German and Russian:

[To clean any detergent residue from the soap dispenser]$_1$ [proceed as follows:]$_3$ [open...]$_2$

[Um den Behalter von evtl. Waschmittelruckstanden zu reinigen]$_1$ [ist wie folgt vorzugehen]$_3$: [...]$_2$

Для [промывания ванночки от остатков стирального порошка]$_1$, [необходимо действовать следующим образом]$_3$: [открыть...]$_2$

Use of the PURPOSE relation diminishes syntactic constraints on the syntactic form of proposition 1. In contrast to its realization as a grammatical subject (way A'), this realization provides the possibility to have a complex internal structure of the goal (in satellite) without stylistic “overloading”. The nucleus of this relation contains both the abstract predicate and concrete “process steps”. The abstract span (3) is connected to the subsequent span (2) by the ELABORATION relation as a method of development “abstract/concrete”.

5 Parameters and modalities

Parameters mentioned are determined by the design of appliances, i.e. in the knowledge base. For example, volume of engine oil that is necessary for changing depends on the capacity of the oil reservoir of the engine. Parametric values are described either in tables or in simple propositions. So, they do not have an internal structure in terms of RST-analysis. If parameters are expressed in text, they are connected to a previous statement in terms of “theme-subtheme” alternation e.g., oil and its volume. This is usually expressed by the ELABORATION relation.

Constructions with modal words are divided into two categories that differ in their intended illocutionary force. The first category includes various sorts of recommendation and advice which structure is similar to the structure of process steps. The difference is in introduced modal construction such as: *не рекомендуется ..., избегайте ...; vermeiden ..., vorsicht ..., care should be taken in ..., avoid ..., eviter de ...* The second category includes warnings on dangers that could adversely affect the user’s health or the performance of the device. Warnings are signaled in some way (bold face and/or border around the text). They also exhibit an internal rhetorical structure including such relations as MOTIVATION, CONTRAST and VOLITIONAL-RESULT. These relations emphasize reasons for the warning and are intended to ensure that the reader will consciously prevent eventual

incidents. It is natural to represent a link between this type of constructions and a text body by means of the CAUTION relation, which was introduced in [0].

6 Realization of rhetorical relations

According to the classical definition of rhetorical relations they are not necessarily expressed in a uniform way. They are defined as “structures of functions rather than structures of forms” [0, p. 19]. As Mann and Thompson write [0, p. 49], they were unable to find reliable, unambiguous signals for any of the relations. However, if we want to generate a text from its plan that is represented by means of rhetorical structures, we should constrain the set of their possible realizations.

Rhetorical relations do not form a homogeneous unity. They differ in their function for the expression of knowledge structures from the viewpoint of an author of text. A correlation exists between language means that are used for realization of a rhetorical relation and an SFG stratum which resources it belongs to. A tentative classification of rhetorical relations according to SFG strata is provided in [0]. Relations that belong to the interpersonal stratum (EVALUATION, BACKGROUND, MOTIVATION, EVIDENCE, etc) usually do not have language-specific means for their expression. These relations are signaled by semantic correspondence between ordered spans. Relations that belong to the ideational or textual strata and refer to circumstantial, causal or logical meanings are expressed via language-specific constructions including conjunctions, prepositions, etc. The ELABORATION relation (from the ideational stratum according to [0]) describes conceptual relations between spans: whole/part, system/element, object/attribute, etc. Such methods of text development are expressed in investigated languages by message organization of a clause (in other words, in textual stratum), for example, by theme-rheme partitioning.

Methods for expression of rhetorical relations that are signaled by special lexemes can be divided into a canonical way (using cue word or phrase [0]) and in peripheral ways. Rephrasing in a canonical way is useful for drawing borders between different rhetorical relations, because sometimes it is hard to attribute a relation to a particular type of conditional or causal relations. This means that, on the one hand, the detection of a rhetorical relation is indirectly related to its language form. On the other hand, this language form is realized under influence of adjacent words, clauses and general linguistic context. In NL-generation system this influence is taken into account during lexical choice and grammatical ordering of the clause. In the subsequent section we analyze conditional rhetorical relations found in technical manuals together with methods of their expression in different languages.

7 Conditional rhetorical relations

Texts of technical manuals have several types of conditions which are imposed on modes of operations. These conditions are expressed by rhetorical relations CONDITION, PRECONDITION and UNTIL.

The canonical way for the realization of classical conditions (the CONDITION relation) is similar for different languages: conditions are expressed by conditional subordinate clauses. For example, *Если [уровень масла...], [следует долить масло...]*; *Falls [der Oelstand...], [Oel ...nachfuellen]; If [the level...], [add oil...]; Si [le niveau...], [faire l'appoint...]*. If this rhetorical relation is expressed in another way, a canonical paraphrase should be possible, for example, the following sentence (from the TU-204 manual):

При наличии болевых ощущений в глазах, обратиться к врачу-окулисту.
With pain in eyes you should visit an oculist.
can be expressed as: *Если возникли..., то обратиться...* (*If you feel ..., visit ...*)

A type of conditions that cannot be expressed by a canonical paraphrase is the PRECONDITION relation which is introduced in [0]. The meaning of PRECONDITION is similar to that of CIRCUMSTANCE relation, because it describes circumstances that condition a state of other subsystems of the same appliance or external systems before initiating an action. For example,
Check the coolant level when the engine is at normal operating temperature.

This relation can be found only in few registers, in particular, in technical manuals, while it is rare for the most of texts. Marginal use of this rhetorical relation is manifested in language by the absence of its canonical realization. Realization of PRECONDITION separates four investigated languages into following groups. The prepositions *bei* and *при* are often used in German and Russian for this task. *Bei* has wider possibilities for use, it can be regarded as the canonical way for expression of PRECONDITION in German. Russian *при* has lesser use while English and French lack standard ways for its expression. In some cases, prepositions *with, avec,* are used, otherwise, PRECONDITION is expressed in a hidden way. Compare sentences from a manual for an electric kettle:
При неправильном включении чайника в сеть гарантия аннулируется.
Bei fehlerhaften Auschluss des Gerates erlischt die Garantie.
Dans le cas d'un mauvais racordement, la garantie n'est plus valable.
Any error in connecting the appliance invalidates the guarantee.

Russian and German sentences use prepositions *при* and *bei.* Preposition *dans le cas de* in French is often used in standard conditions. In English the proposition with a condition is introduced as the subject of predicate *invalidate*. This changes communicative organization of the sentence, a wrong connection is expressed as an active influence on the guarantee.

PRECONDITION is often rendered by temporal conjunctions *when (while), alors que, когда*. For example, *[Check the engine oil] when [the car parked...]; [Verifier le niveau d'huile moteur] alors que [la voiture est gare...]; [Следует проверять уровень моторного масла], когда [машина стоит...].* If such an expression is used, an action is mentioned before a condition for its implementation and this condition is external for the action. Sometimes, a satellite of PRECONDITION describes an action with a member or subsystem of the appliance and this action precedes a main action described in the nucleus. This case is expressed by means of temporal conjunctions *nachdem, after, apres que, после того как (когда)*, for example: *После того как [свеча установлена...], [повернуть ...]. After [plug seats...], [turn ...].* In this case, a condition is usually placed before an action.

On the border between CONDITION and PRECONDITION are several cases when canonical rephrasing is possible and a condition is expressed as an advice. Compare the following sentences from a manual for an automatic washer:
В случае, если [вода из водопроводной сети содержит большое количество известковых отложений] [целесообразно запросить...]
[Bei stark kalkhaltigem Wasser] [empfichlt sich...]
[Si l'eau du reseau d'alimentation presente des residus calcaires] [nous vous conseillons de demander au service...]
Three languages expresses this construction in different ways: by means of the CONDITION (French *si*), PRECONDITION (German *bei*) and peripheral condition (Russian *в случае если*).

Another rhetorical relation that expresses a condition is UNTIL. It is introduced in [0] for the description of conditions for stopping some action. There are two ways for the realization of this relation. The first one has the following structure for all investigated languages: <Action> conjunction <Condition> (*[add oil] until [it is*

even...], [faire l'appoint d'huile] juscu'a`ce que [il arrive...]¸ [добавлять масло] до тех пор, пока [его уровень не достигнет...].). The second way for the realization of this relation is by "packing" the condition into an appropriate prepositional phrase: *[bis zur oberen Pegelmarke] [nachfuellen], [refill] [to the upper mark], [добавлять масло] [до верхней метки]*.

Conclusion

We have described language-independent functional structures from technical manuals as well as several types of rhetorical structures found in these texts. We also discussed language-dependent ways for expression of these structures in target languages. These investigations provide a basis for the development of systems for multilingual generation. In particular, TECHDOC, a system for multilingual generation of technical manuals is under development at the Institute for applied knowledge processing FAW (Ulm, Germany). It uses LOOM for knowledge representation, RST and PENMAN for generation. In its turn, we used production rules of system SNOOP [0] as the basis for our experiments in generation. We would like to thank Dr. D. Roesner from FAW for his support of our investigations. We are also thankful to I. Antonova (Moscow University) for her help in contrastive analysis of rhetorical structures in different languages.

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